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A TREATISE ON THE CONTINUUM OF GROWTH IN THE AGING CRANIOFACIAL SKELETON. (VOLUMES I AND II)

The University of Michigan PH.D. 1984

A TREATISE ON THE CONTINUUM OF GROWTH IN THE AGING CRANIOFACIAL SKELETON

VOLUME I

by

Rolf Gordon Behrents

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Human Growth and Development)
in The University of Michigan
1984

Doctoral Committee:

Professor Robert E. Moyers, Chairman
Professor James K. Avery
Professor Stanley M. Garn
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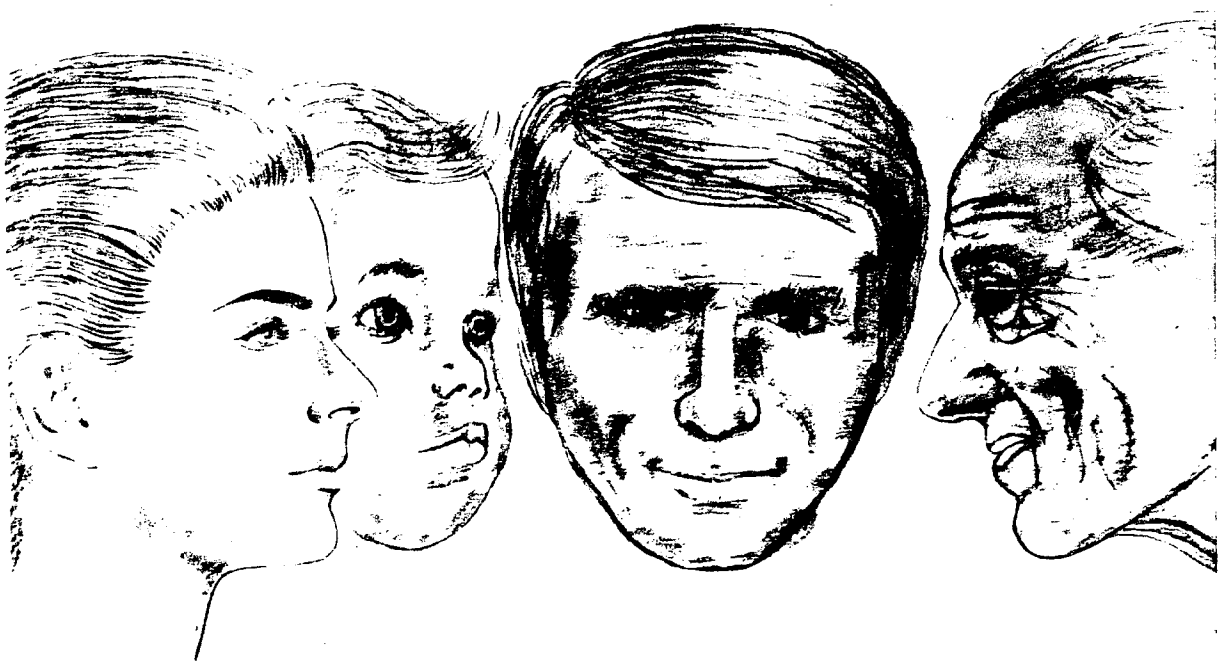
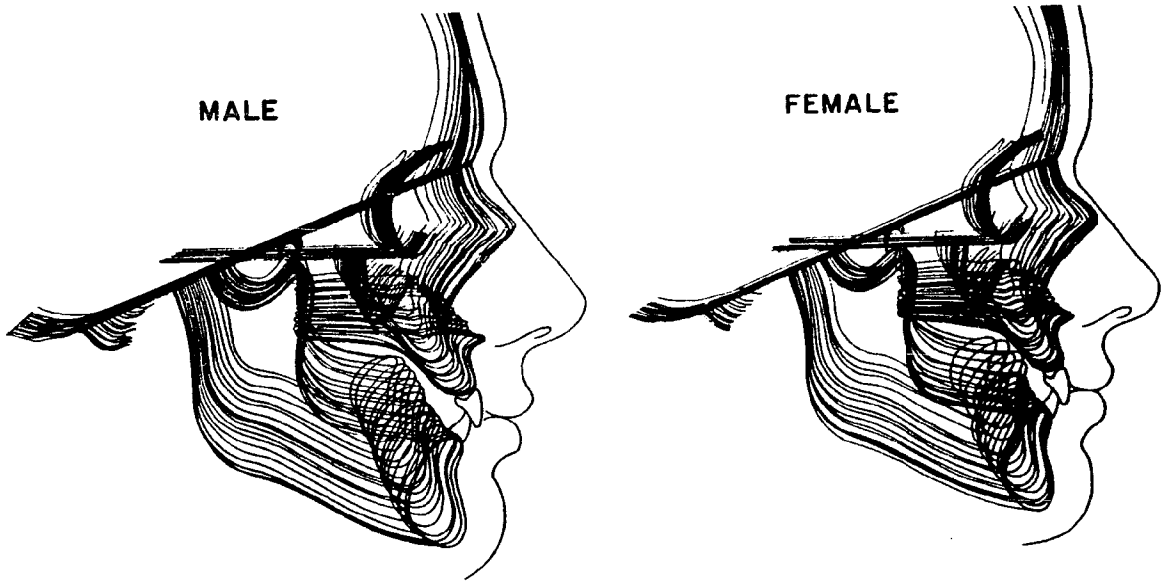


A TREATISE ON THE CONTINUUM OF GROWTH IN THE AGING CRANIOFACIAL SKELETON

A LONGITUDINAL ASSESSMENT OF THE BOLTON-BRUSH STUDY PARTICIPANTS RECALLED IN THE 1980's



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DEDICATION

This work is dedicated to the vision and the light:

To the light--my family: Eileen, my wife, and Nathaniel my son, whose love, encouragement, patience and sacrifice made this work a goal to be reached.

To the vision--Dr. B. Holly Broadbent and Dr. T. Wingate Todd who insightfully instigated the Bolton-Brush investigations to study the normal child and now the normal adult.

ACKNOWLEDGEMENTS

I am deeply indebted to many who have contributed greatly, directly and indirectly, to this study. Although words will be chosen to express my thoughts, my gratitude to these people can really not be expressed in other than feelings.

The University of Michigan

The following men, my thesis committee, have guided me through my doctoral work in an effective and dedicated fashion.

Dr. Robert E. Moyers. This educator has been my conceptual leader as committee chairman and has pushed precisely when needed both in thought and deed. His impact on this work and in the field of orthodontics will never be appreciated to the extent it should, although I do. Aware of the imperfections of life, but continually striving for the perfect.

Dr. James A. McNamara, Jr. I am continually fortunate to be influenced by leaders. Jim is a friend, a confidant and a leader. Always a giving, caring man whose relationship to me I will always endeavor to strengthen for he is worthy in all aspects.

Dr. Stanley Garn. He is perhaps the most published scholar in history, and knows much more than a mere man can. Cryptic at times, but only because of my ignorance. He is a scientist.

Dr. James K. Avery. He is a rock and a friend who taught me much. A gentle soul who works too hard, I appreciate all his thoughts and help.

Dr. Charles Kowalski. An encouraging and likeable fellow who has kept me statistically honest, and guided me in fruitful directions.

Case Western Reserve University

Dr. Donald H. Enlow. He has assisted me in every fashion throughout this study. He put up with my frustrations and always refocussed the important. A diplomat who has done much for me in terms of maturity and career. Each thought he has should be written down.

Dr. B. Holly Broadbent, Jr. He permitted and encouraged this study. A busy man who found time to help. I also am deeply indebted to his office staff for their many hours of "list checking".

The staff who helped me at Case Western Reserve University graciously accepted my requests to do more than their job. They did the typing, copying, lab work, etc. that made me look productive. Without them very little would have been accomplished. A special thanks to:

Mrs. Esther Mendelsohn

Mrs. Marcia Dunner

Miss Louise Krystosik

Mrs. Gizelle Poulos

Miss Deborah Guzzo

Mrs. Marion Hurwitz

Miss Sarah Foster

Miss Mary Lesinski

I also thank the graduate students who helped, who did without and were so patient with their Director when he was doing his work on this project.

For invaluable support I thank Kenneth Little, M.D. for information, Kevin Griffith for his expert help in computer programming, Ms. Lisa Johnston and Mr. William Golden for assisting in the illustrations, and Ms. Linda Nicholl for her excellent typing.

Colleagues

I am very indebted to the following orthodontists who provided several key ingredients to this study. Many were themselves participants in the study when they were graduate students in orthodontics at Case Western Reserve University, or they graciously agreed to help by conducting very precise examinations on participants who lived outside the Cleveland area. It should be noted that all orthodontists asked to help were extremely willing to assist--the profession is to be applauded.

Dr. Ike Slodov (Ohio)

Dr. Leroy Vego (California)

Dr. Norman Nagel (California)

Dr. Michael Sabat (Ohio)

Dr. Larry Z. Greenberg (Texas)

Dr. Mike Horii (California)

Dr. Charles H. Boester (Ohio)

Dr. Alan H. Winters (Virginia)

Dr. Jeffrey Benson (Pennsylvania)

Dr. Joseph Belhobek (Ohio)

Dr. L. William Schmohl (California)

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Dr. Alton Moore (Washington)

Dr. Wilton Krogman (Pennsylvania)

Dr. Robert Chiappone (California)

Dr. Robert A. Stoner (Indiana)

Dr. Alan F. Besas (Connecticut)

Dr. Frank R. Barbieri (South Carolina)

Dr. Hal T. Perry (Illinois)

Dr. Gerald H. Kess (Ohio)

Dr. Robert McGonagle (Ohio)

Dr. Steven I. Fein (New York)

Dr. Arnold E. Binder (Massachusetts)

A special thanks to my fellow "post-docs" at the Center for Human Growth and Development: Dr. David Carlson and Dr. Lee Graber. We went through it together and formed bonds never forgotten. My only regret is that such friends so close together for a few short years now only occasionally cross paths, except in thought.

PREFACE

A study such as this can be described in a very simple fashion. The calcified image of the bones of the head, as structures reflective of the state of the human organism, are measured at the least at two different times to determine what has occurred during the intervening period.

In this regard, the present study received a valuable assist in that magnification present on each of the x-rays has been documented. Because of this changes in the bones of the head which may be occurring at a level below the power of gross observation, may be recognized and measured with relative precision. To an approximation that is perhaps the best that the roentgenographic cephalometric technique and the present sample can offer, the following study is presented as an attempt to decipher continuing biological alteration in the adult.

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INTRODUCTION

Craniofacial biology, and the related clinical disciplines, have been traditionally concerned with the growth and development of the craniofacial complex from birth only up to about the second decade of life. This period of time covers the rapidly accelerating and dramatically obvious changes in the craniofacial skeleton and soft tissues, and it is the period when treatment has traditionally been undertaken to correct problems of growth. Thus the gathering of growth data has focused principally on this period in most previous growth studies because the information gained is deemed necessary for childhood and adolescent patient care. However, as more and more adults are undergoing orthodontic, orthognathic and other forms of medical and dental care, it would appear quite useful to now gather similar information for the older ages. Further, later-life changes may have a profound influence on the ultimate success of adolescent therapy, the longevity of the dentition and the general health of the aging individual.

Most adolescent craniofacial studies to date have presumed that changes which may occur in the post-adolescent craniofacial skeleton to be minimal. Indeed, the presumption that the adult state is simply one of maintenance of form pervades the literature. This is perhaps inappropriate as it is known in other disciplines that developmental processes and changes in morphology continue long after puberty.

CHAPTER I

REVIEW OF THE LITERATURE

Biological Changes in Aging

> Growth is a word, a term, a notion, covering a variety of diverse and complex phenomena.
>
> - Paul Weiss

It is fairly well established that a wide variety of basic histologic and physiologic alterations are at least coincident with aging. However, even with manifest alteration, the only consistent thought that can be applied to all aging systems is one of progressive change (Kohn, 1971).

Some of the changes may be viewed as increasing the functional capabilities of the living being and thus part of pre-maturational development; other changes may be viewed as impairing the capacity to function and thus associated with the development of senility. However, this discrimination is for convenience only because the delineation between early development and later changes in the aged is unclear as to when one process ceases and another begins. In fact, the only beginning may be life with all processes continuing until death.

Early changes are often spoken positively of in terms of "life", "growth", "development", "increase"; while later changes are

spoken of in terms of "death", "deterioration", "senescence", "involution", and "degeneration". This too, is perhaps inappropriate as the words conclude as qualitative emotional judgments about the alterations throughout the biological continuum of life. Ambivalent change is the only consistency throughout aging with all developmental terms applicable to all phases of life differing only in the relative amount of activity.

Functional Alterations with Age

The outward changes of aging are most often noted, generally in regard to performance, superficial appearance, and function. The acuity and range of performance of the special senses diminishes in regard to sight, hearing, taste and smell. Memory, problem solving, concentration and the ability to learn are also somewhat diminished (Sinclair, 1978). Breathing capacity is altered (vital capacity decreases). Generally, blood pressure increases although a fall in systolic pressure may be noted upon standing apparently due to a depression of autonomic control (Sinclair, 1978), as well as a dramatic drop in diastolic pressure between heart beats. Cardiac output decreases. Thermal regulation by the nervous system also apparently becomes altered, with basal heat production decreasing. General motor performance as well as coordination, precision of movement, reaction time, and strength change with age (Stern et al., 1980). Examples familiar to the lay person are seen in aging athletes and very aged individuals. Posture is altered and changes

in body composition (more fat, less muscle) are noted during middle age periods. Iatrogenic functional alterations are also quite possible as a result of long term medication given in response to systemic diseases, which tend to become more prevalent in the older age groups (Baum and Bodner, 1983).

While these notations represent some of the outward assessment observations, diverse physiological changes within the organisms establish the basis for such changes. A limited discussion of age changes follows to exemplify the multitude of progressive alterations that occur. For more extensive reviews the reader may consult Andrew (1971), Sinclair (1978), Kohn (1978), and Finch and Hayflick (1977).

Intracellular Changes

It is very clear that different cell types have characteristic life spans; with evident intracellular changes; the simplest example being a microscopic view of stratified squamous epithelium. It would thus be expected that changes within the cells as they age are numerous. Many cell types have been studied extensively and such changes have been described in detail. However, while it is clear that cells change through time in structure, function, and response to stimuli, there has been great difficulty in quantifying any such changes as due only to age because of the continuing process of cell renewal.

In spite of this, varied experimental evidence suggests, in general, that macromolecules, organelles, structural elements (such

as membranes and myelin) and chromosomes change through time (Kohn, 1978). Long-lived cells lose their ability to synthesize certain cell components, properties of organelles change, enzyme content changes, and accumulation of several types of insoluble substances such as lipofuscin and various minerals occurs through time.

While it is apparent that a great deal of research still needs to be done in the area of intracellular aging, it is usually surmised that the chief disabilities of aging begin with changes within cells and tissues of the body, especially in the processes of growth and cell replacement. It is clear that mitoses begin to fail to compensate for cell death in the aging organism.

Extracellular Changes

Although equally as difficult to study as intracellular changes, alterations also occur in the extracellular component with age. Generally, there appears to be some loss of proteoglycans, changes in polysaccharide content (Sobel, 1967), a redistribution of water with total extracellular water decreasing (more in females), basement membrane thickening, and an accumulation of various salts, lipids, and extrácellular minerals (Kohn, 1978).

Collagen, as an integral part of the body in general and as an important component involved in aging, has been studied extensively. With increasing age, collagen fibers demonstrate an increase in number and greater crosslinking (Butzow and Eichorn,

1968) a process which is most rapid and extensive between 30 and 50 years of age (Kohn, 1978). The fibers also increase in diameter (cornea, schlera, tendons, meninges) to a stabilization and a later decrease in size (Linken, 1955). Soluble collagen disappears as the organism ceases growth (Banfield, 1952). There is also a decline in the resistance of collagen to proteolytic enzymes such as collagenase, a decrease in tensile strength and in extensibility. In high stress areas collagen also appears "bent" and damaged.

Elastin becomes thickened with age and altered in distribution throughout the body (for example, increased in the stroma of heart skeletal muscle and skin of neck). It is also sometimes described as frayed, fragmented, brittle or less elastic, altered in color (more yellow) and showing evidence of calcium deposition.

While cellular and extracellular changes appear to provide a basis for the aging process there is great difficulty in their study. Aging effects relating to tissues and organ systems are more grossly apparent and as such have been more thoroughly documented in the literature.

Skin

Perhaps the most obvious signs of aging are apparent to all upon viewing the skin. Both on microscopic examination and visual inspection, the skin comes to appear pale, yellowish, flaccid and inelastic in the aged.

Structurally, it is apparent that the epidermis becomes thinner, and at advanced age levels there is a loss of subcutaneous fat. The wrinkling of the skin apparently results from a combination of factors including a change in connective tissue arrangement, fiber property alterations (more basophilic), fibroblast changes (cell number and secretory activity decreases, nuclei are pyknotic), a decrease in proteoglycans, and repeated muscular action coupled with a loss of elasticity of the skin.

Atrophic changes are also noted in the sebaceous glands and hair follicles. Increased pigment deposits are also noted. Slowing of nail growth in the adult consistently occurs (in the rabbit and mouse nail growth increases).

Healing of the skin becomes slowed and often complicated by ulcers. This is apparently induced by a diminished blood supply along with lower scar strength resulting from diminished collagen formation and a declining rate of scar contraction.

Blood Vascular System

Age changes are noted from the smallest capillary to the heart, both in morphology and in the regulatory mechanisms related to them. In the larger arteries there is increased rigidity and loss of tensile strength and stretchability (Kraflea, 1940; Haas, 1943). Internal changes include manifest alterations in the composition and thickness of the various layers, increased deposition of collagen, calcification, changes in lumen size and shape, and fraying or splitting of the internal elastic lamella.

A gradual reduction in the number of capillaries and an increase in the irregularity of the capillary network occurs as evidenced by the extensive tortuosity that develops in the hand and foot (Bastai and Dogliotti, 1937). These conditions may lead to increased intravascular aggregations of red blood cells. Histological changes include an increase in the reticular connective tissue.

The veins show increasing thickening with age along with a decrease in muscle fibers. Increased collagen fiber accumulation is also present along with focal deposition of calcium.

The heart becomes smaller with age in the absence of disease and shows considerable change. By differing amounts in the walls of each chamber there occurs diffuse thickening of the endocardium, calcification, fat deposition, plaque formation, collagen fiber accumulation, atrophy of the smooth muscle and other similar changes involving the valves, conduction system and epicardium.

In the blood there is apparently little observable change with age in terms of cell characteristics and cell numbers except for the lymphocytes. In the hemopoietic system the marrow tissue is apparently little changed except for a decrease in response to stimuli. Similarly, Knobloch (1954) showed the intensity of erythema brought about by noxious stimuli is greatest in the third and fourth decades and least in the seventh.

Lymphatic System

In lymphoid tissue striking changes occur with age. Gen-

erally it has been shown that lymphatic tissue shows progressive atrophy and thus diminishes with age (Ivy, 1952), except in the lung (Miller, 1924, 1937). The germinal centers of the lymph nodes start to change at puberty as the cortex becomes thinner and the distinction between the cortex and medulla fades. For the palatine tonsil, it appears to reach maximum size at puberty; the size is maintained until the 70's when decreases are noted (Hieronymus, 1933). In the adenoids, Todd (1936) found they first appeared at about 1 year of age; increased in size to 3 years of age and then remained stable to adolescence, thereafter undergoing gradual involution. While the thymus shows gradual decline in size, a total degeneration does not occur as has been thought. In the spleen, it is noted the organ's weight and size increases into the 20's and is stable until the 60's when a decrease is noted. The lymphoid tissue within the spleen increases into the 20's followed by a later gradual decline.

Respiratory System

Unexpectedly there appears to be a definite increase in elastic connective tissue with age in the respiratory system. However, the respiratory cage overall apparently becomes less elastic in nature due to muscle and cartilage changes, resulting in decreased breathing capacity. Lymphoid tissue increases along the respiratory tract with age.

Urinary System

For the kidney gross age changes include generalized atrophy, capsular thickening and surface irregularities. Histologic changes include glomerular, tubular, interstitial, and vascular alterations. The cortex diminishes in size in the 60's as does the number of glomeruli. With kidney impairment due to the loss of functioning tissue, blood urea tends to rise as does blood cholesterol, sugar, creatinine and uric acid. There is also decreased excretion of calcium, phosphorus and hydroxyproline (Dequekar, 1972; Salch and Coenegracht, 1968). The kidney is less responsive to stimuli in terms of diminished hypertrophy in one kidney in response to removal of the other kidney.

Reproductive System

For the male, production of viable sperm continues into old age in spite of notable gross and histological changes in the testis, prostate and other related tissues. The frequency of intercourse is said to taper with age. For the female, at menopause the active cycles cease. This then affects the many related structures especially seen in atrophy of the ovaries and uterus with age. Related endocrine change and systems interplay are also apparently quite important in the age changes of other body components.

Digestive System

With the changes noted in the body tissues in general, it

would not be surprising that considerable age changes would be noted in the complex digestive system.

In the oral cavity, with age it is apparent that the teeth undergo considerable change (see A.E.W. Miles, 1961 for a review). Perhaps the most recognized change involves attrition of the teeth, but there also appears to be considerable alteration in the position, continuing eruption and inclination of the teeth with age (Beyron, 1954; Parma, 1943; Ackerman, 1946; Wild, 1946; Moses, 1946) with uprighting of the incisors noted by Lysell and Myrberg (1971), Humerfelt and Slagsvold (1972), and Forsberg (1976, 1979). The chemical composition, physical characteristics, resistence to decay and color of the teeth also appear to change as does the blood supply to the teeth (Bernick, 1967).

The salivary glands become altered in structure (accumulate fat and oncocytes) and the quantity and quality of their digestion-related secretions are changed (Meyer, Spier and Newvelt, 1940). This perhaps accounts for the mouth and lips being drier than those of the young.

The tongue shows a decrease in mobility, muscle tone and strength and a decrease in muscle fibers. Baum and Bodner (1983), in assessing oral motor function in individuals ranging in age from 23-88 years, found diminished oral function with age regardless of dental condition. Males showed the most deviant behavior in tongue function and swallowing. A change in the ability to chew, lack of tongue support and altered swallowing

patterns were noted. This is consistent with the work of Feldman and his associates (1980), who found that the oral musculature changes resulted in an increase in the time the aged needs to prepare food for swallowing.

The related tissues of the oral cavities also undergo change with age. Temporomandibular joint changes include an apparent hardening and loss of elasticity of the capsular ligament and inter-articular disc. In conjunction with muscle changes, the bite force is reduced with age (see Massler, 1971; Kaplan, 1971; Elfenbaum, 1970; and Shear, 1967 for more details). Obvious general alterations are noted for the lips, gingiva and oral mucosa.

In the stomach a chronic atrophic gastritis is common in people over 50 years of age with a thinning of the mucous membranes, leucocyte infiltration and a structural change in the gastric glands. Achlorhydria is also noted along with the presence of increased benign gastric polyps. The stomach is also less distensible due to a decline in elasticity.

In the intestines marked changes are noted with smooth muscle decreasing, amyloid deposits, atrophic crypts of Lieberkuhn and an increased incidence of diverticulosis. In the appendix, age changes include obliteration of the lumen, fusion of the walls and considerable fibrosis. Functional alterations regarding motility, tonicity and absorptive capacity of the intestines are also affected. For example, there appears to be reduced absorption of calcium and phosphorus. Vascular, muscle and neuronal control changes are also apparently causative in terms of hemorrhoid formation and constipation.

Related organs such as the pancreas and liver also show evidence of age changes. The pancreas exhibits a smaller size, metaplasia of the epithelium, an increase in fat tissue and evidence of pigment accumulation. The liver shows a decrease in size and weight with age and additional histological changes which are reportedly difficult to interpret.

Endocrine Glands

In general the endocrine glands demonstrate a generalized fibrosis with age (especially the suprarenal medulla), calcification (especially the pineal gland) and other routine histological changes associated with generalized atrophy. It is important to note the age-related changes in the end products of endocrine gland production.

The production of hormones is altered substantially with age. Because of the complex interaction of endocrines among themselves and with many and varied tissues, knowledge of age changes is limited. However, in general it is clear that aging affects many aspects of endocrine regulation, does not affect all the endocrine glands equally, at the same time, or all the different hormones secreted by the same gland to the same extent (Gregerman and Bierman, 1974). Aging can cause altered secretion rates, patterns of secretion, responses by the tissue for which the hormone is a target, blood transport mechanisms of the hormone, and altered breakdown and excretion rates. Specific changes in hormones with age are summarized in Table I (derived from Gregerman and Bierman, 1974).

TABLE I

CHANGES WITH AGE IN PLASMA HORMONES
AFTER GREGERMAN AND BIERMAN (1974)

HORMONAL AGE CHANGES

HORMONE	BLOOD CONCENTRATION	RESPONSE TO STIMULATION	DISPOSAL RATE	SENSITIVITY OF TARGET ORGAN
GROWTH HORMONE	NO CHANGE	↓		↓
GONADOTROPHIN	↑			
THYROTROPHIN	NO CHANGE	↓		NO CHANGE
THYROXIN	NO CHANGE	NO CHANGE	↓	↑
PARATHYROID HORMONE	↓			↑
CORTISOL	NO CHANGE	NO CHANGE	↓	
ADRENAL ANDROGENS	↓	↓		
ALDOSTERONE	↓		↓	
INSULIN	NO CHANGE	↓	NO CHANGE	NO CHANGE
GLUCAGON	NO CHANGE	NO CHANGE		
TESTOSTERONE	↓		↓	
ESTROGEN	↓		↓	

Nervous System

In general there is a decrease in brain weight, a narrowing of the cerebral gyri, and a widening and deepening of the sulci. Shortly after puberty a diffuse atrophy of the brain begins, especially for the frontal lobes and olfactory bulbs (Terry and Gershon, 1976; Lenman, 1975; Marshall and Berrios, 1979; Sinclair, 1978). The number of cells in the temporal lobes and the number of Purkinje cells in the cerebellum are steady to the early 60's followed by a decline (Sinclair, 1978). There is a relative increase in neuroglia tissue, lipofuscin deposits are common, the organization of the dentrites change and it is estimated that by the 60's some 20% of the total number of neurons are lost.

The number of nerve fibers in the dorsal roots of the spinal nerves decrease after about age 30 years. In general for the spinal cord and posterior root ganglia, atrophy and pigmentation accumulation are progressive with age.

In the peripheral nervous system it is noted that the maximum speed of conduction in large nerves decreases, but the speed of conduction in simple reflex arcs does not. Although skin sensibility does not change, the number of Meissner's corpuscles decreases. The number of taste buds also decrease. Nerve injuries heal less satisfactorily in the aged.

For the eye, grossly there is a loss of fat in the orbits which makes the eyes appear sunken. The sclera becomes infiltrated with fat, and many changes are noted in the cornea and retina. For the iris there is a fading of the pigment. The lens becomes less elastic reducing the power to accommodate, a gradual opacity occurs, and it progressively becomes thicker (Weale, 1963). For the ear a gradual loss of acuity occurs and a high tone hearing loss with age is noted.

Muscle

Muscle tissue has been extensively studied in regard to aging and it is very evident manifest morphological and functional alterations occur (Gutmann, 1970; 1977). While the changes vary somewhat according to location and species (human and rat in this discussion), certain generalities occur. With age skeletal muscle decreases in volume by as much as 30% in weight between 30 and 90 years (Sinclair, 1978). In the muscles themselves capsular thickness increases (Swash and Fox, 1972), and there is an increase in collagen and elastic tissue throughout the stroma of the muscle. Pigment accumulations are common as well as extensive fatty infiltration, with perhaps more in females (Frantzell and Inglemark, 1951; Inokuchi et al., 1975). Mast cell numbers also increase.

Skeletal muscle myofibrils show considerable change in terms of arrangement, pattern and integrity. With age there is a de-

crease in the total number of fibers (Gutmann, 1970; Kawamura et al., 1977) as the fibers lose their striations and disappear to be replaced by connective tissue (Andrew et al., 1959). Aged fibers may show a decrease in width, a decrease in the amount of sarcoplasm, there may be a decrease in the number of nuclei, and a large centrally placed nucleolus. "Ringbinde" (a striated ring of myofibulary origin surrounding a fiber) occur (Bergstrand, 1938), as demonstrated in the tensor tympani, laryngeal muscles, diaphragm and temporal muscles (Greenfield et al., 1957).

Together with a decreased blood supply and testosterone level with age, further critical alterations would be expected in regard to muscle function. Age changes also include changes in several enzymes involved in catecholamine synthesis and degeneration (McGeer and McGeer, 1976; Pradhem, 1980), decreased neuronal axoplasmic flow, motor nerve cell death and motor unit atrophy with lapses in activation of single motor units (Petajan and Jarcho, 1975), and a decrease in transmitter release. With these changes together with more inelastic tendons (Kohn and Rollerson, 1959), the following would be expected: decreased speed of contraction, a decrease in the force of contraction and frank movement disorders (Marshall and Berrios, 1979).

Smooth muscle has received little attention in regard to age changes except in conjunction with the blood vessels and the uterus. In this regard age changes include an increase of fat accumulation and collagen between the muscle fibers.

For the cardiac muscle, in general there is an increase in the size of the muscle fibers until the 60's and a decline thereafter. Lipofucsin granules accumulate and there appears to be an increase in the number of nuclei in an old heart. Beyond these general features there are age changes which are found unequally in different areas of the heart muscle. For the atria (differs also somewhat for right and left) more fat tissue develops with age and more elastic connective tissue appears compared to the ventricles. Also, in the atria, fatty tissue is later replaced with fibrous connective tissue. In the ventricles there is an increase in reticular fibers. Alterations are also present in the conduction system which would affect muscle function.

Skeletal System

With such manifest changes occurring in the body tissues in general it is apparent that adulthood is not a stable physiological and morphologic period. Also, since these changes affect the many different tissues and biochemical mechanisms involved in bone production and destruction, it should not be surprising that alterations can occur at the osteological level.

While the earliest concepts regarded bone as quite static in nature during adulthood, it is now felt that various dynamic changes occur throughout life even after epiphyseal union. Furthermore, with cartilage and bone, some age changes are more conspicuous and more easily preserved than for soft tissues and thus have received a great deal of attention in regard to aging.

With cartilage, it is readily apparent that a short term cycle of life exists when one views growth, maturation, hypertrophy and degeneration of chondrocytes seen in epiphyseal columns (Scott and Pease, 1956; Policard and Boyd, 1958). On a long term basis, after epiphyseal union, calcification of certain cartilages in relatively young adulthood and progressing into old age is a common occurrence (Amprino and Bairati, 1933). Chondrocytes may reproduce by amitosis in older people (Elliot, 1936), and ossification may in essence add to the length of the bone throughout life (Johnson, 1964, 1966). In this instance cartilage is invaded by collagen which converts the cartilage into fibrocartilage. The collagen fibers may also thicken and clump together (asbestos formation), and calcium salts may be deposited around the fibers (calcified cartilage). Further mineralization of the extracellular matrix may convert cartilage to bone. This has been demonstrated in the larynx (Noback, 1949) and in the cartilages joining the ends of the ribs to each other and to the sternum (which can restrict breathing movements).

It should be noted in articular cartilage, however, that a combination of growth and regressive change often appears to be found with aging. Fatty inclusions within cartilage cells may occur leading to some erosion of the articular surface. This along with generalized stiffness in the joints due to a loss of elasticity in the joint connective tissue may lead to pain, conscious movement limitation, more collagen formation and degeneration, and more stiffness and pain.

In terms of the intervertebral disk, after about the third decade, there is some evidence that degeneration occurs through time which can lead to collapse under stress. The nucleus pulposus shows a decrease in the number of cells, water content, mucoid substance, and an alteration of proteins present. Ultimately the disk becomes dehydrated, pigmented, fibrotic and sometimes calcified. This may lead to a reduction in stature especially in the lower part of the vertebral column. The secondary curvature of the spine is usually unaffected, but the primary curvature regresses to a state more like infancy which, along with weakness in the postural muscles, results in "stooping". As a result the xiphisternum is brought closer to the pubis and the muscles of the anterior abdominal wall slacken. Together with the accumulation of adipose this may bring on a "bulging tummy".

Bone in regard to aging alters quantitatively and qualitatively. With age the weight of the skeleton decreases, there is a decrease in bone mass, and the physical density (weight/volume) decreases (Trotter and Peterson, 1955; Trotter et al., 1960). There is also a decrease in the thickness of the cortex of the rib (Sedlin, 1963), second metacarpal (Nordin et al., 1966; Garn et al., 1967; Morgan et al., 1967; Dequeker, 1972), and femur (Smith and Walker, 1964). Some trabecular bone loss is also noted especially in females (Beck and Nordin, 1960; Sisons, 1964).

In regard to bone matrix composition, no great significant changes are noted, although some conflicting reports have been

made. There are varying reports regarding bone collagen depending on the bone studied and the condition of the subject. There also appears to be great variation in mineral density; calcium content, phosphorus content and their ratios (Follis, 1952; Dequeker, 1972; Johnston, 1964, 1969). Water content is altered dramatically from some 60% in the very young to about 10% in the aged. There is an increase in apatite and an increase in its crystal size (Robinson and Watson, 1955), which are factors which may affect the piezoelectric properties of bone which in turn may affect the prevelence for fracture and the lessened ability to heal in the aged. However it must be stressed that no significant differences in age or sex for bone minerals or collagen content are clearly substantiated (Dequeker, 1972).

The histological changes in aging bone are numerous. The cellular components are altered with the osteocyte changing from a filamentous to a spherical shape as its processes retract. Filled lacunae, mainly in interstitial bone, indicating cell death are noted with age and the total number of osteocytes decreases (Johnson, 1964, 1966). Curiously periosteal osteoclasts also have been noted to decrease in number in the rat and mouse femur (Tonna, 1960) and in guinea pig condyles (Myers et al., 1959). Mitochondrial differences are noted with age for the osteoblast, but not the osteoclast (Tonna, 1960).

The Haversian system or osteon, originally formed by deposition of concentric lamellae within an irregular resorption cavity and demonstrating a central canal with blood vessels, demonstrates a configurational change with age. The osteon changes from an eccentric cylinder in childhood to a small rounded structure, the osteonal column becomes shorter and the number of fragments of older osteones increases as does the total number of osteons (Johnson, 1964, 1966). The central canal becomes wider with the extra space filled with fibrous or adipose tissue. Plugged canals, mainly in periosteal bone, become more prevalent perhaps due to an interrupted vascular supply. Kerley (1965), found non-Haversian canals were virtually absent after 55 years.

In regard to bone turnover, bone remodeling appears to be slower with age. Manson and Lucas (1962) noted an increase in deposition activity (mandible) after 50 years of age, but a more marked increase in resorption activity. Josey (1960, 1963) found there was a high turnover rate in young bone but a remarkedly lower turnover rate in young adult bone. In young adult bone there was little bone formation and destruction. The osteons appear to fully close and rapidly attain a high mineral density. In old bone the delicate balance between deposition and resorption was disturbed with a gradual increase in resorptive activity, particularly on the endosteal surface with little evidence of bone formation changes (i.e., no reduction in bone formation with age).

Kerley (1965) similarly found that new circumferential lamellar bone was high in childhood and decreased with advancing age (femur, tibia and fibula; birth to 95 years). In some older specimens this process was virtually absent while in others it was present to 95 years. Also Villanueva et al. (1963) showed that an increase in bone deposition occurred in the forties following a peak in infancy and a period of gradual decline from infancy to the forties.

Enlow (1975) also pointed out there may be some areas of primary (non-Haversian) periosteal or endosteal bone encountered in old bone as these deposits may represent remodeling alterations in response to changes in skeletal morphology associated with changes in weight, posture, loss of teeth and other factors.

Bohatirchuk (1954, 1955) also pointed to new bone formation in the vertebral column (with no associated disease of the joints), especially for males. Also, according to Amprino and Bairati (1936), the phenomena of appositional growth and functional adaptation continue into senility.

These seemingly sometimes inconsistent findings of the above studies may be due to the sample studied, but do appear to point to some degree of bone turnover at all bone surfaces which may be episodic in nature continuing well into adulthood. Such a situation, if general for the human, would perhaps be expected to result in measurable morphologic changes in bone through aging.

Besides the general processes of cancellous and cortical bone being constantly replaced by resorption and deposition, gross changes are noted in regard to age. Enlow (1975) points to a change in the width of the cortex with age (as noted previously by Sedlin, 1963; Nordin et al., 1966; Garn et al., 1967; Morgan et al., 1967; Smith and Walker, 1964) and an increase in the width of various canals and cancellous spaces of the aged as the result of osteoporosis. This aspect of bone development or bone redistribution involving gross bone changes on both periosteal and endosteal surfaces has been extensively studied by Garn and others. Their studies have demonstrated that up through the fourth decade continuing bone gain in both sexes is accomplished from both subperiosteal deposition and endosteal deposition resulting in an increase in cortical thickness and a maximum bone mass between 30 and 40 years of age (Garn, 1970, 1972, 1981; Garn and Wagner, 1969). Beyond that period of age subperiosteal apposition continues throughout life (Garn, 1981) resulting in increased external dimensions (more for females) and in an expansion of the medullary cavity (Garn et al., 1964, 1966, 1967, 1968, 1972, 1981; Dequeker, 1972). These two effects result in a decrease in cortical thickness with age. This phenomenon is apparently a human generalized condition regardless of genetic, socio-economic, nutritional and environmental factors (Garn et al., 1967; Garn et al., 1966). The cortical size decrease also has been implicated in accounting for the greater incidence of "spontaneous" fractures noted in the aged as

individual bones have less flexural resiliency and greater compressive strength (Smith and Walker, 1964). These findings are in contrast to the assumptions of Todd (1937), Krogman (1962) and Tonna and Cronkite (1962) who felt periosteal apposition ceases at about 20 years of age.

This generalized remodeling of bones along with increases in bone diameters (periosteal and endosteal) due to continued periosteal apposition, endosteal resorption and decrease in cortical thickness has been reported more-or-less conclusively for the ribs (Epker and Frost, 1965, 1966; Epker et al., 1965; Sedlin et al., 1963), femur (Smith and Walker, 1964; Trotter et al., 1960; Ruff and Hayes, 1982; Smith and Frame, 1965), second metacarpal (Garn et al., 1967; Garn et al., 1968), humerus (Pfieffer, 1980), tibia (Garn, 1970) and skull (Israel, 1973). The ages included within these studies generally extends from the fourth decade until the nineties for both sexes (Garn, 1981).

Further, it has been noted that the bodies of the vertebrae become shorter and broader with age (Erickson, 1976, 1978) along with vertebral density decreases and trabecular thinning (Smith and Frame, 1965; Arnold et al., 1966). The entire skeletal volume increases although it loses in mass (Garn et al., 1967). An enlargement of the marrow cavities has been noted in the ribs (Epker et al., 1965; Stoker and Epker, 1971), mandible (Manson and Lucas, 1962), and frontozygomatic suture (Kokich, 1976).

A View in Sum

It is thus clear that the basic tissues in general and the skeleton in particular are far from quiescent in histologic activity during aging. Distinct, sometimes complementary and sometimes contradictory (different than adolescence) processes are involved in aging. Changes are evident in regard to pathology, hyperplasia, atrophy, use of structures, timing and growth. Further, the term degeneration is often applied to age changes, but this is really a quality assessment. The operative term is "change" in understanding what effect physiological changes may have on the skeleton. Thus it does not follow that a "degeneration" of one tissue or system results in a "degeneration" or diminution of bone. Change in a tissue or function could change a structure so as to decrease or increase its prominence. As it appears that tissue alterations are prominent in aging, it would be expected that such change could be noted also on the anthropometric and craniometric levels.

Physical Assessments

With the manifest physiological changes occurring in general and osteologic changes in particular, it would be expected that complex systems would also be altered through time. One of the systems which has been extensively studied in this regard is stature as an additive measure of the condition of the skeletal system and as an indicator of the cessation of growth (adulthood).

Many studies have been accomplished in this regard from birth to old age. It is generally asserted that stature becomes constant once epiphyseal union is complete, remains so for several decades of life and then declines after about the sixth decade due to compression of the intervertebral disks. However, different opinions are expressed as to the precise age when stature stabilizes, and the age where a decline in stature could be expected. For men statural increases have been reported from birth to the forties and for females to the late thirties. Growth cessation has been documented to occur from 17-45 (Clements, 1953; Roche et al., 1972; Buche, 1950; Shigeru et al., 1973; Wunsche, 1953; Lasker, 1953; Trotter and Gleser, 1951; Martin and Saller, 1959; Parizkova and Eisett, 1971; Backman, 1938; Miall et al., 1967; and others). A decline in height variously estimated to be of the magnitude of about 1 cm per decade has been shown to occur after about 40-50 years (Dequeker et al., 1969; Kalliomake et al., 1973; Trotter and Gleser, 1951; Buchi, 1950; Suzanne, 1967, 1974, 1977; Hertzog et al., 1969; Parizkova and Eisett, 1971), although decreases have been noted for earlier ages (Lasker, 1953; Mial et al., 1967; Gsell, 1966; Borkan and Norris, 1977). No decrease in height was noticed by Lipscomb and Parnell (1954) or Damon (1965).

In terms of studies which have sought to isolate areas of the vertebral column in regard to aging, Albrook in 1956, in assessing the lumbar vertebrae in Black Africans, found that vertebral heights increased in males (not females) into the fifth decade. Similar results were noted by Erickson (1976, 1978) for Black Americans.

In regard to these studies it is clear that long bone growth could continue after epiphyseal union probably as the result of cartilaginous deposition on joint surfaces (Buchi, 1950). It is also clear that increases are possible for the skull and vertebral column (Isreal, 1973; Albrook, 1956), along with a gain in fat within the scalp and plantar surfaces of the feet (Garn, 1981). These factors could account for increases in height into middle age.

In regard to the various estimates of age cessation and statural decreases several factors may indeed introduce confusion. Postural changes due to muscle and nervous alterations with age and a weight augmentation (observed till 60 years by Suzanne, 1977), along with a loss of hair and fat in the aged, may affect a postural decrease assessment. Other major factors may influence these studies, as follows:

1. Sample selection; racial, ethnic and genetic differences.
2. Time of measurement effects; environmental, selective survival, migration and nutritional factors among others.
3. Diverse criteria for establishing cessation.
4. Varying methods of study sometimes including secular changes (Backman, 1938).

It is relatively clear however, that height may continue to increase until middle age followed by a decline (Marquer and Charmla, 1961); similarly for weight (Stoudt et al., 1965; Pett and Ogilvie, 1956; Hooton and Dupertuis, 1951). Similar relationships are seen in anthropometric assessments of biacromial diameter (Hooten and Dupertius, 1951; Marquer and Charmla, 1961; Parot,

1961). Chest width increases followed by decreases were noted by Marquer and Charmla (1961) and Hooton and Dupertuis (1951). Chest depth and pelvic width, however, appear to grow in a continuous fashion throughout life (Marquer and Charmla, 1961).

Secular Trend

A secular trend can add a degree of uncertainty to interpretation in all cross-sectional studies, including stature. This is because the secular trend for stature is for a progressive increase in height (Hultrantz, 1927; Ingervall et al., 1972; Hertzog et al., 1969; Suzanne, 1967, 1977). This factor plus time of measurement effects, and selective survival migration patterns, may all serve to complicate cross-sectional study results.

Secular trends may also impose a difficulty in cross-sectional studies of the craniofacial complex as secular changes have been found to affect the head and face (Buchi, 1950; Udjus, 1964; Hunter and Garn, 1969; Ingervall et al., 1972; Shigeru and Ohtsuki, 1973), and the teeth and dental arches (Garn et al., 1968; Bowden and Goose, 1968; Lavelle, 1972, 1973).

It may also be remembered that application of the results of studies on stature as one part or system of the body, and as only one criterion for establishing the cessation of growth, cannot necessarily be applied to a different system such as the craniofacial complex, because great differences are present between the two systems (Brown et al., 1971).

Craniofacial Growth Assessments

Studies on morphological changes of the craniofacial skeleton are numerous. For the most part these studies can be historically dated as before or following the invention and utilization of the cephalometric technique as introduced by Broadbent (1931).

Prior to the development of the cephalometer, most studies were cross-sectional in nature dealing with measurements on dry skulls or cadavers, casual observations or gross body measurements on living individuals. After the advent of the cephalometer, precisely controlled longitudinal cephalometric studies became possible on living, growing individuals.

Most studies during either period have tended to center attention on the young, and most did not address craniofacial growth in the adult because the growth of children was dramatically evident with little noted for the post-adolescent, in longitudinal studies sample sizes tended to diminish as the individuals approached the late teens, funding for the long term studies was not obtained, and the interests of the researchers did not include the adult period. As a result there are many cross-sectional studies regarding adult craniofacial change, but little long term serial data.

Cross-Sectional Studies

Cross-sectional studies of human craniofacial change with age are numerous. Various samples (sex, race, ethnic origin, etc.) have been evaluated, and the subjects were often grouped into large age groups. Group means were determined and compared as

to differences between younger and older groups or used for describing general size trends. However, there are difficulties in interpretation of such data as disease states, secular trends, timing of measurement effects, inaccurate age estimates, and selective survival effects, all serve to confound assessment of individual ontogeny. Thus, interpretations of findings in these studies are limited in many ways. Their value lies primarily in the study of adaptation and in pointing out trends which can then be confirmed or denied only by longitudinal assessment.

Humphrey in 1858 noted that the cranium becomes thicker with age. In 1865 he also pointed out that the loss of teeth results in a change of function and a widening of the gonial angle.

Pfitzer (1899) conducted a study of Alsatians and reported that certain growth changes continued throughout life to such an extent that they could be measured anthropometrically. Augmentations (non-significant) of head breadth and bizygomatic breadth, for example, were noted.

Todd (1924) performed a cross-sectional study of 484 male skulls (20-84 years of age) and concluded that up to the seventh decade the calvaria increased in thickness with no discernible change thereafter.

In a series of studies, Hellman (1927, 1932) sought information on the adult face and cranium utilizing skeletinized material grouped on the basis of dental characteristics which he felt would help him understand natural development. His studies on adolescent to aged American Indian cranii enabled him to conclude that

the face continues to grow in height and width until "old age" at which time a degeneration occurs. Some sex differences were noted in early adulthood. This view encountered considerable criticism at the time.

Saller (1930, 1931) observed an increase in the bizygomatic dimension, head length and breadth (significant). Frontal breadth was non-significantly larger. Nose height increased significantly, as did ear height.

Jarcho in 1935 reported increases in adult head and face length and breadth to the fourth and possibly the sixth decade using a sample of Russians, Kirghiz, Uzbeks, and Armenian individuals. Nose height increased as did ear and lip height.

Contrary findings were reported by deFroe (1936) in assessing skulls of known age and sex. He noted a decrease in face height and concluded people actually got smaller with age.

The same year, Goldstein (1936) reported on an anthropometric investigation on American Jews (various ethnic origins). He minimized the nature of facial changes and even suggested there could be an overall decrease in head size. Part of his measures were performed on a group of 50 people with a mean age of 74 (approximately 60-106 years of age), and he found decreases with age for face length (nasion-menton, nasion-prosthion and ramus height). He also attempted to assess the anterio-posterior growth of the face and found increases from the external auditory meatus to infradentale and menton. Head diameters tended to decrease and nose height increased. Facial width measures all increased (bizygo-

matic, bicondylar, nasal and oral). Secular trend (and tooth loss) effects on facial dimensions could be important in assessing the result of this study. Later, Goldstein (1943) also noted an augmentation in head length, head breadth, frontal breadth, bizygomatic breadth, nose height, and ear height in an larger sample.

Hrdlicka (1936) in summing up some forty years of observations on various samples concluded that growth does not cease in the early twenties, but rather procedes at a slower rate involving certain features of the body as a whole including the face, into and beyond the fifth decade. For stature, Hrdlicka believed increases continued into the fourth decade; for the skull and face into the fifth or sixth decade; and for the length and breadth of the nose, length of the ears, width of the mouth, and depth of the chest beyond the sixth decade. Like Hellman, he believed very aged persons showed a decrease in size. His assumptions were based on his own studies on "old American whites" and "American Indians" (1925, 1935) and those of Parchappe (1836) on a French sample (age 20-60; growth till 60), Quetelet (1836); Pfitzner (1899) on adult Alsations (15-80 years; growth to 40) and Jarcho (1935). In another interesting study, Hrdlicka (1938) submitted individual reports from people who did "brain work" with the belief that very active use of the brain at work would cause the head to grow, and submitted evidence that brain weight does not stabilize until the thirties. The individual reports were consistent for an increase in hat (head) size, weight increase, and hair loss.

Goldstein and Stanton (1937) attempted to assess facial height in people with normal occlusion and malocclusions. Using Hellman's approach to dental age grouping for a male sample, they demonstrated a tendency for an increase in facial height in the normal occlusion group, but none for the malocclusion group.

Oldberg (1945, 1946) in assessing lateral head films on a cross-sectional sample spanning 7 decades, found no marked changes after 25 years of age in regard to the thickness of the frontal and parietal bones. He noted a tendency for internal thickening of the frontal bone in the oldest women (7th decade).

In a study of 17,341 male members of the U.S. Army categorized in two groups (17-18 and 19-26 years), Randall (1949) found no change in head circumference during the age spans studied.

In another large sample, Hooton and Dupertius (1951), utilizing cross-sectional anthropometric data on approximately 10,000 Irish males, found continued facial growth into the sixth decade. They felt there was an increase in head circumference, head length, bizygomatic dimension, head breadth, and total face height which continued well into the thirties. Nose, lip and ear height also increased.

In 1953, Wunsche reported on a cross-sectional study regarding facial height in 572 men and 430 women ages 20-91. The results indicated that in men, total facial height increased (from 20 to approximately 40 years) on the order of 1.1 mm. After 60 years

of age the men showed a decrease in facial height amounting to 2.4 mm. In women the greatest facial height was noted in the age group 26-30 years of age, and it decreased thereafter to the extent of 7.7 mm after 71 years.

A cross-sectional study of two Mexican adult populations was conducted by Lasker (1953) who also compared his data with that of Goldstein (1943). He reported significant increases in head breadth and height for females and a tendency for increases in males. In total face height, males showed an increase in one of the samples, with females showing an increase in both sample groups. Bizygomatic and bigonial diameters increased with age in both sexes. Significant increases were also noted in nose height, nose breadth and ear height.

Zuckerman (1955) in investigating the cranial base could find no alteration in the later years on the basis of a cross-sectional comparisons of a series of European skulls. Zuckerman studied age changes in the basicranial axis of the human skull in 109 adult and senile skulls. He found that angular values changed little, but absolute distances tended to increase. He felt that the basioccipital, basisphenoid, presphenoid and ethmoid continue growing between puberty and maturity.

Moore (1955) in studying hyperostosis cranii in a large sample spanning 8 decades concluded that no definite trend exists toward craniofacial enlargement after the second decade. This conclusion was made in spite of a suggestion in his published graphs that cranial growth continued.

Tallgren (1957) utilized cephalometric methods to cross-sectionally study face height in 165 women between the ages of 20-81 years. Results indicated that facial height increased from the youngest to the eldest groupings with the highest mean value for the 30-39 year olds. The increase was considered significant.

Horowitz in 1964 conducted a study involving 100 males and 100 Caucasian females, age 20-30 with class I occlusion. Male values were found to be larger than among females except for the gonial angle. He concluded that sex differences in size and relationships of the facial components tend to increase with age.

A cross-sectional comparison of 60 males and 106 females (Caucasian) with various dental conditions was conducted by Heath in 1966. No relationship was noted between the upper facial dimensions and the number of years the patient was edentulous. In the same year, Campbell (1966), a radiologist, suggested that the calvaria continues to thicken throughout life.

In an anthropometric study of the head and face, Lewis and Hedegard (1970) studied 87 male and 77 female Swedes ages 25-49. Although they concluded males were larger than females no age-related data were discussed.

In a 1971 cross-sectional study of females ages 26-90, Isreal could find no marked age changes except for a thickening in the bregma region. Isreal's work in aging of the craniofacial skeleton, which is extensive, will be evaluated in detail in a later section.

Very little change in craniofacial dimensions was noted by Boersma (1974) who used a cross-sectional approach to study changes in the older ages (58-91 years). Unfortunately, no distinction was made as to the state of the dentition in this sample, which could influence interpretations. He did note that the length of the nasal floor (ANS-PNS) became significantly increased in females. Pooled sex data revealed a significant difference with age in the distance Sella to Nasion, a larger cranial base angle, and a larger nasal floor. Error of measure was determined to be 1.8 mm or less for absolute values and 7.3 degrees or less for angular values. As previous investigators had demonstrated (van der Linden, 1959; Boersma, 1967) women were smaller than men, and these differences appear to become more pronounced with age.

A discrete trait investigation over age was conducted by Carrucini (1974) on 321 human skulls (20's to 60's). Few discrete traits (loosely: presence or absence of structures) varied beyond maturity--except for genial tubercles, trochlear spurs, inion salience, the mastoid and pterygoid foramina, and the post condylar canal.

Nasjletti and Kowalski (1975) sought to determine whether vertical facial proportions change through time by examining 510 Caucasians 20-86 years of age. Age groups examined demonstrated total facial height increases, but upper-to-total facial height ratios remained very constant (43.5%). This corroborated the assumptions of Broadbent (1937), Brodie (1940, 1941), Herzberg and Holic

(1943) and Sarnasi (1957), but was in conflict with Thompson and Kendrick (1964) who found that the lower face increased more than upper facial height during the 3rd and 4th decades of life.

Kowalski and Nasjletti (1976) applied the same technique to a sample of American Black males and, although the ratio was smaller than that of Caucasians, it remained fairly constant through time even with increases in facial height. Harris et al. (1977) continued studies of these samples (244 Black males, 20-80 years; 1039 Caucasians, 20-80 years) in regard to mandibular and alveolar characteristics (dentulous sample) and concluded that craniofacial changes may be age and race specific.

Ruff (1980), based on his own findings (cross-sectional study of 136 adult male skulls) as well as those of others, suggested that the evidence tilts in favor of the skeletal system in general and the craniofacial skeleton in particular undergoing a small but significant increase in size during aging which is not sex-specific, population specific, and little affected by genetic, mechanical or environmental factors. He studied prehistoric skulls and found an overall increase in size with increasing age. He did observe a change in gonial angle.

Lestrel et al. (1980) in looking at the effects of edentulism studied two groups: edentulous (mean for age groups 38.8 years and 58.7 years) and dentulous (age groups 37.3 and 56.8). Utilizing cephalograms he measured the inferior border of the mandible and symphysis area and concluded that in the former cortical thickness increased with age while in the latter a decrease occurred.

Heathcote (1981) suggested on the basis of a cross-sectional study that the general rules regarding craniofacial growth during aging should include age-related decreases in certain craniofacial aspects, based on some of his facial measures demonstrating a significant decrease while others were increasing.

Champion et al. (1982) investigated 266 Venezuelans of Negroid descent between 8 and 60 years of age. Anthropometric, cephalometric and dental measures were taken. However, the age groupings used precluded any assessment of adult changes.

Additional cross-sectional morphological studies of the human head have been conducted. For example non-significant decreases in head lengths have been reported by Dahlberg and Walhlund (1941), Coon (1950), and Marquer and Charmla (1961). Other studies would include Bartucz (1917), Boas (1911, 1935), Bouliere (1966), Kaufman et al. (1858), Lee and Lasker (1958), Parot (1961), and Quetelet (1870). Except for noting characteristics of individual samples, little additional information could be determined as a result of the cross-sectional approach.

It is clear these studies gave varying results and indeed opinions as to the effects of aging on the craniofacial skeleton. The factors confounded or unaccounted for include the pathology of tooth loss, individual changes, secular trends, selective survival, racial effects, sex effects, and other similar conditions. While important for pointing out possible trends, a longitudinal approach to growth during aging would perhaps give a clearer indication of individual ontogeny.

Longitudinal Assessments of Craniofacial Growth

Cross-sectional studies have some inherent limitations in that they can often demonstrate what is not true, but can offer little in the way of clarifying or providing information as to what is actually occurring. However, cross-sectional studies do point out the features worth pursuing through subsequent longitudinal assessment.

Since earlier cross-sectional studies, several decades of longitudinal assessment have revealed much better information of what had already been suspected on the basis of cross-sectional comparisons. Studies involving samples of known age, normality, and various environmental controls were thus able to show individual differences in rate, duration, pattern, and amount, and thus permit both the study of individual ontogeny and of group trends. However, while longitudinal assessment may be the desired manner of study in assessing adult craniofacial changes, because of the inherent difficulties in such study, the adult studies conducted to date have for the most part suffered in application due to difficulties involving short age spans studied, non-normal dentitions, small samples, and technical limitations.

Buchi (1950) studied some 200 Swiss adult individuals separated into 6 age classes. All individuals were measured twice at 9 year intervals. On the basis of growth curves he suggested that facial height increased in the group 20-28 years over the

period of study for both men (0.29 mm) and women (1.06 mm). Also, facial height decreased during the period of senility (after 70). He also pointed out that the distance from nasion to the upper lip increased with time and, in an earlier study (1949), that hand length and breadth increased in size except for the oldest age groups studied. He concluded (1950) that aging (young adult to 8th decade) resulted in a steady increase in the diameter of head and face and also in long bone dimensions even after epiphyseal union up to the ages 56-64. He felt that "old people" have approximately a 2% larger head than "young people".

Thompson and Kendrick in 1964 reported on a serial cephalometric study of 71 males age 22-34 years of age who had measures repeated at one year intervals. These people had negligible attrition of the teeth. Vertical assessments of the face (total, upper and lower) demonstrated significant increases. For lower face height there was an increase on the order of 0.37 mm in one year. Kendrick and Risinger (1967), reporting on the same material, found significant increases in head length, anterior and posterior cranial length and upper, middle and lower facial depth.

Carlsson and Persson (1967) and Carlsson et al. (1967), utilizing longitudinal material with a five year span between the initial and final recordings, found no changes in the length of anterior cranial base, the height of the upper face and the gonial angle. The only major changes involved substantial decreases in the alveolar processes as would be expected since the final record was obtained five years after complete dental extractions.

Utilizing lateral radiographs Tallgren (1967) conducted a longitudinal study on mature denture wearers with 7 years between recordings. She found no changes in the cranial base and upper face and no alterations in the length, height or shape of the mandibular base. She thus felt no growth occurred. A further study in 1972 added no information in regard to age changes. In 1974 she reported further on a longitudinal study involving 32 females age 20-73 years measured over a 15-16 year span (final ages 35-88). She reported no real change in the cranial vault or base except for an increase in the distance between sella to glabella and an increase in the cortical thickness over the glabellar and frontal areas. Contrary to the findings of others, notably Israel, no changes in the external or internal size of the calvaria or skull thickness was discerned. The mandible displayed a condition described by Tallgren as a positional change due to tooth loss. She specifically questioned Israel's results on the basis of unstandardized record gathering. This attack was acknowledged by Israel (1977) who felt Tallgren had refuted every claim for continuing growth in the head. Tallgren (1974) concluded that there is a marked stability of dimensions in the adult craniofacial skeleton.

In a series of longitudinal and cross-sectional studies beginning in 1967, Israel sought to determine the effects of age on the craniofacial skeleton. Israel (1967) measured the entire skull (very few facial measures) utilizing lateral skull x-rays in 43 male and 53 female subjects with the initial x-ray taken at 24-56 years of age

and then the final some 13-25 years later. This generally represented a 4-5 decade span. The subjects were dentulous. Lateral oblique (45°) x-rays were also assessed on 119 males and 94 females to investigate bone loss in the jaw. Jaw height decreased (more for females); tooth bearing bone decreased (more for females) while cortical thickness increased. Measures taken on the skull (Nasion to Anterior Nasal Spine, Basion to Nasion and others) demonstrated skull thickness and craniofacial size increases for all measures.

In 1968 Israel reviewed the 1967 material in regard to the information gained on the lateral skull x-rays. He reiterated that the skull gained in all dimensions studied. Difficulties were encountered, however, in that even though continuing growth was present, the hypothesis that greater gain is associated with older ages or increased age spans was not clearly supported. He raised the possibility that measuring error approximated mean cranial gain, thus obscuring the "real" situation. He suggested that sutural and remodeling activity apparently were responsible for changes which were "different" from changes noted in the appendicular skeleton.

In 1969 Israel published a cross-sectional study designed to determine the morphology of the mandible relative to age, particularly in regard to tooth-supporting bone. Two male dentulous samples were used with an age range 20 to 69 years. Trends pointed to an increased thickness in the body of the mandible, and loss of alveolar crest.

In his 1971 thesis Israel performed a cross-sectional study on 176 white females using lateral head films. The sample comprised an age range of 26-89 years divided into age groups. Several interesting findings were noted: there was no evidence of age changes in the external or internal skull size, except in the area of Bregma; the Basion-Sella-Nasion angle increased significantly till about age 55 then declined in value; and the only facial measure utilized (because of dental complications in interpretation), Nasion to Anterior Nasal Spine demonstrated no significant change. He further noted an increase in the size of the frontal sinus to age 60 followed by a decline. No change was noted in mandibular characteristics except for the alveolar crest associated with loss of teeth. The third cervical vertebra tended to grow in width, but no change was noted for the dimensions of the cervical spinal canal.

Israel (1973) reported on an apparently different sample (no males, 152 females between 26 and 89.4 years, cross-sectional and longitudinal samples (N=18), minimum span 14 years). It was also reported that only 9 of the participants in the longitudinal sample had utilized a cephalostat. It was not stated whether the cephalostat was available for both the initial and final x-rays (sample age 25 at start and a maximum of 65 for final), but it is likely that cephalostats were available for the 9 at the final x-ray only. At least 5 of the 18 people were completely edentulous at the final x-ray. The cross-sectional sample was separated into age and edentulous-dentulous groups (56 and 96 participants, respectively).

The dentulous group had a minimum of anterior occlusion. It was concluded that the gonial angle does not change over age regardless of dental status.

In 1973, Israel also reported on longitudinal and cross-sectional material evaluating the third cervical vertebra. The x-ray material was derived from his previous studies (1971, 1973). It was evident that an increas in vertebral height and width occurred with age (about 5%).

Also in 1973, Israel reported on longitudinal material on 26 female subjects (previous 18 plus 8 more) with a similar age span: 24-48 years initial film, age span 13-28 years, final ages 41-64 years. Where radiographs were obtained without a cephalostat, films were scrutinized in regard to rotation and those films included were selected on the basis of "images which had a high degree of superimposition" (apparently asymmetry is thus denied). Three technical situations existed in regard to record gathering (focal spot to object length, object to film distance), but Israel felt this biased the younger films as "too large", and thus no enlargement was accounted for. Estimated enlargements were 14%, 10% and 9%, respectively, for the historical alterations of technique.

Dimensional increases were noted for cranial thickness (1-11%), skull size (3-5%), sella position (3-4%), upper facial height (4%), sinuses (7-12%), size of the sella turcica (9-13%, 22% for area), and cervical spinal canal (4%). Israel concludes that his results infer a virtual symmetrical magnification enlargement process

(except for skull thickness, frontal sinuses and sella turcica) in the range of 3-5%. Remembering that the technique used disregarded one to 5% of gain, the enlargement overall might amount to 5-7% overall and in certain areas substantially more. Israel also apparently believed the sutures played no role in the changes seen. Contrary to the appendicular thinning, cranial thickening was noted and the response was similar for both the neurocranium and viscerocranium (unlike childhood).

In a further summary study Israel (1973) again analyzed 176 Caucasian females from the Fels Institute with an age range of 26 to 90 years by means of lateral radiographs. This study utilized both cross-sectional and longitudinal components as 26 of the females had records over a 14 to 28 year span. No males were reported on. Through a series of craniofacial measures it was clear that the calvaria thickened from the frontal region posteriorly to the bregma area from adulthood to senescence. The frontal thickening apparently amounted to approximately 15%. The skull demonstrated a consistent size increase (5-6%) as measured by both external and internal dimensions, presumably due to ectocranial deposition and endocranial resorption. He felt this relationship peaked at about 70 years of age, and thereafter the converse was in force (presumed ectocranial resorption-endocranial apposition). This observation was apparently based on the cross-sectional material for the later ages. No evidence of differential growth was noted. In viewing the distances from Basion to Sella to Nasion, it

was clear that a similar size increase was occurring. Also the area appeared to retain its shape even though a considerable increase in the size (height, width and area) of sella turcica occurred (more of an increase than for the cranial base in general). Bergstrom et al. (1973) also demonstrated an increase in sellar volume with age in females, but not in males. In the facial region, Israel noted that the upper face height (6%) and the frontal sinuses increased (9-14%) with time. In the mandible continuing growth in over-all size (5-7%) was consistently noted, and no shape change was seen regardless of the status of the dentition. The symphysis demonstrated an increase in thickness with age. Based on his work, Israel concluded that for the neurocranium and viscerocranium including the mandible, remodeling procedes in a virtually symmetrical "magnifying" fashion on the order of 5-7%, with the result being a retention of shape and enlargement of dimensions. Growth occurs through remodeling. It should be noted that percentage enlargements reported in this article were slightly enlarged from those reported previously.

In 1977 in an attempt to dispel concerns about his cephalometric technique, Israel performed a study involving 26 females and 26 males (age 24.9 to 78.8; span 13.9 to 28 years). Citing his own previous studies (1970, 1973) he felt the increases in the thickness of the skull air sinuses and sella turcica amounted to "roughly" 10%, while the overall enlargement was 4-5%. In the 1977 study he was attempting to demonstrate that differential growth occurred,

which would be inconsistent with radiographic error involving a simple magnification effect induced by technique instead of biology. This was in response to articles by Tallgren (1974), who felt Israel's work was not correct and that no adult changes occurred, and also by Adeloye et al. (1975) who suggested only small increases in skull thickness for a sample of Blacks and Caucasians. In Israel's study (1977), four measures were used involving cranial structures only. The female sample was the same as reported previously (1973). Together with the male sample Israel felt, because skull length percentages were roughly half the values recorded for sella, frontal sinus and skull thickness, that differential growth was demonstrated and that improper radiographic technique had not manufactured the results.

Israel (1978) went on to suggest that the continued expansion was on the order of 1% per decade. He also felt that:

> "since sutures are rigid and individual bone displacement is inconceivable, expansion procedes in such a way as generally to reflect uniform enlargement except for sella turcica, skull tables and air sinuses."

He felt changes occur in the image of that which is already present.

In 1979 Israel reevaluated the 1969 data and concluded that the results demonstrated "continued expansion of the mandible with age", involving the thickness of the body and ramus width dimensions.

In sum the works of Israel clearly point to an enlargement of the cranial skeleton. However, the lack of precision and consistency utilized in record gathering, over which he had no control,

clearly confuse the amount of change. It is likely that biology was assessed but was difficult to accurately quantify.

Forsberg (1976) performed a longitudinal cephalometric study of men and women in their twenties at the initial exam and then, one group was re-examined at 5 years and the other at 10 years. Some of the group had undergone orthodontic treatment in childhood, but this was not considered to be a factor of any significance. Angular and absolute measures were taken on the 5 year interval group, but only angular measures were utilized to the 10 year interval group due to difficulties in determining cephalometric magnification. Results at age 25 years indicated there was a size difference between the sexes, but no sex difference was observed in regard to the degree of prognathism and inclination of the incisors. Other changes indicated there was an increase in vertical dimension of the face due to an lengthening of lower face height (0.35 mm in lower face height ages 24-29). Anteroposterior jaw relations indicated no change for men but showed a mandibular decrease for women. Uprighting of the incisors was noted. Forsberg concluded that no growth changes occurred beyond 29 years of age based on comparison of angular measures (only) between the two groups and further felt the changes do not indicate "growth" but rather are due to a posterior mandibular rotation with a resultant uprighting of the incisors.

However, Forsberg in 1979 performed a follow-up examination on 25 men and 24 women using angular and linear measures. In the main the results were consistent with his 1976 report. How-

ever, further increases were noted for lower face height up to age 34 (0.56 mm in 10 years), along with the supposed posterior rotation of the mandible due to tooth eruption and decreased movement of the incisors. No increase was noted for the upper face, but there was a forward movement of the nose, a lowering of the upper lip and retrusion of the upper and lower lips. He suggested in this study that changes continue in the adult and that he would further investigate after 15 and 20 year spans.

Susanne (1977), in a longitudinal anthropometric study of 44 Belgian males measured twice between the ages 25-60 at an interval of 22 years, found consistent increases in head length and head breadth. He also demonstrated increases in bizygomatic width, facial height, nasion to stomion height, head breadth, nose height, ear height and a decrease in lip length and frontal breadth. Susanne summarized in 1978 by stating that it appears that the face continues to grow during aging into the 4-6th decades, mainly involving facial heights and diameters, the mouth and ears. He points to an increase in bizygomatic width, on the basis of many studies, until age 60 as evidence of periosteal apposition and to continued growth of the nose due to cartilage growth and fat deposition. He also points out that cross-sectional studies have demonstrated an increase in nose breadth, size of the ears and a decrease in the size of the lips.

From these longitudinal studies it is fairly clear that continued bone expansion is possible involving the tubular bones,

round bones, vertebrae, skull, mandible, sella turcica and the volume of the entire cranial vault. It is likely human growth continues for a considerable time. Thus, to the question of what triggers the onset of growth, sustains it for a finite period, determines its magnitude and turns growth off, we still know little of the first but are beginning to have further insight into the latter.

Consequences of Edentulism

Many studies have been conducted in regard to the craniofacial effects of the removal of teeth. Besides obvious changes in the alveolar processes, prime emphasis has centered around other possible mandibular changes. A major difficulty has been the inability to separate age effects from edentulism effects as well as possible treatment effects. Nevertheless, several studies are summarized below to reflect the consensus regarding the effect of the lack of teeth on osseous morphology.

For the most part cross-sectional studies have promoted the view that the gonial angle increases with age and the loss of teeth (Goss, 1954; Inkster, 1964; Humphrey, 1858; Hrdlicka, 1940). However, Brodie (1940) opposed in general the idea of change in the gonial angle. Conversely, Rogers and Applebaum (1941) felt that there was a flattening of the gonial angle with both tooth loss and age, resorption of the anterior surface of the condyle and a reduction in the height of the coronoid process. Keen (1945) felt these changes occurred only with the loss of teeth but not aging. Lonberg (1951), in comparing early denture wearers (early tooth

loss) to old denture wearers, found that an increase in the gonial angle occurred among the former. He also noted a reduction in the height of the body of the mandible and width of the ramus. For age alone he suggested there was actually a decrease in the gonial angle.

Edwards (1954) felt also that after loss of natural teeth, the corpus, rami, condyles and coronoid processes undergo changes as a result of less extensive use of the muscles. Sicher (1960) similarly concluded that with tooth loss there was a change in function and thus a widening of the angle. He felt this was a consequence of disuse atrophy of the masseter and medial pterygoid muscles which was more marked if dentures are not worn. Coulson (1960), in an x-ray cross-sectional study, found varying degrees of resorption in the symphyseal region. Kettunen (1965), however, observed no change.

Longitudinal studies do not support the view of gonial change with age or edentulism. Johnson (1963, 1964), found no such change. Fish (1979) in studying lateral skull radiographs with a seven year interval, Israel (1973), Tallgren (1967) with a 7 year interval, Carlsson and Persson (1967) with a 5 year interval, all found no change in the gonial angle. Hedegard (1962) in a three year x-ray follow up of immediate denture wearers, found a significant increase in the gonial angle along with increases in upper facial and anterior skull base dimensions. Atwood (1957, 1962) in 18 patients followed for 34 months after extractions, found large individual variations.

From a histological standpoint, Enlow et al. (1976) studied the remodeling patterns of edentulous mandibles and found the medial and lateral surfaces of the corpus to be depository, while the lateral posterior and anterior surfaces of the ramus were resorptive. The net effect was to make the corpus longer. Neufield (1958) felt that tooth removal also caused a disorganization of the trabecular system.

What is apparent from these studies is that perhaps the gonial angle may change, but not due strictly to age or loss of teeth. The discrepancies noted may result from other complex factors. For example, different morphological musculoskeletal jaw types would surely respond not in general terms to total tooth removal but at best would show "type" specific alterations. Individual responses to loss of teeth and denture wear could evoke any of the possibilities for gonial angle change. It is also felt the question of the effects of tooth loss on the craniofacial skeleton will have diminishing impact and relevance in what must now be regarded as our less dentally pathologic society.

Adolescent Study Implications

In the main earlier studies regarding craniofacial changes have seldom been extended beyond early life except for the few summarized above. Studies by Welcher (1866), Weissenberg (1895), Keith and Campion (1922), Connolley (1928), Sheridt (1931), Smyth and Young (1932), Todd (1930), Flemming (1933), Freeman (1933), Godin (1935), among many others for the most part did not attempt

to investigate age levels beyond adolescence. These studies, also, generally encompassed various kinds of samples, were cross-sectional in design, and did not use the cephalometric technique.

More recent accounts have contributed more to the understanding of adolescent craniofacial growth (Enlow and Harris, 1964; Brader, 1956; Tebo and Telford, 1950; Scott, 1954; Symons, 1951; Savara, 1965; Brodie, 1949, among many others), but again were not intended to add to our understanding of adult growth. However, several studies merit noting in regard to various concepts about growth cessation and adolescent changes, perhaps providing a basis for extrapolation to later ages.

Broadbent (1931), in introducing roentgenographic cephalometrics, developed a series of diagrams (1937) in which he illustrated an orderly, consistent growth pattern and the obvious straight-line path of landmark migration later published (1975) for ages one to 18 years. Hellman (1935) concluded that the infant face is transformed into the adult by increases in size and changes in proportion and position. He noted that depth of the face increased the most followed by height and width. Goldstein (1936) felt the face was fully developed by 19. Davenport (1940) studied the heads of some 200 children and reported striking variability. Brain case growth was felt to be 98% complete by age 15.

Brodie (1941) published the results of a serial study of the human male head from the third month to eight years. During this

period he noted little change in the developmental behavior of the mean pattern, although considerable individual variation was found. He felt that after 3 months all landmarks tend to progress on straight growth lines. Enlargement of the various anatomic areas was found to be proportional. After an early age the nasal floor, occlusal plane, and lower border of the mandible were all shown to retain stable angular relationships. No change was found in the gonial angle, and no growth spurts were in evidence.

Realizing that individual variations need to be pointed out Downs (1948) and later Wylie (1947) designed several cephalometric analyses.

Bjork in 1947 concluded on the basis of a cross-sectional comparison of males 12 years of age and 20-22 years of age that in the later ages the face lengthened in vertical height with an increase in prognathism but with the mandible exhibiting a greater prognathic change than the maxilla. It was also felt the incisors upright between the ages of 12 till the early twenties.

Similar results were noted by Lande (1951) who studied a serial sample of males from 4-17 years of age. Regarding mandibular prognathism, his findings were similar to those of Bjork (1947) after 7 years of age and of Brodie (1941) for ages prior to 7 years.

Roche (1953) studied increases in thickness of various regions of the parietal and frontal bones and reported slight increases up to age 17. This was also reported by Young (1957).

Coben in 1955 reported on the results of a serial cephalometric study of 47 children from 7-17 years of age with similar findings. From 8 years of age the distance between Basion and Articulare did not change. Also after 7 years of age the distance between Sella and the internal surface of the frontal bone did not change.

Nanda (1955) performed a serial study to age 20. Growth rates continued, even after the plateau in body height, up to the end of the period studied. This is different than the conclusions of Tanner (1955) who felt face height follows a general growth curve.

Bjork and Palling (1955), in a longitudinal study of 243 Swedish males (12-20 years of age), observed no significant uprighting of the lower incisors.

In 1960 two studies by Nelson and Elmajian on two adolescent samples up to the age of 20 years found that point Sella moved with time. Sellar movement has also been noted by Latham (1962) for at least 10 years after birth.

Bambha (1961) followed 25 males and females from 1 month to 30 years, gathering craniofacial measures. He felt that the growth of the calvaria and cranial base was completed before maximum body height was obtained, although, the face continues to grow. Inspection of at least one female case (#69) demonstrated that slight growth occurred between 22 and 28 in Sella-Infradental, Sella-Gnathion, and Sella-Gonion.

Hunter in 1966 reported that facial growth changes can continue late into the second decade for females and frequently into the third decade for males. This was based on a study of 25 males and 34 females from 7 years through adolescence. It was found that at age 18 only two males had completely terminated their growth. Termination of growth was judged on the basis of five subsequent annual exams apparently showing no change.

Bergersen (1966), in assessing the directions of facial growth utilizing a longitudinal sample of 60 individuals from ages 1-30 years, found that facial landmarks Anterior Nasal Spine, Nasion and Rhinion exhibited growth directions which most closely resemble a straight line. Pogonion and B point demonstrated the greatest variability. No particular attention was given to the age span from 20-30 years, but it is apparent that his graphs indicated some continued change. Baer and Harris (1969) noted slight increments in external skull length up to 24 years.

Hummerfelt and Slagsvold (1972), using 32 males and 18 females with cephalograms taken at 11 and about 25 years of age, found crowding of the incisors, loss of arch length, an increase in the interincisal angle and "normally" changing facial relationships. Walker and Kowalski (1972) in investigating an extended series of angular cephalometric relationships found age and sex differences.

Roche and Lewis (1974) studied 58 males and 41 females in regard to cessation of elongation in the cranial base. They found that Basion-Sella and Basion-Nasion and Sella-Nasion increases ceased at about 17 years in females but continued for males for

each length beyond 17. Lewis and Roche (1977) also studied the angle Basion-Sella-Nasion on a sample 0-40 years of age, and came to the conclusion that this angle is not static after pubescence even though the angle changes little beyond the age of 16. No sex differences were noted.

In assessing the facial soft tissues, Subtelney (1959) studied 15 males and females age 3-18 years. Nose growth was found to continue in a downward and forward manner. The upper and lower lips increased in length with the upper lip constantly related to Prosthion and the upper incisal edge; the lower lip constantly related to Infradentale and the lower incisal edges. Vig and Coben (1979) further documented this manner of lip growth.

Several other long range growth studies have been reported (Riolo et al., 1974; Broadbent et al., 1975) in which the generalized normal growth of the craniofacial complex is described. In all studies the impact of age, sex, ethnic backgrounds, and many other factors are all deemed to play a role in the nature and magnitude of growth which proceeds in a differential, rapidly accelerating and decelerating manner throughout the adolescent period.

While this information is valued, investigations were often terminated before growth curves had reached a plateau. Inspection of curves in several studies give evidence to suggest that small increases still occurred (Simmons, 1944; Dearborn et al., 1938; Gray and Ayers, 1931; O'Brien and Girshick, 1939; Bergerson, 1966). In spite of some evidence to the contrary many researchers have indicated that major growth terminates before 20 years (Baer and

Harris, 1969; Roche, 1953; Young, 1957; Bjork, 1966). Thus, biases in regard to adult growth exist despite a lack of in-depth study.

Phylogeny

Viewing the growth characteristics of other life forms besides man may give some insight about growth in general throughout the aging period.

Non-mammalian Vertebrates

Although there are exceptions, cold blooded vertebrates (fishes, amphibians, reptiles) are considered examples of an indeterminate mode of body growth with little evidence of loss of vigor and without a definite life span (Backman, 1938). Many times, using scales for determining age, it has been shown that as a fish becomes older, growth continues but with a gradual slowing. Indeed, female fishes may become more fertile with age (Andrew, 1971). In general the larger fish grow larger and live longer. Among reptiles there is apparently an extended longevity with an extended active growth period. Examples given center around species of turtles, some of which have been recorded to live over 150 years, and attain great size. The snakes studied (Fitch, 1949) show rapid early growth which then slows but continues throughout adult life. For birds (warm blooded), size relationships to longevity appear to

be similar to those in mammals (Bourliere, 1959).

Mammals

In regard to longevity, some mammals are believed to live quite long (horse, elephant), but man apparently is among the longest lived. Monkeys, lemurs and some other primates apparently represent the longest-lived order of mammals. Regarding mamalian growth during adulthood, documentation is sparse, but is clear growth continues in the adult period in the monkey. McNamara and Graber (1975) in studying the growth in Macaca mulatta demonstrated small but measurable changes at a reduced rate in the mandible of the adult monkey. The posterior border of the mandible showed significant additions throughout all growth periods with more demonstrated in the male. They concluded that growth and remodeling continued to occur in the oldest age group studied. Continued growth of cranial structures has also been demonstrated in the adult pig (Brash, 1934), the rat (Baer, 1954; Behrents, 1975) and the guinea pig (Rogers et al., 1964).

Morphogenetic Implications

Humphrey in 1858 put forth a basic thought of his period regarding the differences between young and old bone in regard to remodeling patterns. He proposed that a balance is in effect between apposition and resorption, depending on age, which results in quantitative increases, decreases or no change.

It is also important to note the work of Brash (1934) who attempted to study the growth and development of the skull vault in the pig. He came to the conclusion that the vault grows by surface deposition and endocranial resorption with little sutural activity. Baer (1954) suggested, however, that the pigs used in Brash's study were too old to show sutural growth. Mednick and Washburn (1956) clarified the situation by studying the young pig compared to the adult. They did demonstrate the importance of sutural growth at younger ages, but in essence they also clearly demonstrated that the growth of the adult pig occurred as described by Brash.

It should also be remembered that continued periosteal apposition and endosteal resorption in the appendicular skeleton with age has been demonstrated (Garn et al., 1964; Garn et al., 1967; Smith and Walker, 1964; Trotter and Peterson, 1967; Epker and Frost, 1966). The net result is greater cross-sectional diameter with diminished cortical thickness. Thus it is clear that age can result in resorption in excess of deposition.

From a morphogenetic viewpoint Professor Enlow's famous work has given the craniofacial biologist a great deal of information in relation to the generalized patterns of facial growth with the corresponding patterns of structural remodeling which occur in the underlying bones. However, his observations are based primarily on child and adolescent skull material and cannot necessarily be

extrapolated to further aging. In this regard Enlow (1981) feels that once basic adult form is obtained, unless there is an intrinsic environmental alteration (change of function, change in biomechanical circumstances, loss of teeth, etc.) that gross (not histologic) remodeling basically is static in effect. Environment changes, however, are quite likely, indeed certain. As evidence of this relationship, a study by Enlow and others (1976) regarding the changes in mandibular basal bone and the ramus after dental loss found that extensive remodeling occurs throughout all mandibular areas.

Further, it is interesting to note that in view of the various studies on craniofacial aging the evidence suggests a symmetrical increase in all dimensions (Israel, 1973). If a gradual magnification or enlargement of the craniofacial skeleton is accepted, and if the sutures are basically inactive contributors to change in the craniofacial skeleton, a generalized surface accretion of new bone conforming to the existing osseous contours remains as a plausible mechanism, a view which Enlow (1968), however, would deem false. He feels it is not possible for a bone to undergo any significant degree of overall enlargement without corresponding deposition at the sutures and without remodeling. Proportional additions to the sutural margins and regional remodeling are both necessary in order to maintain proportionate morphology of the bone and proportionate position. It would be unlikely that the complex remodeling of childhood is entirely absent or very simplistic during aging as may be suggested by previous studies.

It would thus be helpful to understand what mechanisms present in adolescence for growth participation and adjustment are also present in adulthood. While it is difficult to imagine that the mechanisms evoked by Scott and Moss are active in aging (in regard the nasal septum, brain growth, etc.), considerable literature is available as to the availability of sutures during aging.

Krogman (1930) feels that all sutures are closed by time of eruption of the third molars. The facial sutures close soon after the cranial sutures with the sutures that connect the cranium to the face the last to close. Saying this another way, growth at the sutures ceases on the average two years before completion of body height with the condyle growing for a short time after that.

Sicher (1965) in studying the posterior end of median palatine raphe found that the facial sutures close in the middle thirties, but the frontozygomatic remains open in the oldest ages. Wright (1911) found that the intermaxillary and palatine sutures are unossified as late as 35 years of age. Latham and Burstone (1966) in also studying the midpalatine suture found no evidence of fusion at 18 years of age, or for other facial sutures. Persson (1973), however, found fusion of the midpalatine suture at age 17. Scott (1967) in an overall view found most sutures appear open on old skulls although some union may be present. Todd and Lyon (1924, 1925) in studying 307 skulls according to dentally-aged groups, found synostosis of the sagittal and sphenofrontal sutures at 22 years, at 24 years in the coronal, and at 26 years in the lambdoidal

and occipitomastoid. The most rapid fusion occurred during the period of 26-30 years with ectocranial and endocranial sutural fusion occurring simultaneously. Dwight (1890) studied 100 cadavers aged 17-91 years in regard to the sagittal, coronal and lambdoidal sutures. He felt sutures begin to close at 30 years starting in the posterior part of the sagittal and lower end of the coronal and lambdoidal sutures. Singer (1953) determined that cranial suture closure was too variable to be a reliable source of information for forensic procedures.

Kokick (1976) studied age changes in the human fronto-zygomatic suture from 20-95 years of age. He sought to determine at what age this suture could no longer participate in remodeling. He showed a tendency toward union very late in adult life with synostosis occurring during the 8th decade but not completely fused by 95 years. It was thus felt that this might permit a lateral translatory effect and thus perhaps an increase in bizygomatic width. In addition the zygomatic bone showed lamellar bone at the facial periosteal surface (a decrease in thickness with age) and a zone of secondary osteon formation at the resorptive orbital periosteal surface. He felt that it is evident that craniofacial growth due to periosteal deposition continues throughout adult life and will most likely be demonstrated histologically in other facial areas.

Another area that has received attention are the cranial air sinuses where continued expansion appears to occur with age (Campbell, 1966; Israel, 1973; Sicher, 1960; Sicher and Dubrul,

1975). Sicher (1960) felt expansion of the cranial air sinuses was due to altered mechanical stresses caused by loss of teeth and thinning of the skull bones.

In regard to the teeth as a factor in facial growth, Sicher (1949) and Weinman and Sicher (1947), on the basis of histological data, felt that with age there is normal wearing of the dental surfaces which leads to continued eruption of the teeth, with cementum formed along with deposition of bone within the fundus. This eruption along with deposition at the free margin of the alveolus, after facial growth has ceased, equals the loss of tooth substance and thus facial height is kept constant.

While it is clear that the major growth mechanisms are perhaps not operative during aging, it is also clear that remodeling and perhaps sutural adjustment indeed occurs. Condylar adjustment may also be operative as evidenced by pathology relating to acromegaly. The teeth and surrounding tissues may also be influencial in effecting craniofacial changes and themselves provide a basis for continued remodeling responses, as evidenced by the controlled pathology known as orthodontics. Thus, in spite of the apparent questioned absence of the "popular" translative mechanisms of aging, enough mechanisms seem to exist to effect change in craniofacial morphology should there be an influence requiring or affecting such change.

Age Cessation Biases

As the result of a number of studies concerning the age at

which human growth slows and ceases a number of "basic information" textbook biases are presented which in essence summarizes the current concepts of growth in the post-adolescent as a period of osteological-craniofacial quiesence.

Stedman's Medical Dictionary (1966) defines the adult as: "Fully grown and mature; a fully grown individual." Grays Anatomy comments on the adult as:

> The skull grows rapidly from birth to the seventh year, by which time the foramen magnum and petrous parts of the temporals have reached their full size and the orbital cavities are only a little smaller than those of the adult. Growth is slow from the seventh year until the approach of puberty, when a second period of activity occurs; this results in an increase in all directions, but it is especially marked in the frontal and facial regions, where it is associated with the development of the air sinuses.
>
> Suture closure begins at twenty-two years in the sagittal and sphenofrontal, at twenty-four years in the coronal and at twenty-six years in the lambdoid and occipitomastoid. The process is most rapid from twenty-six to thirty years then slows down and may not be complete until old age. The sphenoparietal, sphenotemporal, parietomastoid and squamous begin to close at twenty-nine, thirty, and thirty-seven years. Closure progresses very slowly with a final burst of activity in old age. There is considerable individual variation.
>
> The most striking feature of the old skull is the diminution in the size of the maxillae and mandible consequent on the loss of the teeth and the absorption of the alveolar processes. This is associated with a marked reduction in the (occlusal) vertical measurement of the face and with an alteration in the condylar angles of the mandible.

Basic curves derived from Scammon (1930) would indicate little change in adulthood (Figure 1). Scott (1954) presented data which indicated that growth may only gradually cease (Figures 2-3).

Ranly (1980) comments on aging to the adult state in his

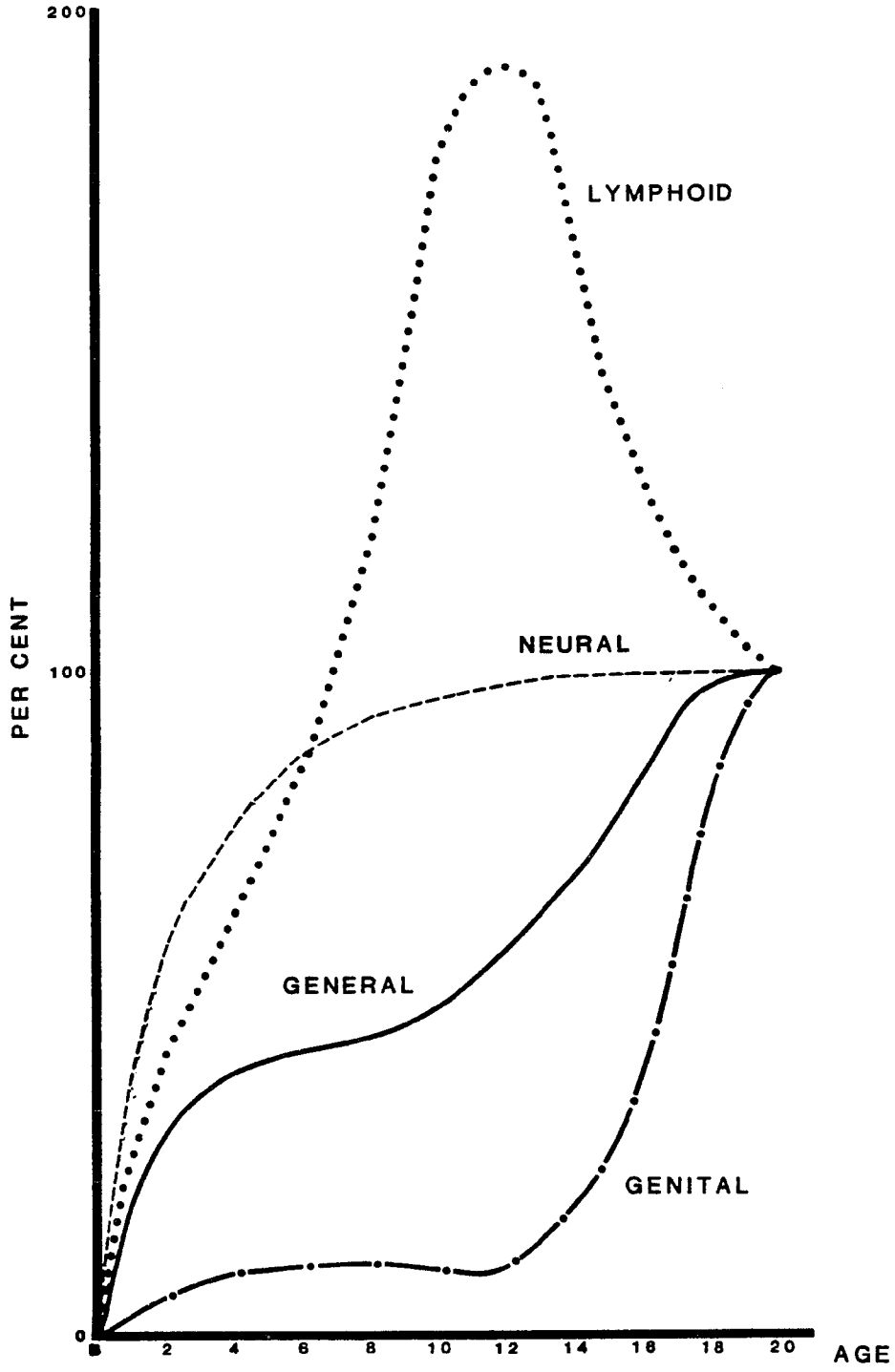


Figure 1. Differential growth rates for different tissues. After Scammon (1930).

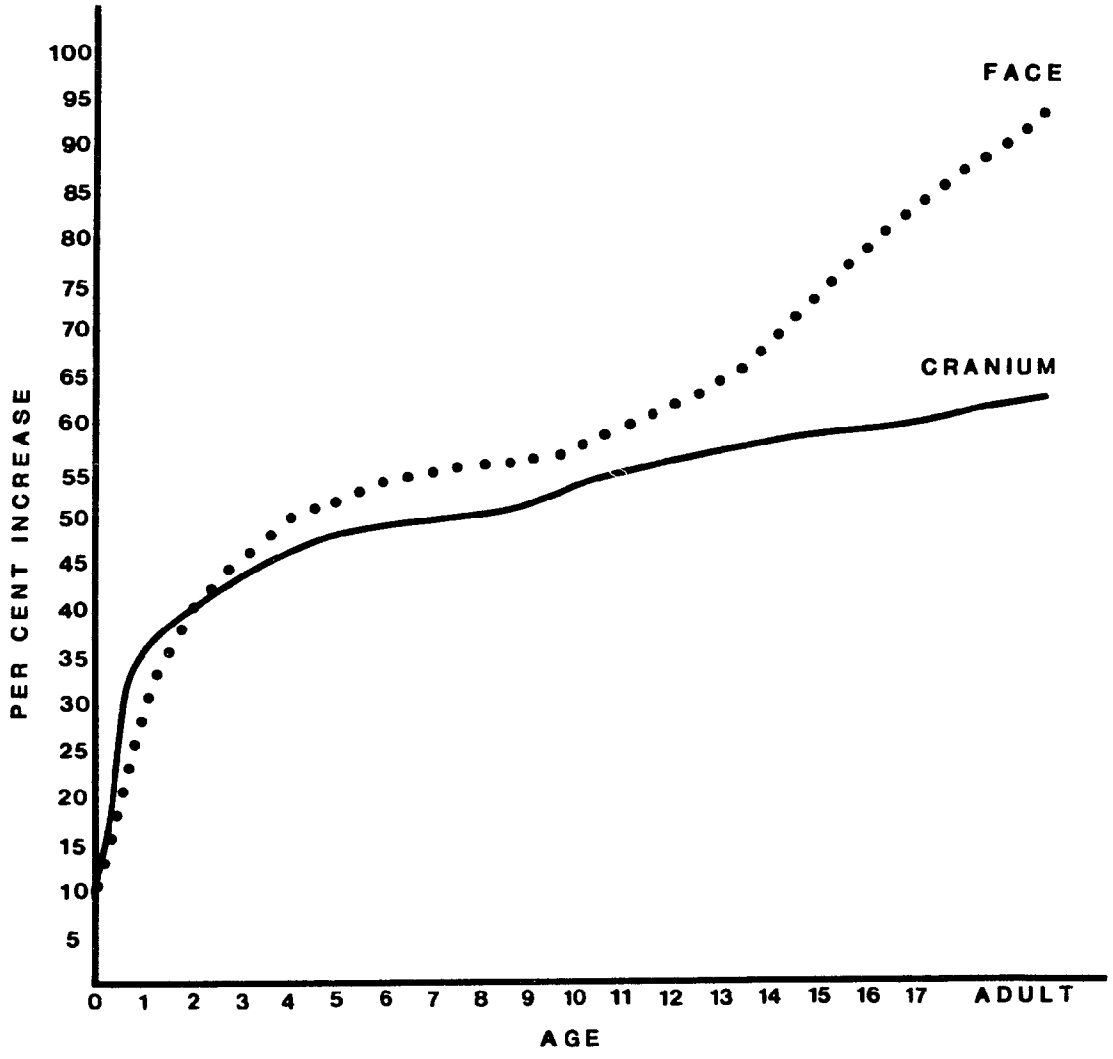


Figure 2. Comparison of cranial and facial growth. From data compiled by Scott (1954) as redrawn from Ranly (1980).

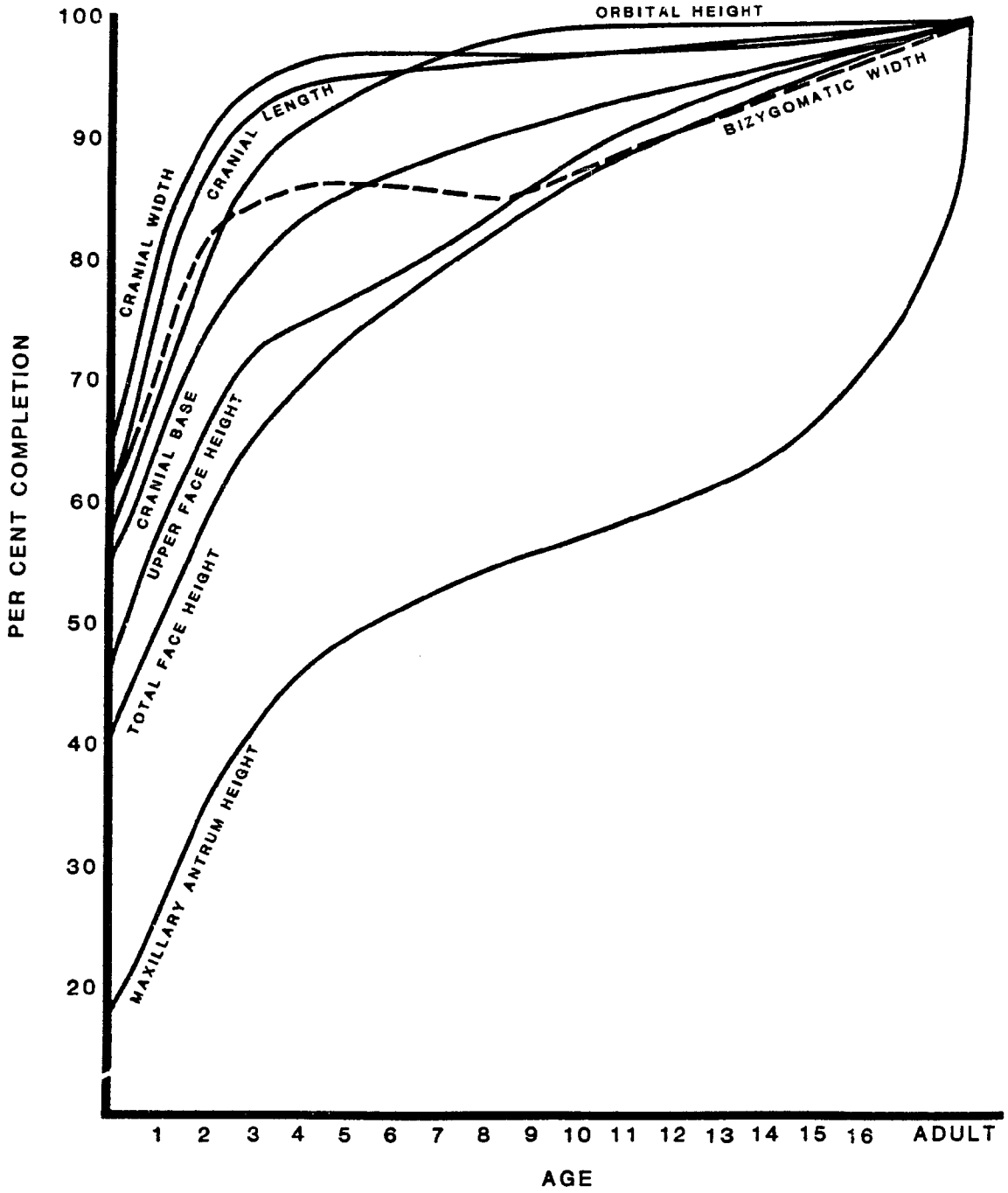


Figure 3. Male craniofacial dimensional change. Data from Scott (1954) as redrawn from Ranly (1980).

Synopsis of Craniofacial Growth:

> Day by day, year by year, almost imperceptibly, the face of the newborn child is transformed by growth and by aging; inexorably, the cute, pug-nosed, bland face of infancy assumes in turn the expression of youth, the individuality of adulthood, and the character of age. The first 20 years are anabolic, growing and developing; the years after are maturing, catabolic and degenerative.
>
> After adolescence, changes in the face can be ascribed mostly to soft tissue changes; only in cases of severe tooth loss are there pronounced alterations of bone.
>
> With age, the fleshy nose tends to enlarge, the texture of the skin changes, wrinkles appear, and the soft tissue of the face can sag.

Krogman in 1943 summarized the post-pubertal period as to imply that growth terminated by 20 years of age (Table II).

In his comprehensive text, Graber (1966) presents several illustrations suggesting that no growth remains after 20 years of age (Figure 4).

Bjork and Helm (1967) presented data which has been widely reproduced and indicates little change in the adult especially beyond 23 years (Figures 5 and 6).

Enlow (1975) expresses his sentiments in this regard (italics mine):

> Note this important feature of facial growth. In many of the growth and remodeling processes described throughout this chapter, one major difference exists between the female and the male. In the female, skeletal growth changes in the face slow and cease shortly after puberty. In the male, however, topographic and dimensional changes continue through the late adolescent period. The facial similarities that exist between the sexes during childhood, therefore, are altered markedly in the teens.

In the Bolton Standards of Developmental Growth, Broadbent, Broadbent and Golden (1975) present the following (italics mine, see also Table III):

TABLE II

MAJOR PHYSICAL GROWTH TRAITS IN THE POSTPUBERTAL PERIOD AFTER KROGMAN (1943)

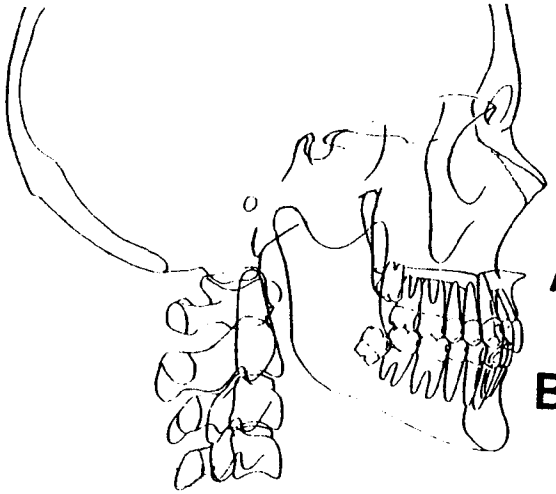
AGE PERIOD	GROWTH			
	BRAIN CASE	FACE	H & W	TRUNK,LIMBS
POSTPUBERTAL (13-20 YEARS)	NONE	SLOW FINAL INCREASE IN HEIGHT	SLOW DECEL. TO FINAL ADULT VALUE	SLOW INC. IN TRUNK VOL. LIMB PROPORTS. ADULT

	OSSIFICATION		ENDOCRINES	
	APPEAR.	UNION	GONADS	SEX TRAITS
	...	VERY RAPID UNION IN LONG BONES	SEX HORMONES UP TO ADULT VALUES	LATE MATURERS FEMALES 13 MALES 14 ADULT PATTERNS ACHIEVED

	DENTITION	
	DECID.	PERM.
	...	M3 ERUPTS, IF EARLY

Figure 4. Differential growth center rates of cranial and facial components. Adapted from Graber (1966).

GROWTH INCREMENTS



N–1 NEURAL GROWTH CURVE

A–2 BODILY OR GENERAL GROWTH CURVE

B–3

Figure 4

	YEARS 0 - 5	5 - 10	10 - 20
1	85 % OF TOTAL GROWTH COMPLETED	96 % OF TOTAL GROWTH COMPLETED	REMAINING 4 % COMPLETED
2	45 % OF TOTAL GROWTH COMPLETED	65 % OF TOTAL GROWTH COMPLETED	REMAINING 25% COMPLETED
3	40 % OF TOTAL GROWTH COMPLETED	65 % OF TOTAL GROWTH COMPLETED	REMAINING 35 % COMPLETED

Figure 5. Periodic variations in growth rate. Redrawn after Bjork and Helm (1967). This is also reproduced in Moyers (1972) and Graber (1972).

Figure 5

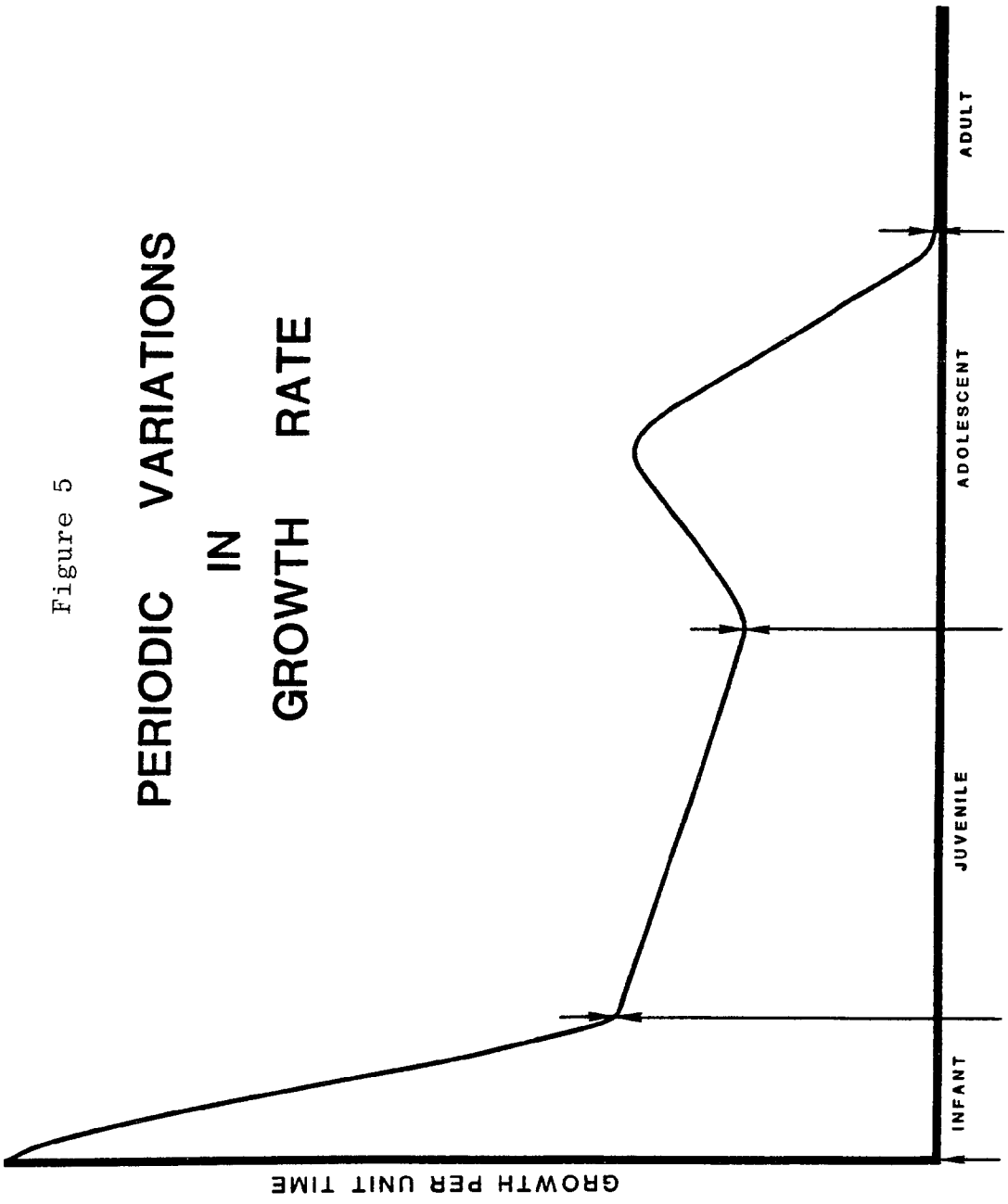

PERIODIC VARIATIONS IN GROWTH RATE
GROWTH PER UNIT TIME
INFANT
JUVENILE
ADOLESCENT
ADULT

Figure 6. Growth timing in males. Redrawn after Bjork and Helm (1967) and also reproduced in Graber (1972).

Figure 6

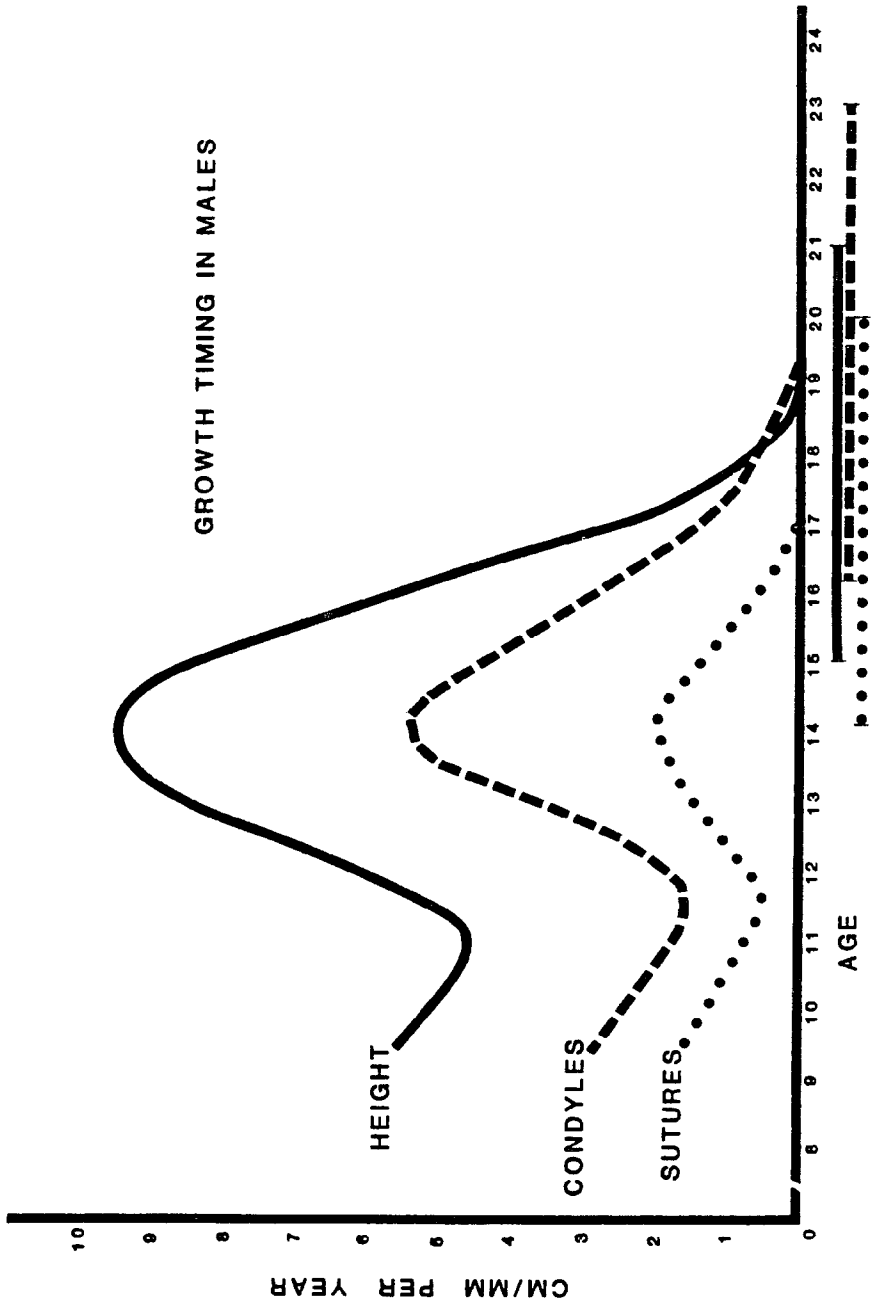

GROWTH TIMING IN MALES
CM/MM PER YEAR
AGE
HEIGHT
CONDYLES
SUTURES
0
1
2
3
4
5
6
7
8
9
10
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24

TABLE III

SEXUAL DIMORPHISM IN CRANIOFACIAL GROWTH ADAPTED FROM BROADBENT, BROADBENT AND GOLDEN, 1975

SEXUAL DIMORPHISM IN CRANIOFACIAL PATTERNS

	FEMALES	MALES
CIRCUMPUBERTAL GROWTH SPURT	10 - 12 YEARS	12 - 14 YEARS
MATURE SIZE	GROWTH PLATEAUS AT 14 WITH INCREASES TO 16 YEARS	ACTIVE GROWTH TO 18 YEARS
SUPRAORBITAL RIDGES	ABSENT	WELL DEVELOPED
FRONTAL SINUSES	SMALL	LARGE
NOSE	SMALL	LARGE
ZYGOMATIC PROMINENCES	SMALL	LARGE
MANDIBULAR SYMPHYSIS	ROUNDED	PROMINENT
MANDIBULAR ANGLE	ROUNDED	PROMINENT LIPPING
OCCIPITAL CONDYLES	SMALL	LARGE
MASTOID PROCESSES	SMALL	LARGE
OCCIPITAL PROTUBERANCE	INSIGNIFICANT	PROMINENT

> Looking superficially at the elements that relate to the popular concept of "craniofacial sexual dimorphism"...one notes that the phenomenon of the adolescent growth spurt (circumpubertal) is generally accepted to occur between the ages of 10 and 12 years in the female and 12 and 14 years in the male and that the termination of active growth takes place in a plateauing of sizechange in the females at 14 years. However, minimal growth continues on to 18 years of age; whereas in the males, in contrast, are observed to continue actively in growth increments to the eighteenth and nineteenth years. Actually sexual dimorphism is in the main an expression of secondary sexual characteristics that occurs after puberty and during the adolescent years. Essentially nine craniofacial areas can be defined as showing notable variability between the male and female...These may, of course, enter into individual treatment planning, but they do not basically alter the skeletal-spatial relationships, that, in fact, are the substructure for the proper alignment of the dentition.
>
> The most familiar differences are the larger size of the frontal sinuses and supraorbital ridges of the male versus those of the female and the larger nose and more prominent chin point in the male as contrasted with those of the female. Then of lesser importance is the lipping out of the gonial angle in the male. Of least importance are the differences in occipital condyles and occipital protuberance. Sexual dimorphism of the craniofacial structures, then, is real but of qualified significance.

Conclusions of Craniofacial Aging Studies and Statement of Thesis

Based on studies involving individual ontogeny it is clear that aging humans may indeed change through time and may indeed retain the ability to change even on an osteological level. However, in attempting to summarize the results of previous studies regarding the craniofacial complex it is extremely difficult to arrive at any definite conclusions. This is because the various studies which have been conducted in this area are not generally compar-

able and thus not corroborative in nature. Different ages studied, different times of measurement, different designs of study (cross-sectional, longitudinal), non-comparable measures, different generations (prehistoric, modern), races, different sexes, different methods of information gathering, and other factors have all served to obfuscate the overall findings in regard to craniofacial aging. As such, no uniform conclusions or even a concensus exists concerning when and if craniofacial increases cease.

Further, there is at present no real evidence of differential growth, a sex effect (except size), or ethnic effects. Longitudinal data on both males and females with long spans are very limited (perhaps a total of 75 people in all studies), and what material exists may be limited in its interpretation. Also little information exists for the face without the neurocranium. In spite of these limitations it appears that the current feeling involves a simplistic enlargement of the craniofacial skeleton by ectocranial apposition and endocranial resorption throughout adult aging.

The results of these craniofacial studies are not consistent with present morphogenetic thought and do not appear to be a direct extrapolation of the effects of growth in adolescence. Indeed, the basic conclusion of a "symmetrical magnification" of the craniofacial skeleton during aging is inconsistent with the known aspects of remodeling.

The present study will attempt to pick up where previous growth studies on adolescence stopped and attempt to clarify previous studies on the aging craniofacial skeleton. The main objective

of the present study has been to determine, document, describe and evaluate the nature of specific morphological changes and adjustments within the craniofacial complex associated with post-maturation and aging. Although it is possible to recapitulate every aspect of previous adolescent growth studies, the present study will be limited to certain aspects of craniofacial growth. It is also the purpose of the present study to discuss the findings in regard to previous knowledge regarding facial morphology, growth, age, sex, normal and abnormal variation, treatment, growth cessation, growth mechanism, and dental and oral disease.

This research has been accomplished in living individuals studied serially by means of roentgenographic cephalometry in order to develop a more meaningful system for the understanding of craniofacial construction at different age levels based on changes produced by growth and aging processes.

CHAPTER II

MATERIALS AND METHODS

> . . .the longitudinal method brings into focus the individual organism, the entity of growth, which merits consideration as the logical unit of study. . .Studies of the type conducted by Broadbent (1937) and Brodie (1941), if extended to cover the adult period, could test and quantify the leads coming from both anthropometric surveys and comparative histological analysis.
>
> Baer, 1956

Sample

The sample used in the present study consists of some of the persons who were participants in the original Bolton Study. The original Bolton Study consisted of longitudinal data gathered at yearly examinations, initiated at various young ages and terminating at various older ages. The Study was actively conducted from 1928 until the 1960's, with intermittent records gathered into the 70's. In all some 22,000 examinations were conducted. Bolton Study records consist of lateral and P.A. cephalograms, hand-wrist x-rays, dental casts, height and weight recordings, and a dental examination. The original Bolton Study population includes almost 6,000 individuals who were generally of European ancestry and considered clinically normal. This population is quite unique because of the size of the sample, the duration of the record gathering, and the completeness and precise standardization of the recordings on each individual. A more complete accounting of the Bolton

Study is given in Appendix B.

Since the Bolton Study was conducted mainly to investigate the normal child (generally ages 1-18), it was necessary to recall individuals for the present study. The sample was gathered on the basis of the following criteria.

1. Availability of young adult records: In order to compare young adult to older adult records the participants must have had records taken previously as young adults. In order to provide for the most information for this study and others based on this new information the original population was screened for those participants who had records existing at 16 years of age or older (1605 possible cases). In order to further limit and refine the sample those cases with records 17 years of age or older were selected for recall (934 possible cases). The sample selected included some of the same individuals who comprised the basis for the "Bolton Standards".

2. Untreated: Those participants who were known to have undergone what is commonly thought of as active orthodontic treatment were excluded for recall even though treatment in all such cases was completed before the period of study (234 cases were discarded leaving 700 possible cases). Some non-comprehensive cases were be included (bringing down an impacted cuspid, Hawley retainer for simple rotations or space closure), but only on the basis that no major appliances were fixed to the teeth, that treatment lasted a short time, and that such treatment was finished at

least two years prior to the years covered in this study. For all intents and purposes an untreated sample was thus selected for recall. Upon recall if it was found that comprehensive orthodontic treatment had been conducted, the participant was examined but not used in the present study (except as noted in the "treated" sample).

3. Availability of quality records: Recall subjects must have had quality radiographs with the necessary measurements to adjust for magnification. This was a routine procedure in the study. In recall exams conducted outside of the Bolton Study, where there was any doubt as to the "cephalometric" nature of the records, they were deleted from the present study.

4. Availability for recall: To be included it was necessary to be able to locate and recall the participants (214 were located to a best geographic approximation and selected for recall). Very few records existed on file before the present study covering various adult ages, thus it was necessary to recall a large number of participants in the Cleveland area and across the country.

5. Health: Any participant whose health was not judged "good" upon recall was deleted from the study. Regarding dental health any participant who was missing more than 3 posterior teeth (not including third molars) was excluded from the present study except as noted in the Discussion for comparative purposes ("Serious Dental Problems" sample).

6. Availability of final records: Final exam records were

gathered at 25 years of age or older.

Recall Procedure

The possible participants were contacted, requested to fill out a health questionnaire, and asked to return to the Bolton Study for examination. Upon receiving a favorable reply the participant was scheduled for an examination. The examination, which took about one hour, consisted of the following determinations:

1. Height and weight: Height measures were taken with the same instrument used to record in the original study (Stadometer, Continental Scale Works). Shoes were removed but not socks. Previous measures were taken similarly except in some instances paper slippers were worn. Weight was recorded by the use of a standard scale (Fairbanks). It was not known when the present scale was first used in this study.

2. Medical and dental histories: The health questionnaire was gone over by the examiner for updates and further documentation.

3. Head and neck examination: A standard screening for facial and oral cancer was given.

4. Dental examination: The dental examination consisted mainly of noting missing teeth and prosthodontic replacements if present. Notations were also made in regard to the condition of the gingiva and angle classification. They were also questioned as to whether they had been treated orthodontically.

5. Temporomandibular joint examination: The participant was asked to report recollections as to any past or present problems with the joint, or any pain, or sounds upon opening or closing the jaw. They were also examined physically by palpation, asculta-tion (non-amplified) over the joint and with fingers in the ears in order to detect any popping, clicking or crepitus. It was also noted as to the type of dynamic occlusion, any deviation upon opening or closing, and any prematurities.

6. Photographic records: Photographs of the intra-oral region (3 views) and of the full face (3 views) were taken using standard photographic techniques.

7. Dental impressions: The participants were also requested to have dental impressions and a bite registration. This was accomplished with standard orthodontic trays and alginate and poured within 1 hour of gathering. A wax bite was also taken in centric occlusion.

8. X-rays: Lateral and posteroanterior cephalograms were taken using one of the cephalometers used in the original study (Broadbent-Bolton Roentgenographic Cephalometer, #7-AKS 60) according to the precise standardized method used in the original study as described in Broadbent et al. (1975). Cephalograms were taken with the patient in centric occlusion. Participants were told to bite their teeth together and just relax (they habitually placed their lips together). ML and P+ measures were recorded for each view accordingly so as to be able to adjust for magnification.

Trimax 8 (3M) rare earth screens with XUD film (3M) was used to obtain maximum detail. Exposures were adjusted per patient, but generally 90 KVP and 15MA was used at ½ second exposures for the lateral view and 1½ seconds for the PA view. Hand-wrist films were taken by placing a cassette in the cephalostat (set at 5 feet) and exposures made at ½ second, 10MA, 70 KVP using a par speed screen (Dupont Cronex) and XG-1 film (Kodak). All films were developed in an automatic processor with fresh chemistry to insure consistency.

All examinations performed in the Bolton Study were performed by the author except in 3 cases (B.H.B., Jr.). Where it was unreasonable for participants to return to the Bolton Study for the examination they were requested to go to an orthodontist near their residence for an equivalent examination. The orthodontist was contacted to verify the necessary examination and records. Magnification in this instance was controlled as modified after Adams (1940). Examples of all patient and orthodontist correspondence and exam forms are included in Appendix C.

Data Analysis

Although a great deal of examination data were collected, most will be reported but not scrutinized extensively at present. Principal emphasis centers around the lateral cephalogram.

Lateral cephalograms were traced and landmarks located according to standard techniques (Broadbent et al., 1975). Where

landmarks were difficult to identify, the posteroanterior cephalogram was utilized with a Bolton Orientator to assist in landmark location. The landmarks were subsequently reduced to x-y coordinate data utilizing a digitizing pad (Summagraphics) and stored via computer memory for later analysis.

The landmarks utilized in the present study are defined in Appendix D, as are the various planes used for some measures. In all some 87 landmarks on each x-ray were utilized. These landmarks and planes may be inferred from Figures 7-11.

Enlargement Adjustment

A special program was utilized to correct for enlargement present in each film. This program used an object-film relation in the lateral cephalogram termed the "midline-lateral film distance" (ML) to adjust the x-y coordinate data for each x-ray to a standard 6% enlargement. This procedure was invaluable in terms of reducing the photographic-like enlargement present in all films to a uniform, standard value. This allowed enlargement due to technique to be distinguished from that due to growth.

Age Determination

Most of the participants were originally examined very near to their birth dates, but rounding to the nearest age was accomplished where necessary except for the age 17 determination. To be

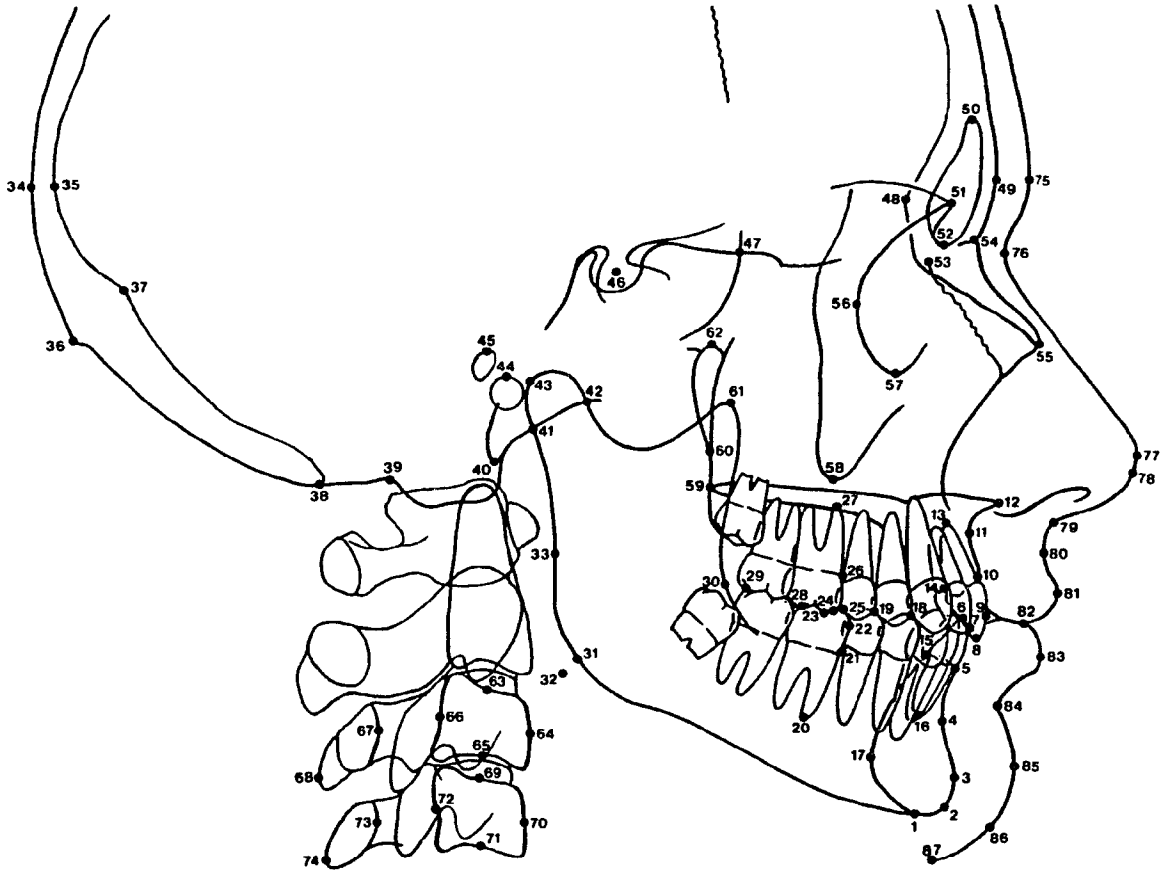


Figure 7. Cephalometric landmarks.

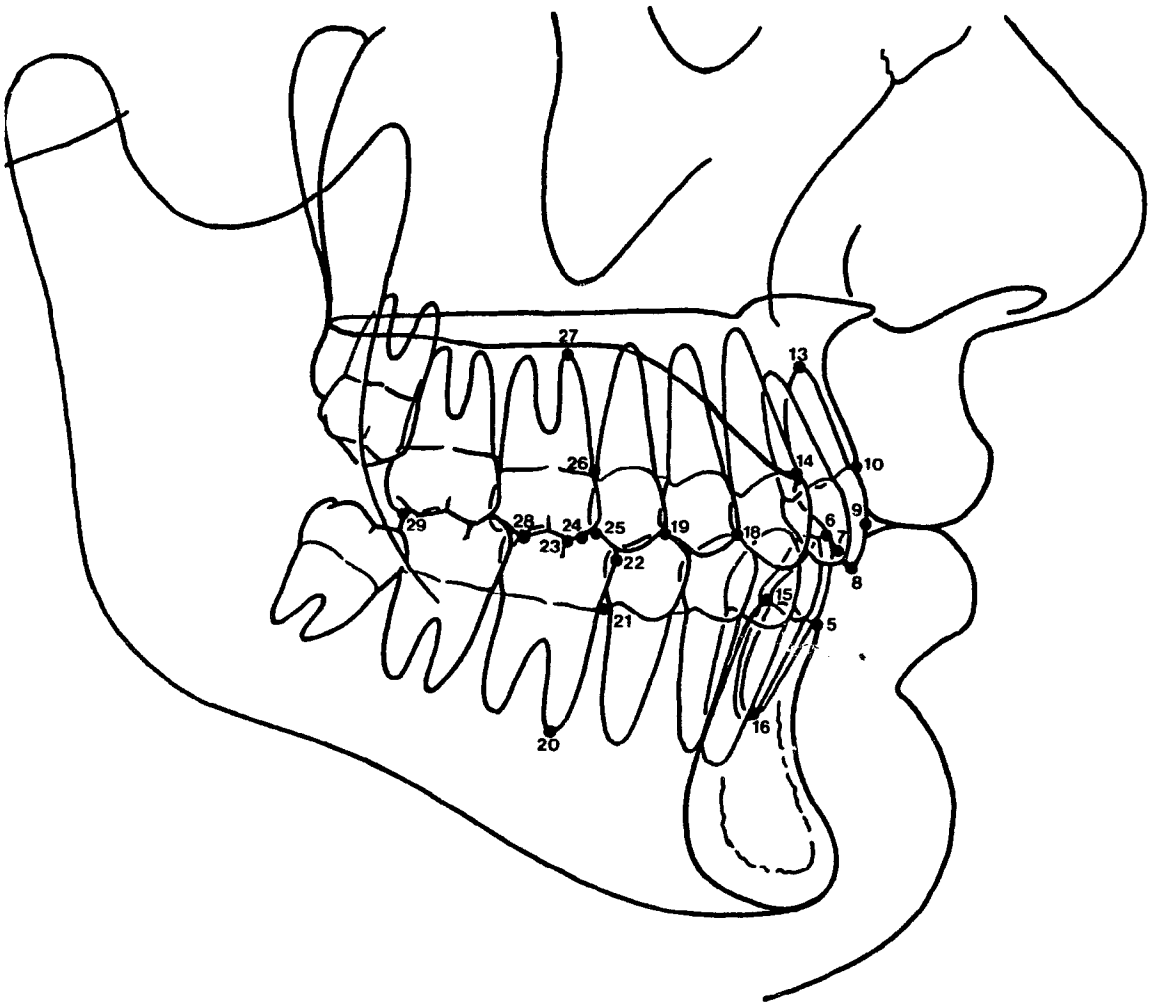


Figure 8. Cephalometric landmarks in the dental area.

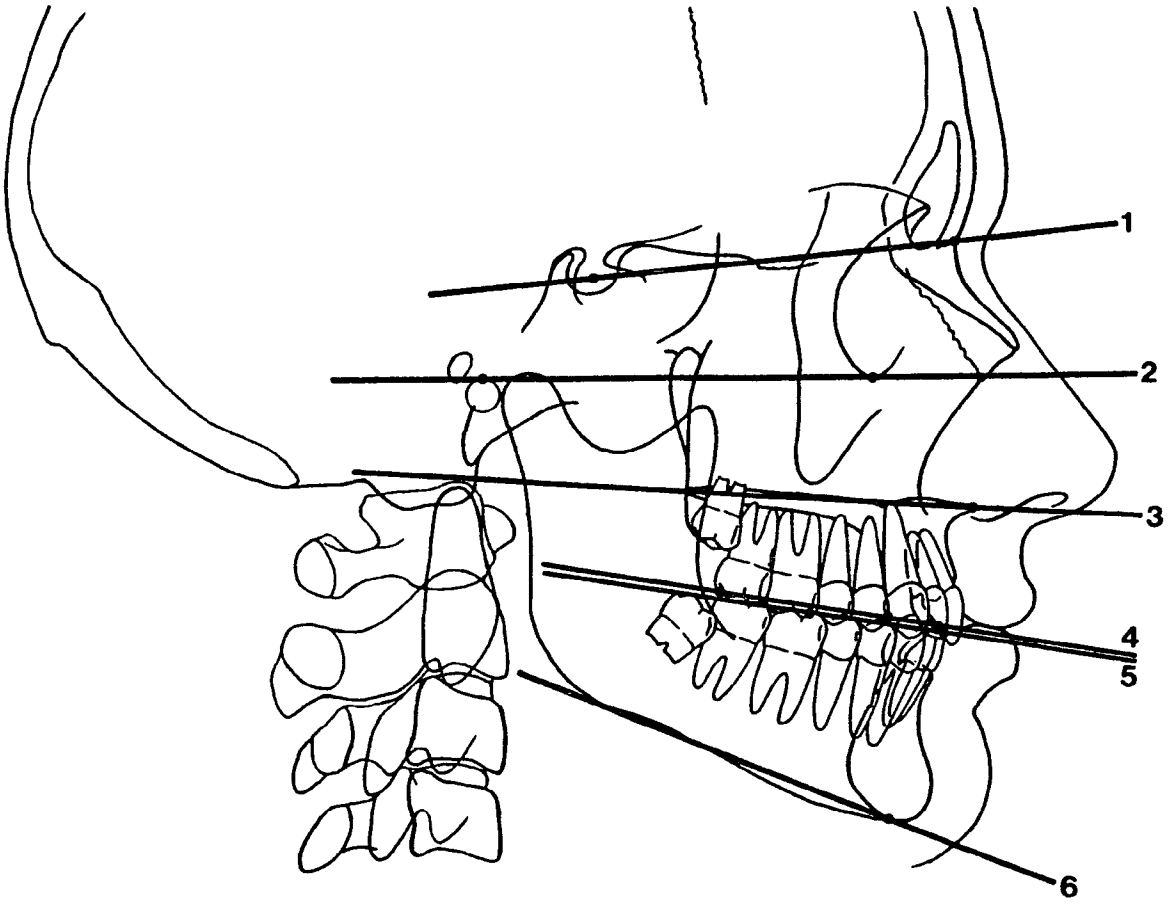


Figure 9. Horizontal cephalometric planes. 1: Sella-Nasion; 2: Frankfort Plane; 3: Palatal Plane; 4: Functional Occlusal Plane; 5: Down's Occlusal Plane; 6: Mandibular Plane.

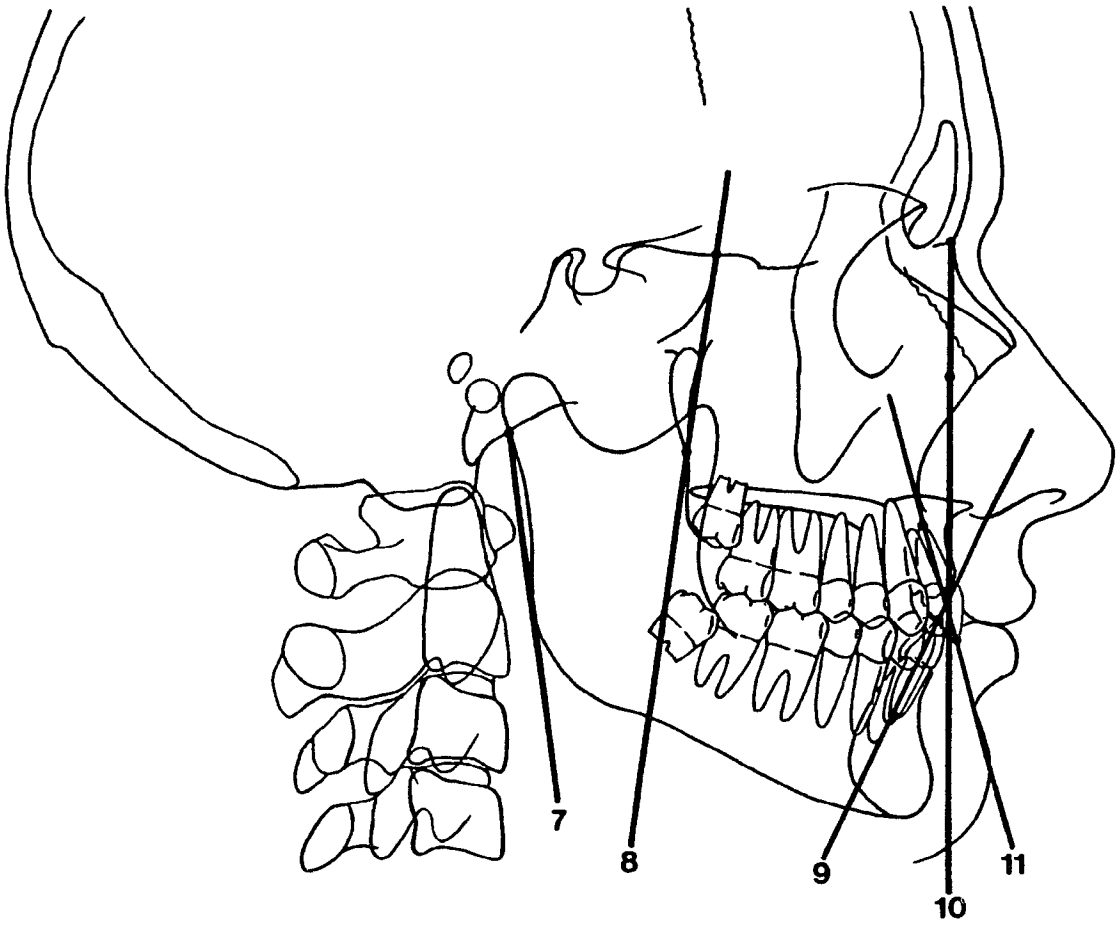


Figure 10. Vertical cephalometric planes. 7: Ramal Plane; 8: PM Vertical Plane; 9: Lower Incisor Axis; 10: McNamara's Nasion Perpendicular Plane; 11: Upper Incisor Axis.

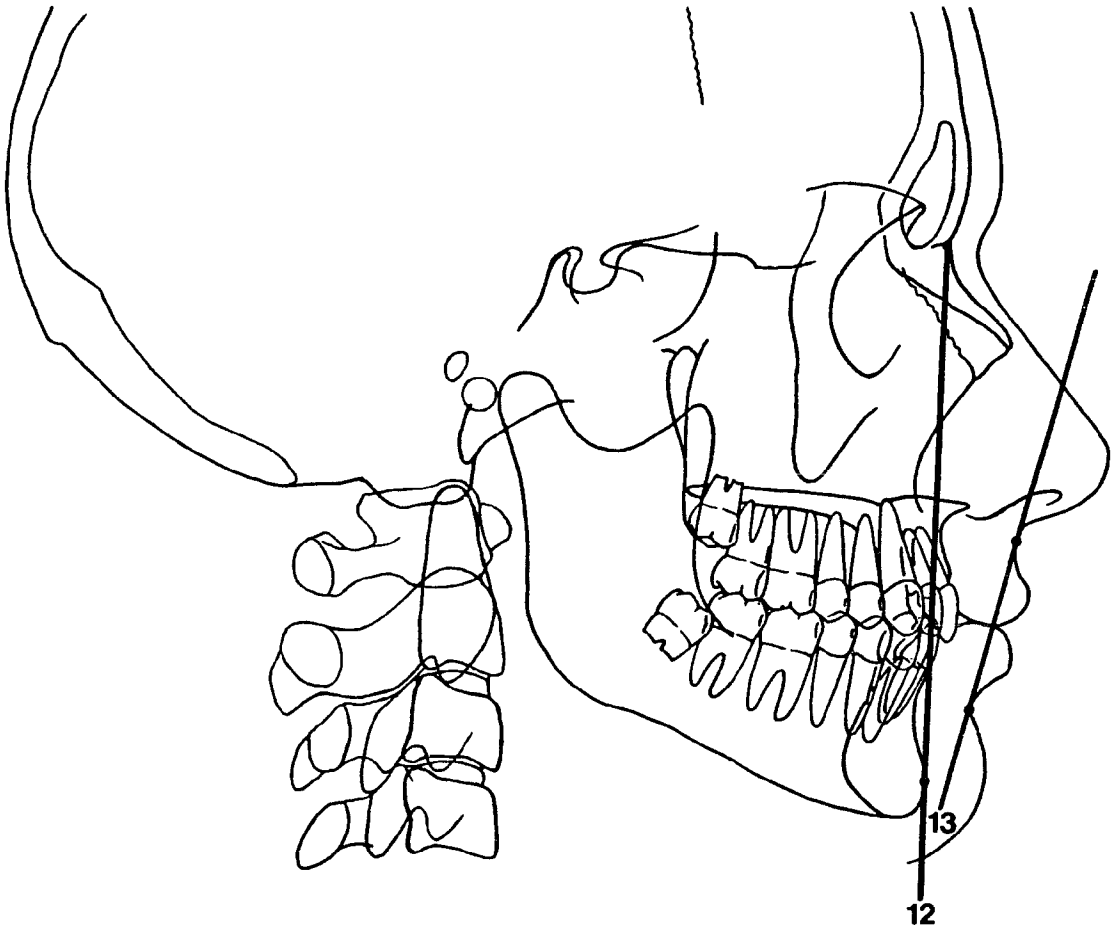


Figure 11. Vertical cephalometric planes. 12: Facial Plane; 13: Soft Tissue Plane.

classified as 17 the person had to be between the ages 16 years, 11 months and 17 years, 6 months at the examination. Two females who unexpectedly returned for a recall exam (siblings were recalled) had available initial films at 16 years of age only, but were included as this was not deemed a problem.

Superimposition

After each series of x-rays was digitized and adjusted for enlargement, the tracings were superimposed utilizing a Sella registration and Sella-Nasion orientation to form preliminary opinions as to what was transpiring in regard to growth. It was fully realized that this procedure did not account for enlargement (except where there was no major difference in the ML difference in the series). Subsequent analysis via computer would verify whether such preliminary opinions were valid.

Measurement

Methods to determine the size and configuration of the osseous representations of bones on cephalograms have been fairly well established in the literature, as well as alignment procedure and cumulative contributions to the composite whole. Therefore the methods of analysis will be essentially the same as in the past literature. Although the analyses are relatively simple and straightforward the data derived are extensive and complex. Thus, computer resources were utilized for recording, organizing, combining, retrieving, and analyzing information.

Two separate groups of measures were utilized. Group 1 (1-139) consisted of all distances from all points to Sella and all angular values from all points to the line Sella-Nasion. The intent of this group of measures was to provide an overall impression as to changes which might be present much as standard superimposition methods attempt to do. The result and values could also be easily displayed graphically by age, sex, etc. to provide a visual display of adult changes. From these graphic displays it is also possible for the reader to determine the approximate value of his "favorite" measures. Or, it will be possible for other researchers to reanalyze the present results and provide their own interpretations of any changes which are taking place. This method of course is not without caveats, however, as the relative error of certain measures would be disregarded (see Baumrind and Frantz, 1971 for a discussion and Bookstein, 1982, 1983 for further caveats).

Group 2 measurements (140-277) consist of measurements commonly used in the orthodontic literature to describe the size, shape and position of the various craniofacial structures. The cephalometric analyses are generally based on those by Downs, Reidel, Tweed, Steiner, McNamara, Ricketts, Israel, Riolo and Broadbent. The intent of this group of measures is to provide values which are easily communicated and understood by craniofacial biologists. Whether these measures are valid in theory is controversial, but they do provide information enough to supply an interpretation of the changes which take place. In Group 1, 139 meas-

ures were made; in Group 2, 158 measures were accomplished. The cephalometric measures taken can be inferred from the illustrations in Appendix A.

Discarding Data

In certain instances records were unusable due to conditions such as poor health (general or dental) of the subject, "uncephalometric" technique (ear rods not focused), lack of magnification data, poor quality films, or unlocatable landmarks. In these instances the single film or entire series was discarded (10 complete series were discarded). Also, no more than 9 films in any one series were traced and digitized. Selections of films in this instance were decided on the basis of providing the "best" age spans (say 17, 20, 25, 30, 35, 40, 50, 60, 70 years of age).

The study also originally intended to assess the posterior parts of the skull (points 34-37) and the fourth cervical vertebra (points 69-74). However, all analyses regarding these points were abandoned. In terms of technique, these points were only variably included on the x-ray film due to cassette positioning, and it was not unusual for some to be missing for several films in a series. The options were to treat these select x-rays as providing missing data, discarding the series or deleting the landmarks and subsequent measurements. The latter was chosen as it was also very clear that selecting only those complete series with posterior skull and C4 points would diminish the sample. The prime emphasis of

the study was the facial region, and including only those complete series having posterior skull and C4 points would tend to bias the study in terms of selecting for "smaller heads", as it was very clear that these missing points were often missing because the subject had "outgrown" the cassette. The only disturbance this posed to the original plan of the present study was that of not being able to compare the present results to those of others in regard to measures involving the posterior skull. Also superior skull landmarks could not be located due to the cassette size which has been used throughout the entire study.

Additional Samples

Besides the orthodontically untreated sample it became clear upon recall that some of the participants had received comprehensive orthodontic treatment as children which was not recorded in the Bolton catalogue system. While other studies have included treated (not in adulthood) cases in their sample (Forsberg, 1976, 1979), it was decided not to include them in the untreated sample but rather to test for differences. This treated sample fulfilled all original criteria except for treatment.

Likewise another group of people upon recall were found to have undergone major dental changes (more than 3 posterior teeth lost). Examples include complete dentures, partial dentures and extensive bridgework. Although these types of cases have been previously studied (Israel, 1971) it was again decided to test for

differences between the untreated (dentally sound) group and those with serious dental problems. All selection criteria were applied to this group except for the number of missing teeth.

Data Reduction

All analyses of the present data utilized the SPSS (Statistical Package for the Social Sciences) programs available at Case Western Reserve University. Because the sample presented differences in starting ages, final ages, varying number of recordings per series (2-9), and different age spans, inferential testing was limited so as not to obscure the individuality of change.

Descriptive Statistics

Descriptive statistics were calculated in the untreated group for both males and females according to the initial and final films in a series. For this initial to final comparison the following statistics were calculated:

1. Gain-No Gain. The number of individuals who gained for a particular value versus those who showed no gain or diminished over the period.
2. Mean Delta.
3. Delta Standard Deviation.
4. Maximum Delta. The maximum positive gain.
5. Minimum Delta. The maximum negative change.
6. Mean Percentage Change. The deltas were divided by the original value to indicate the percentage change. Where an original value could have a value near zero, the mean percent change was deleted as values obtained could be extreme and misleading.

7. Group Means.
8. Male Means.
9. Female Means.

In addition, male and female means and standard deviations were calculated according to age (17-18 years, 19-20 years, 21-30 years, 31-50 years, and 51-83 years) involving all 387 cephalograms in the untreated sample.

Inferential Statistics

In order to characterize the differences between the initial and final films, a paired T-test was used (H_o: = 0). The purpose of this pairing was to reduce the effect of subject-to-subject variability. This would in essence preserve the indication of invididual change by measuring the initial film and the final film with time as the treatment. The following paired T-tests were calculated:

1. Paired T-test for the entire group (pooled) of untreated individuals from initial to final.
2. Paired T-test for the males only.
3. Paired T-test for the females only.
4. Paired T-test for spans starting at 25 years and beyond. This was done to exclude all spans whose initial films fell below 25 years of age to determine whether change was significant if the initial age was 25 years of age or greater.
5. Paired T-test for spans starting at 30 years of age.
6. Paired T-test for spans starting at 35 years of age.
7. Paired T-test for spans starting at 40 years of age.

8. Paired T-test for the treated sample. In order to determine whether change was occurring in the treated group, paired observations were tested.

9. Paired T-test serious dental problems. This was done to determine if the individuals in this group were changing through time.

Also, in order to determine whether there were significant differences among samples, the means of the various groups were tested by way of a two sample T-tests (H_o: $\sigma_1^2 = \sigma_2^2$). Variances were not assumed to be equal. The following contrasts were performed using the initial and final films:

1. Two sample T-test: male versus female.

2. Two sample T-test: untreated versus treated.

3. Two sample T-test: untreated versus serious dental problems.

Significance levels presented will be 0.05, 0.01 and 0.001 as *, ** and ***. Since the significance level is exactly the probability of rejecting H_o when it is true, it is left to the reader to determine if a type I error (rejecting H_o when it is true) or a type II error (accepting H_o when it is false) has the worse consequence. For all practical purposes in the present study it is the author's opinion that a type II error has the worse consequence and a significance level of 0.05 is more than adequate.

Error Studies

Two error studies were conducted to determine the accuracy of the technique. Even though all cephalometric technique is precisely standardized in the Bolton Study, in order to determine whether or not any spurious magnification was being induced by the

equipment (the machinery had been moved when the new dental building was constructed) a number of dry skulls, which were part of the Todd-Hamman collection that been radiographed in the thirties for various reasons, were re-radiographed using the same machine calibrations. As these dry skulls would not be "growing" between the 1930's and the present, the radiographic images also would not be altered unless spurious magnification was induced by the equipment. Indeed the images were coincident and no further regard was given the precision of the technique in regard to time of measurement (equipment).

In order to assess the level of tracing and measurement accuracy, 10% of the series was selected randomly, and the initial and final x-rays were retraced and remeasured. A coefficient of linear correlation (Pearsonian r) was calculated between the first and second determination of the dimensions. This correlation was squared to form r^2 as a measure of the proportion of variance "explained" by the other and as a measure of the strength of the linear relationship. The results of these tests are presented in tabular form with the calculations (Appendix A).

It should also be noted that certain other tests for error were accomplished indirectly as the results were consistent regardless of whether the final x-rays were gathered by the author or others, and were present regardless of the year of final record gathering. While error surely exists within cephalometrics, the results of the present study appear to be biologic in nature to an approximation that cephalometrics can discern.

CHAPTER III

RESULTS

Sample

The results of the recall program are given in Figures 12 and 13. The response from this group of people was quite dramatic and indeed enthusiastic, even though most have had no contact with the Bolton Study for over 30 years. Since 92% of the individuals who responded were willing to undergo examinations, an adequate sample was achieved. The 29 still awaiting examinations at the time of this writing have been arranged for outside the Cleveland area; none are awaiting exams at the Bolton Study. Since it could not be determined if and when the distant examinations would occur, analyses of the present sample preceded. Figure 13 presents sizes obtained for the various samples and characterizes the untreated sample as a group.

The examinations and records in existence (on file) resulted in cephalometric material for 160 individuals (3 people prefered not to have x-rays taken and thus had no final record satisfying the criteria and therefore were placed in the "unuseable sets of records"). The records available for each individual are given in Figure 14. After scrutinizing the films available for study, 7 additional cases were discarded leaving a total of 153 individuals with 524 cephalograms. The age distribution of these lateral ceph-

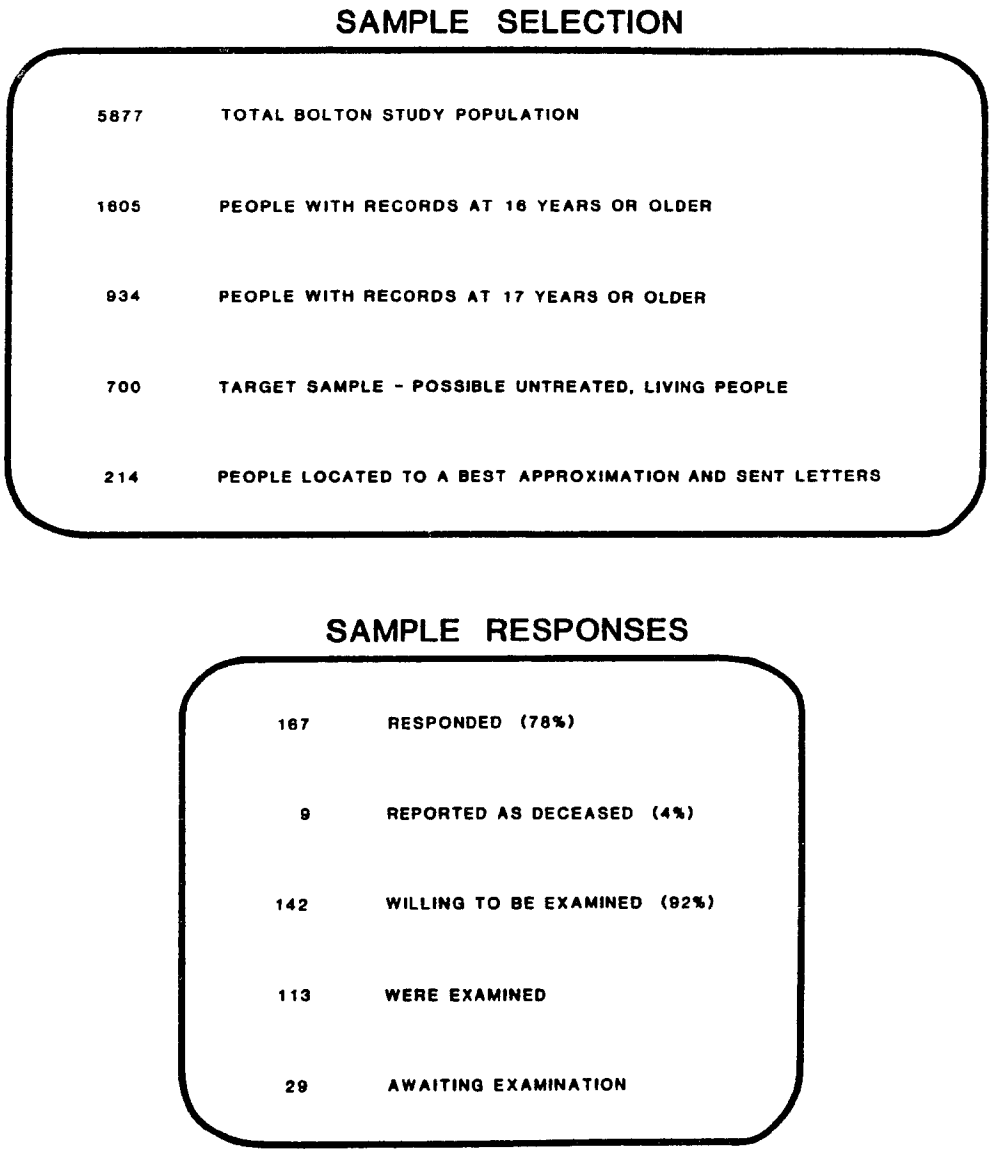


Figure 12. Sample selection results and the responses obtained from the target sample.

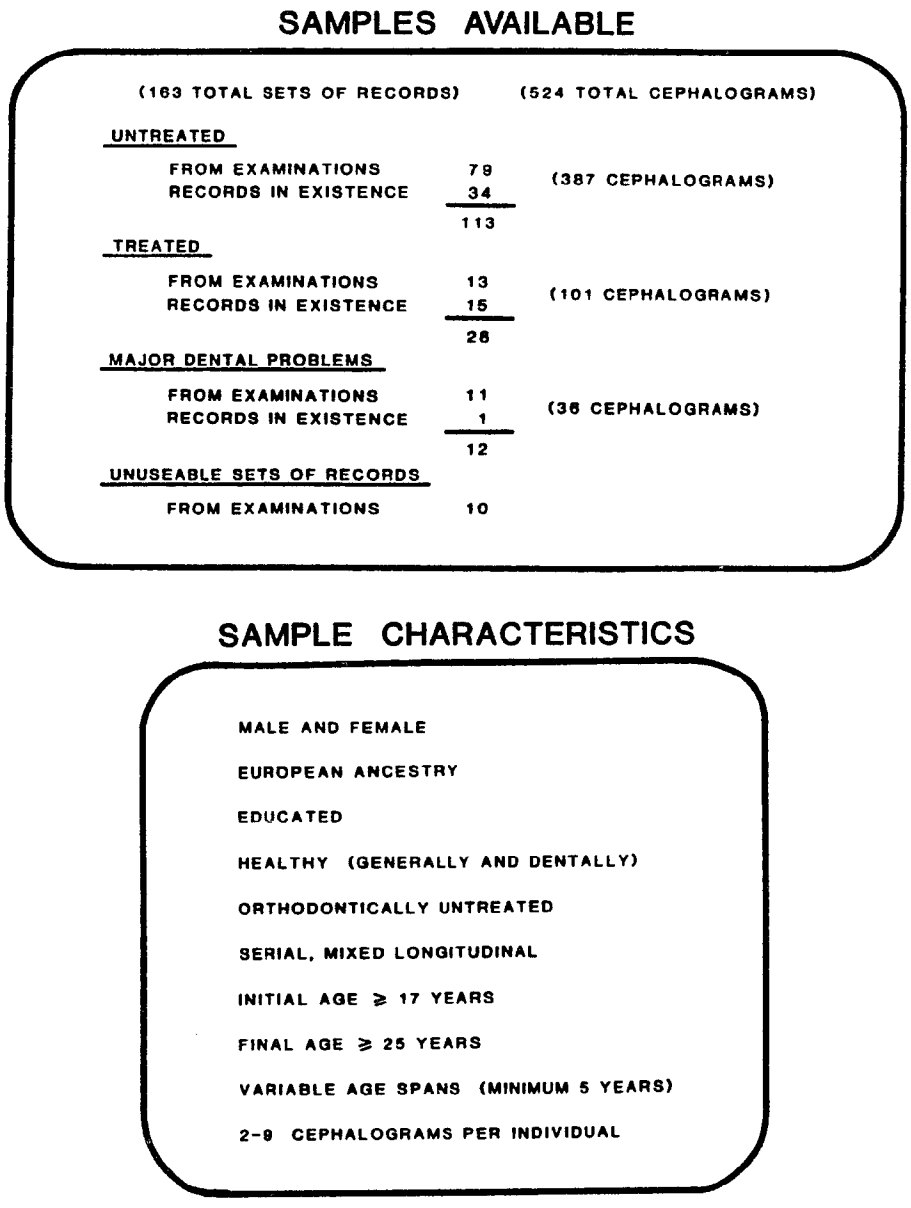


Figure 13. Sample sizes and the characteristics of the untreated sample.

Figure 14A. Cephalometric films available for each person according to age.

Figure 14A

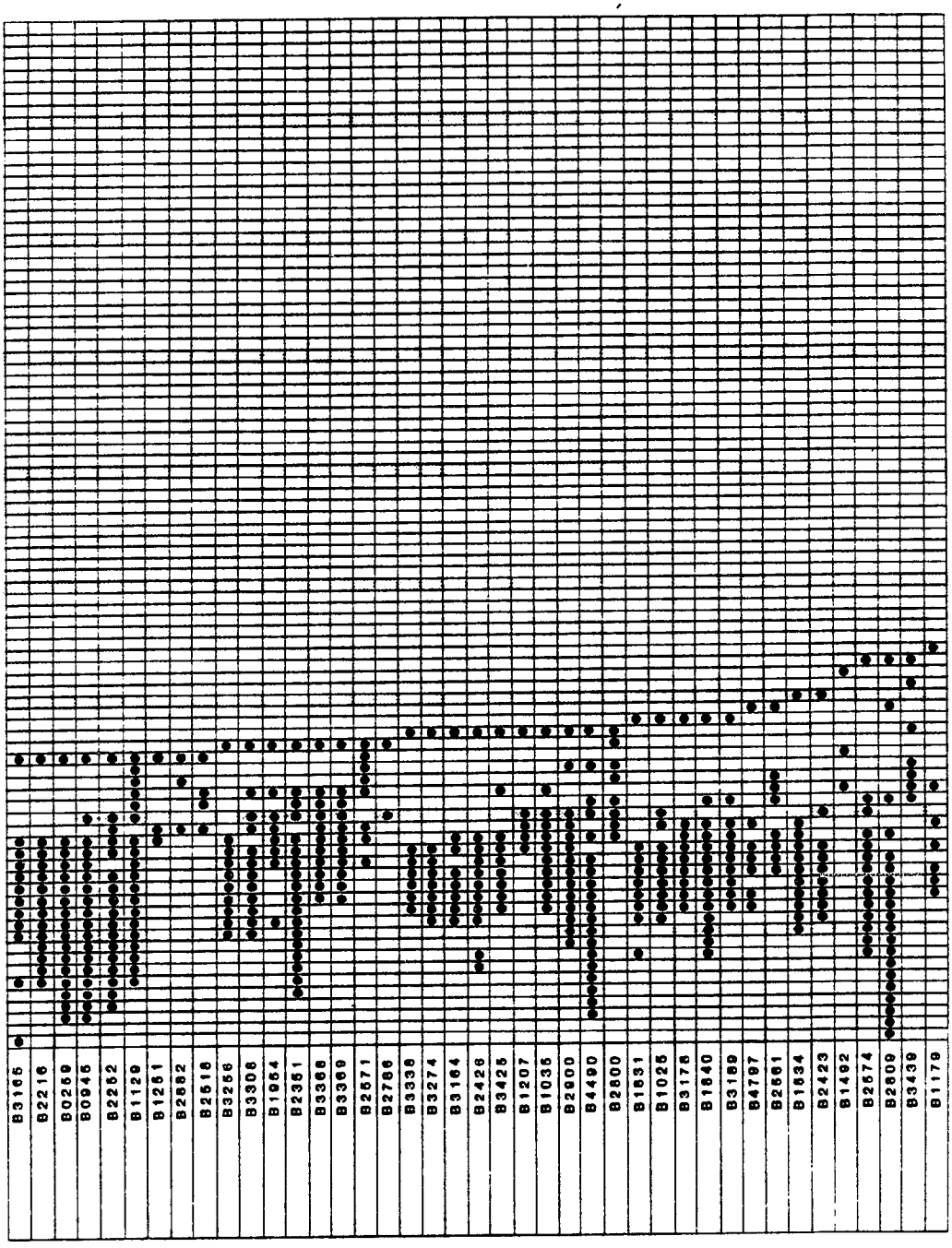

B3165
B2216
B0259
B0945
B2252
B1120
B1251
B2882
B2518
B3256
B3306
B1964
B2361
B3368
B3360
B2671
B2786
B3338
B3274
B3164
B2428
B3425
B1207
B1035
B2900
B4490
B2800
B1831
B1025
B3178
B1840
B3189
B4797
B2561
B1634
B2423
B1492
B2574
B2809
B3439
B1179

Figure 14B. Cephalometric films available for each person according to age.

Figure 14B

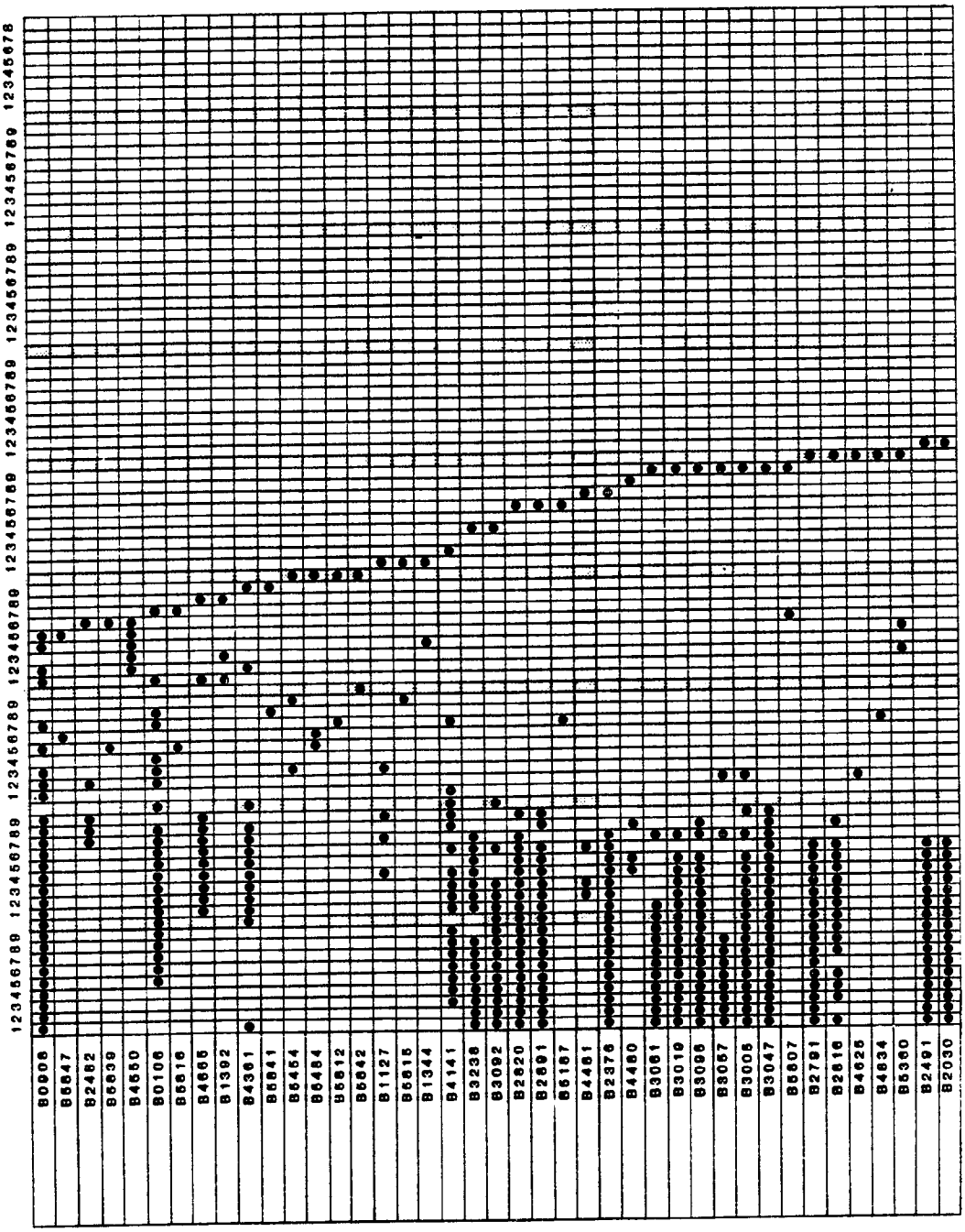

10 20 30 40 50 60 70 80
12345678 12345678 12345678 12345678 12345678 12345678 12345678 12345678
B0908
B5647
B2462
B5639
B4650
B0106
B5816
B4865
B1302
B4361
B5841
B5454
B6484
B5812
B5842
B1127
B5615
B1344
B4141
B3238
B3092
B2820
B2691
B5187
B4461
B2376
B4460
B3061
B3010
B3096
B3057
B3005
B3047
B5607
B2791
B2816
B4625
B4634
B5360
B2491
B2030

Figure 14C. Cephalometric films available for each person according to age.

Figure 14C

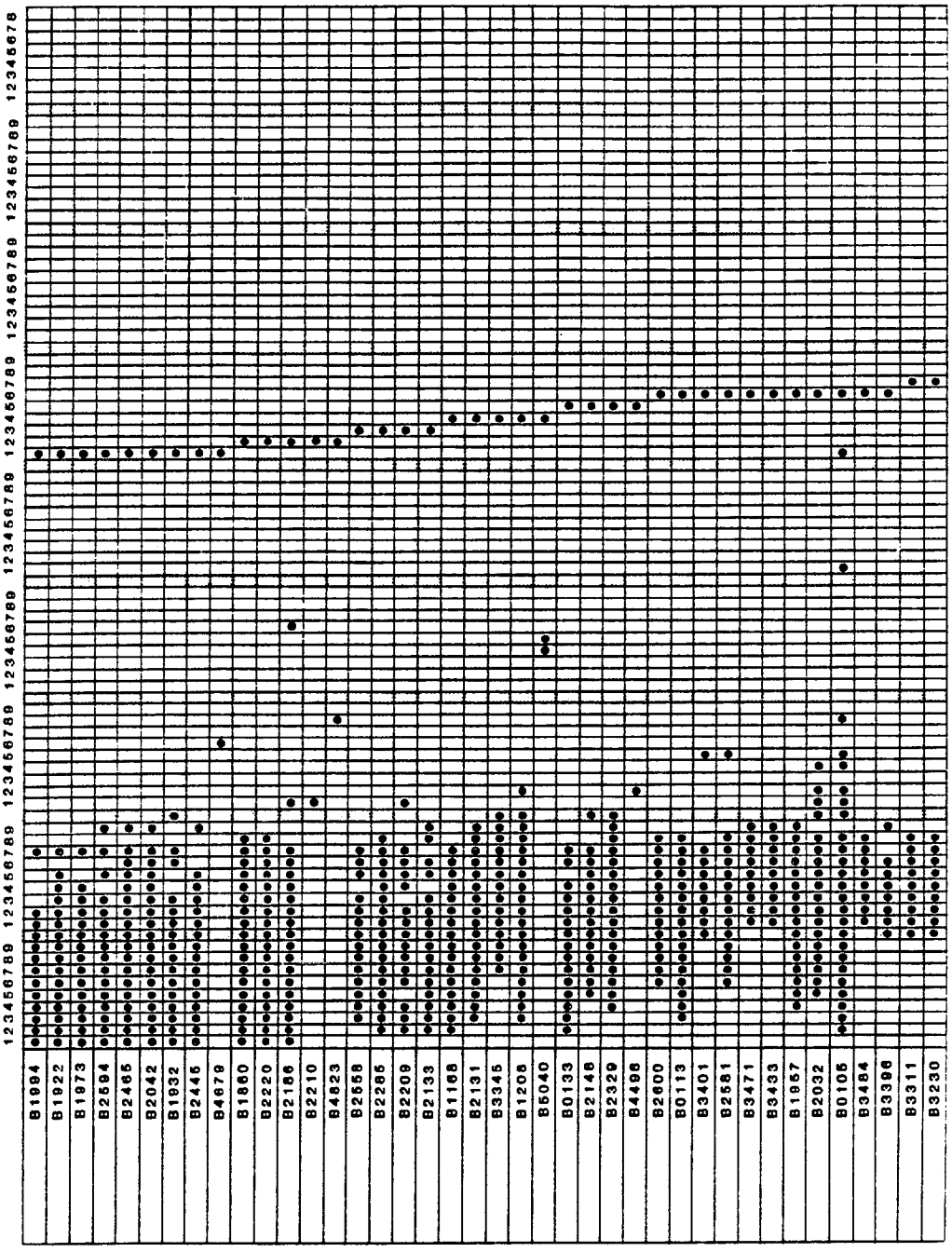
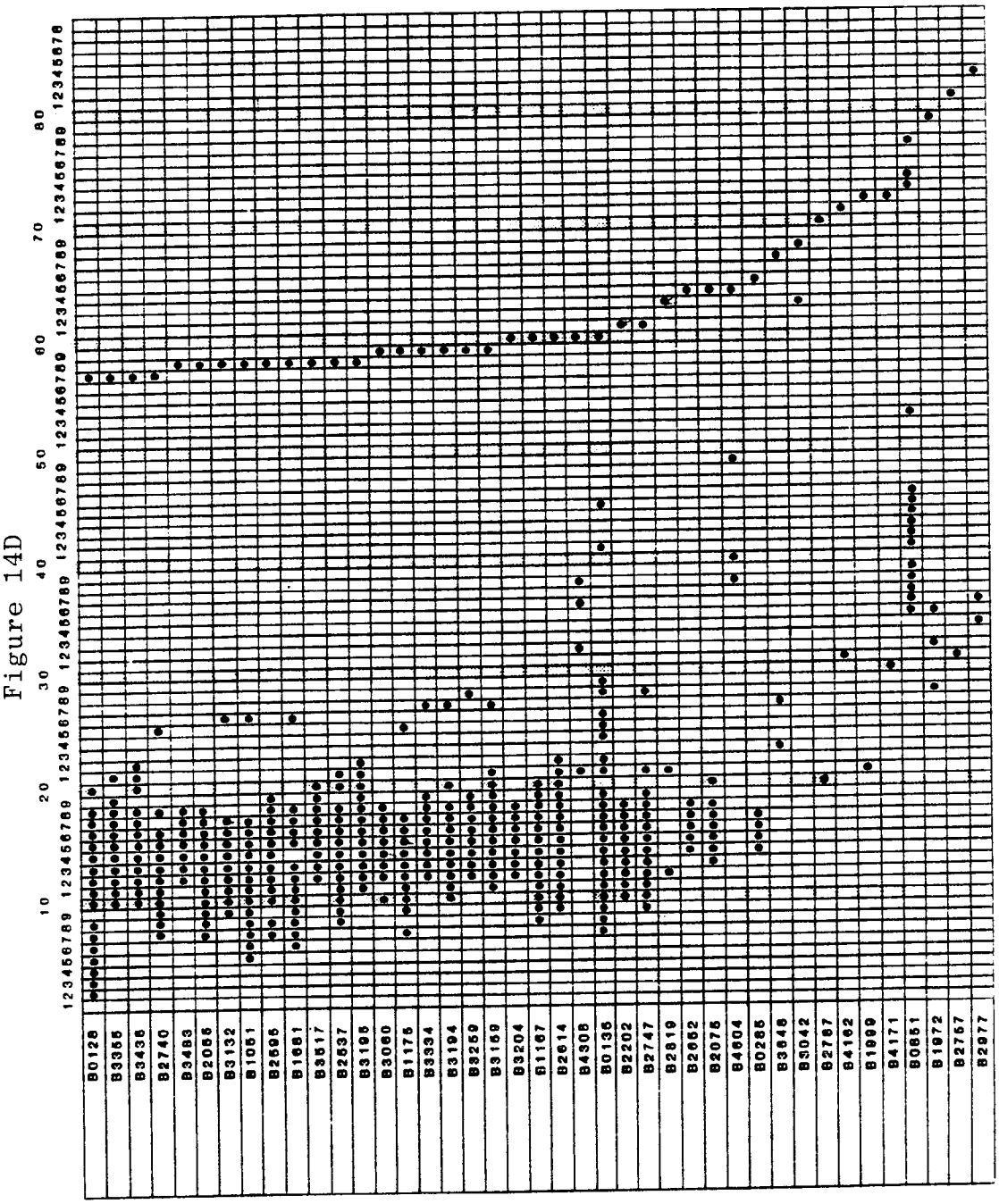

10 20 30 40 50 60 70 80
B1994
B1922
B1973
B2594
B2465
B2042
B1932
B2445
B4679
B1860
B2220
B2186
B2210
B4823
B2558
B2285
B2209
B2133
B1168
B2131
B3345
B1208
B5040
B0133
B2148
B2329
B4498
B2600
B0113
B3401
B2581
B3471
B3433
B1957
B2032
B0105
B3484
B3396
B3311
B3230

Figure 14D. Cephalometric films available for each person according to age.

Figure 14D


10 20 30 40 50 60 70 80
B0128
B3356
B3436
B2740
B3483
B2066
B3132
B1051
B2595
B1681
B3517
B2537
B3195
B3080
B1175
B3334
B3194
B3259
B3159
B3204
B1167
B2614
B4308
B0135
B2202
B2747
B2819
B2662
B2075
B4604
B0285
B3648
B3042
B2787
B4162
B1999
B4171
B0851
B1972
B2757
B2977

alograms is given in Figure 15. The untreated portion of the total sample was selected for in-depth analysis (113 individuals), and the age distribution of this group is summarized in Figure 16.

Examinations

Height and weight change determinations were compiled using all subjects where such information was available. This is presented in Tables IV-VI. Health information for the present samples was judged as good. The results of the health assessments are compiled in Appendix E. In regard to the dental examination the number of missing teeth, excluding the third molars, was calculated to have a mean value of 0.4 for an average age of 46.4 years. The results of the temporomandibular examination are reviewed in the Discussion.

Superimposition

Examples of representative changes noted by the process of superimposition are given in Figures 17-44. It should be noted that to remove operator influence, the tracings and illustrations were performed by an unbiased artist familiar with cephalometrics (William H. Golden). Overlay diazo reproductions were made from his tracings and superimposed by registering on Sella and orienting along Sella-Nasion. This method of superimposition was chosen on the basis of convenience. It should also be noted that if no growth

Figure 15. Age distribution of the total sample.

Figure 15

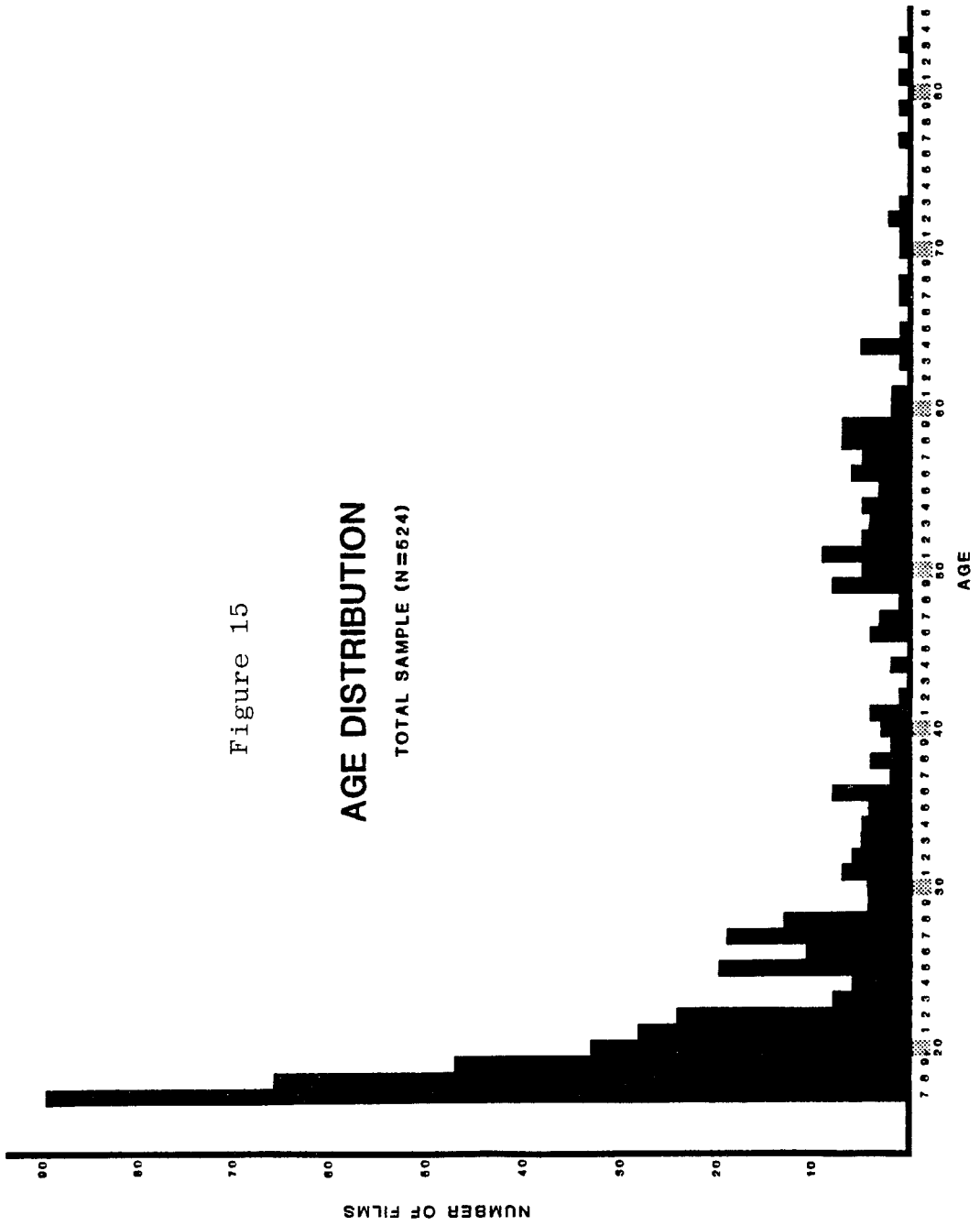


Figure 16. Age distribution of the untreated sample.

Figure 16


AGE DISTRIBUTION
UNTREATED SAMPLE (N=387)
INITIAL FILMS
INTERMEDIATE FILMS
FINAL FILMS
NUMBER OF FILMS
AGE

TABLE IV

HEIGHT CHANGE INVOLVING AGE SPANS WHICH BEGIN BELOW 20 YEARS OF AGE

HEIGHT CHANGE FEMALE (cm.) -YOUNG INITIAL AGE

	MEAN AGE	MEAN HEIGHT	SD HEIGHT	MEAN DELTA	DELTA SD	PROB.	N
FINAL	50.9	163.6	5.9	.2	1.4	.403	25
INITIAL	17.3	163.4	6.0				

HEIGHT CHANGE MALE (cm.) - YOUNG INITIAL AGE

	MEAN AGE	MEAN HEIGHT	SD HEIGHT	MEAN DELTA	DELTA SD	PROB.	N
FINAL	47.1	178.3	6.3	1.8	3.2	.000	54
INITIAL	17.3	176.5	6.9				

TABLE V

HEIGHT CHANGE FOR AGE SPANS STARTING
AT 20 YEARS AND ABOVE

HEIGHT CHANGE FEMALE (cm.) -OLDER INITIAL AGE

	MEAN AGE	MEAN HEIGHT	SD HEIGHT	MEAN DELTA	DELTA SD	PROB.	N
FINAL	57.0	165.5	4.8	-.9	1.6	.157	8
INITIAL	20.8	166.4	5.7				

HEIGHT CHANGE MALE (cm.) -OLDER INITIAL AGE

	MEAN AGE	MEAN HEIGHT	SD HEIGHT	MEAN DELTA	DELTA SD	PROB.	N
FINAL	53.5	179.5	7.6	.8	2.0	.080	21
INITIAL	23.0	178.7	7.9				

TABLE VI

WEIGHT CHANGE FROM YOUNG ADULTHOOD
TO MIDDLE AGE

WEIGHT CHANGE FEMALE (lbs.)

	MEAN AGE	MEAN WEIGHT	SD WEIGHT	MEAN DELTA	DELTA SD	PROB.	N
FINAL	50.9	150.5	22.4	19.4	26.1	.001	25
INITIAL	17.3	131.1	14.9				

WEIGHT CHANGE MALE (lbs.)

	MEAN AGE	MEAN WEIGHT	SD WEIGHT	MEAN DELTA	DELTA SD	PROB.	N
FINAL	47.1	177.8	28.7	29.5	27.2	.000	54
INITIAL	17.3	148.3	22.7				

Figure 17. Superimposition, female ages 17-44. Note this individual is mandibular prognathic especially at the final tracing (solid line). Magnification initial = 6.1; final = 6.4. Format reduction = 74%.

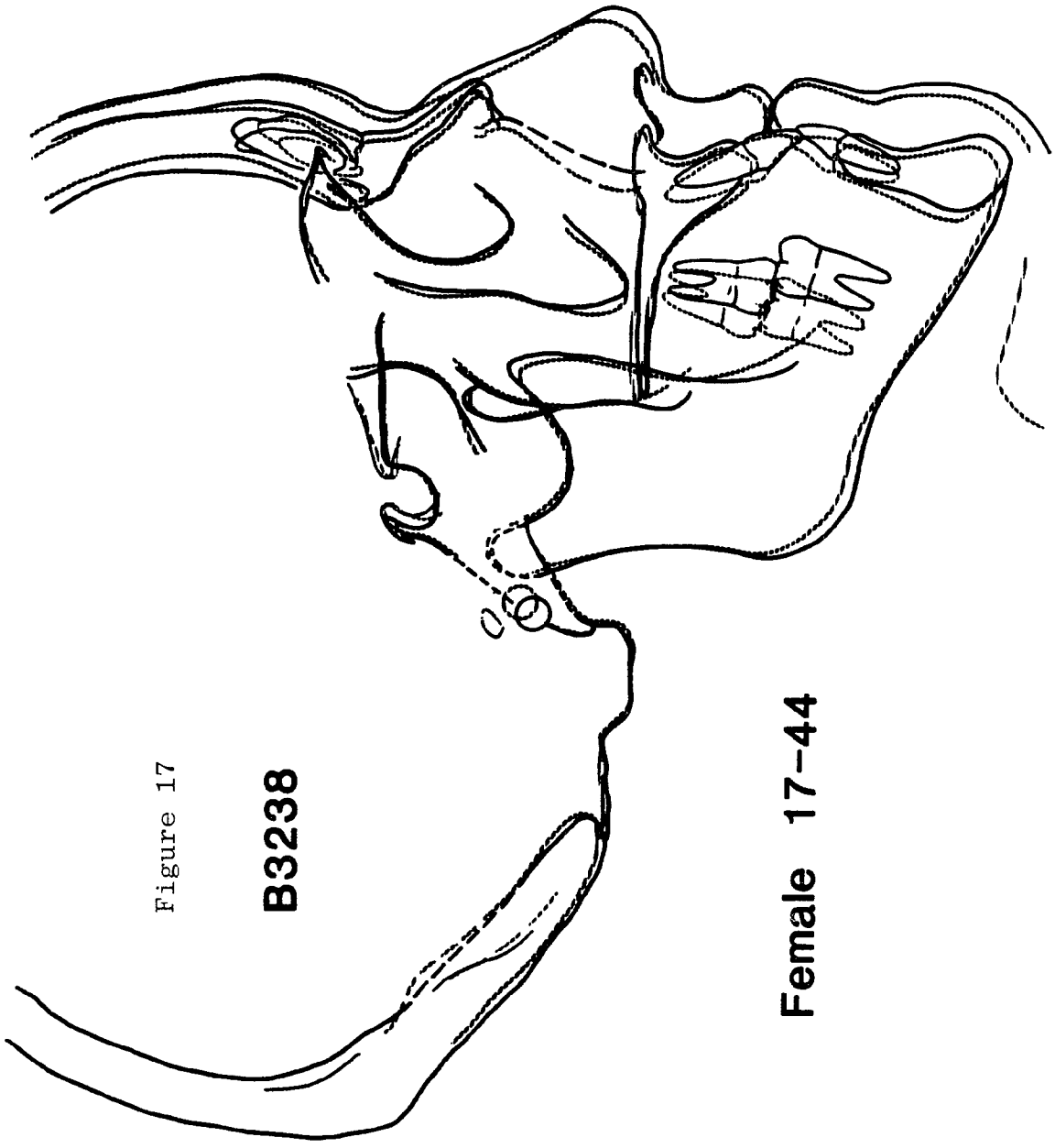


Figure 17

Figure 18. Superimposition, female ages 17-57. The first of a series of three comparisons indicating overall change. Considerable vertical change is noted as is soft tissue and dental change. Magnification = 5.9 and 6.3

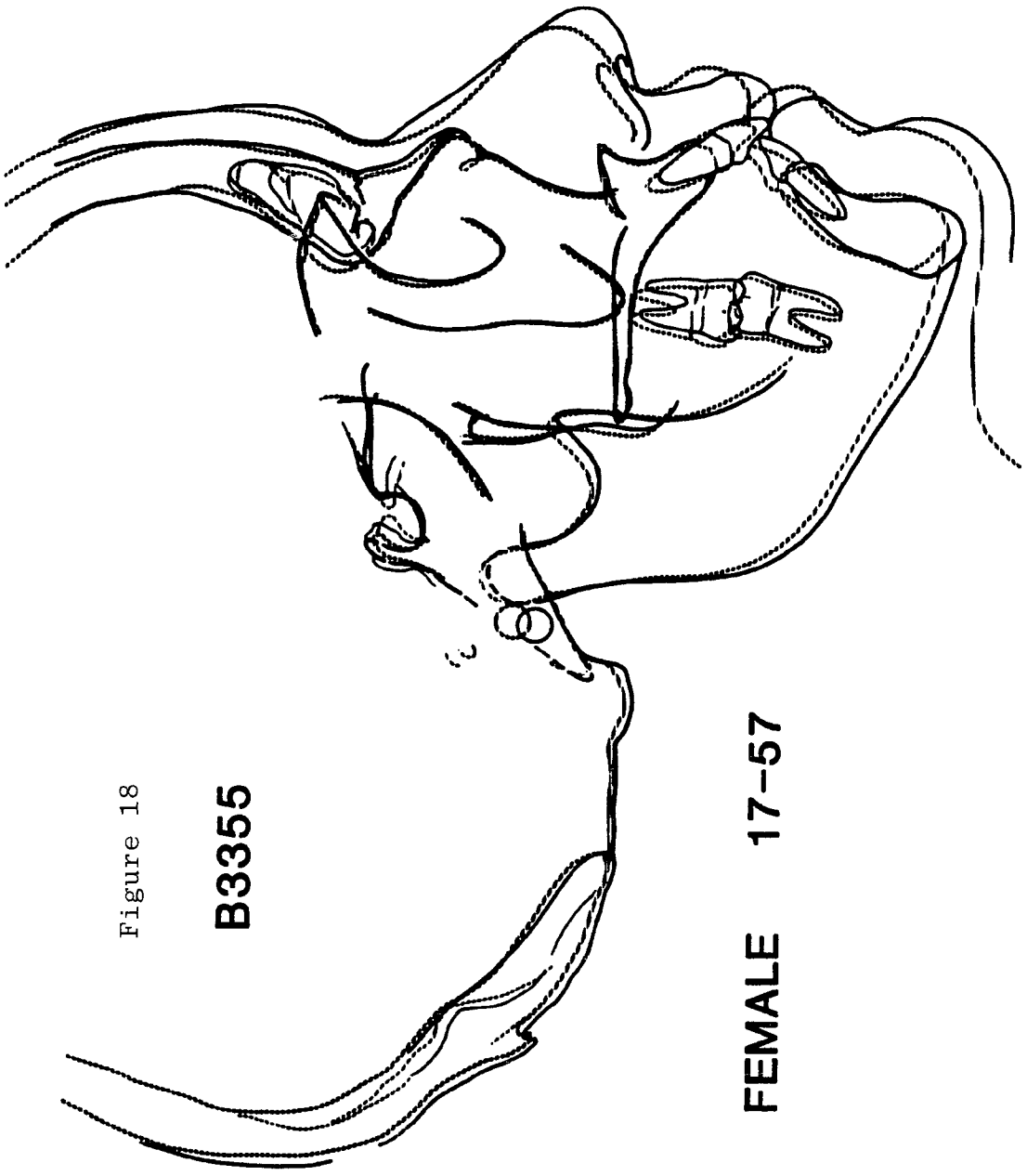


Figure 18

Figure 19. Superimposition, female ages 17-21. Same female as in Figures 18 and 20. In these tracings very little alteration is noted. Magnification = 5.9 and 5.5

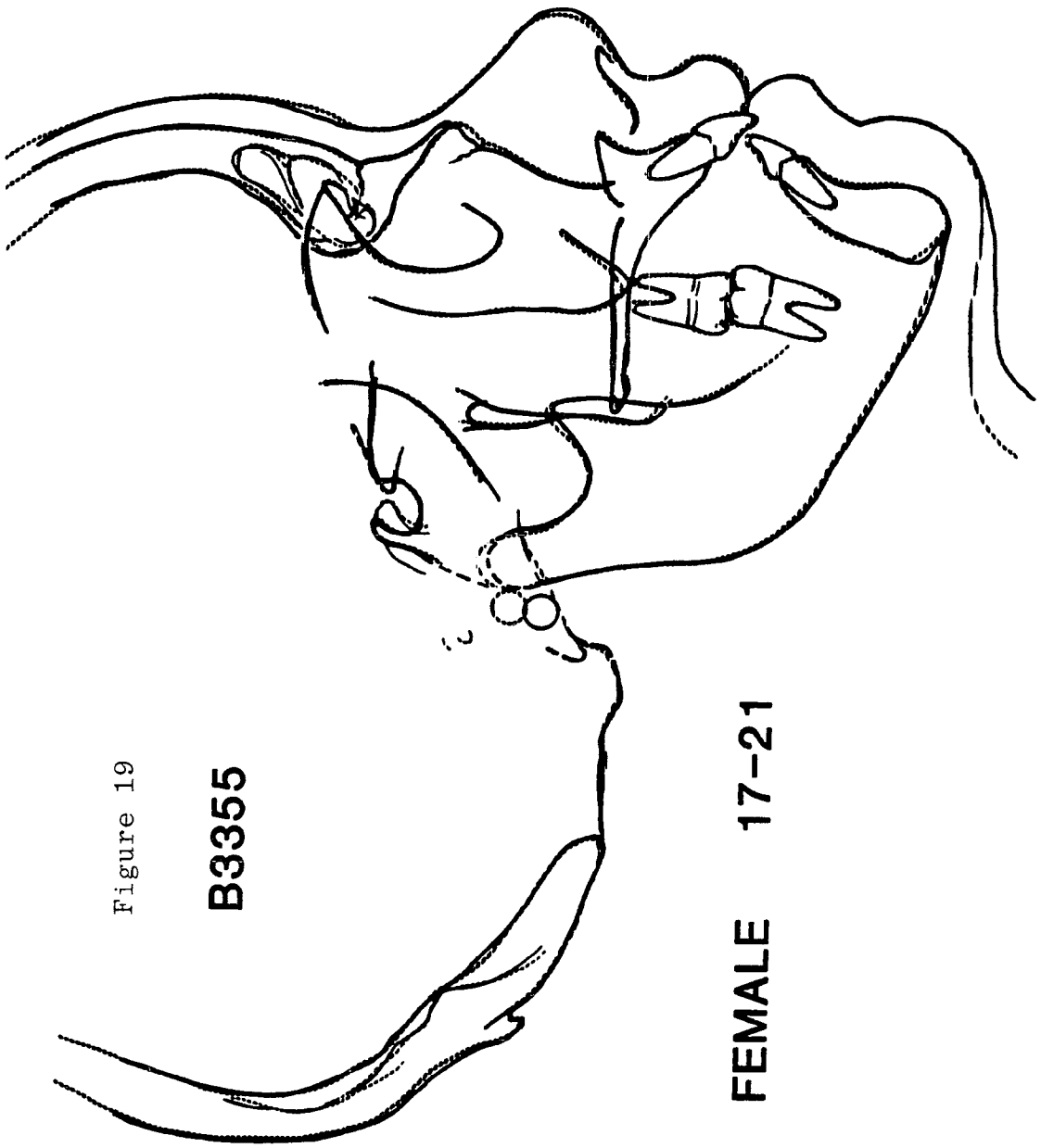


Figure 19

Figure 20. Superimposition, female age 21-57. Later age comparison of female shown in Figures 18-19. Apparently the major changes noted for this individual occur after 21. Magnification = 5.5 and 6.3

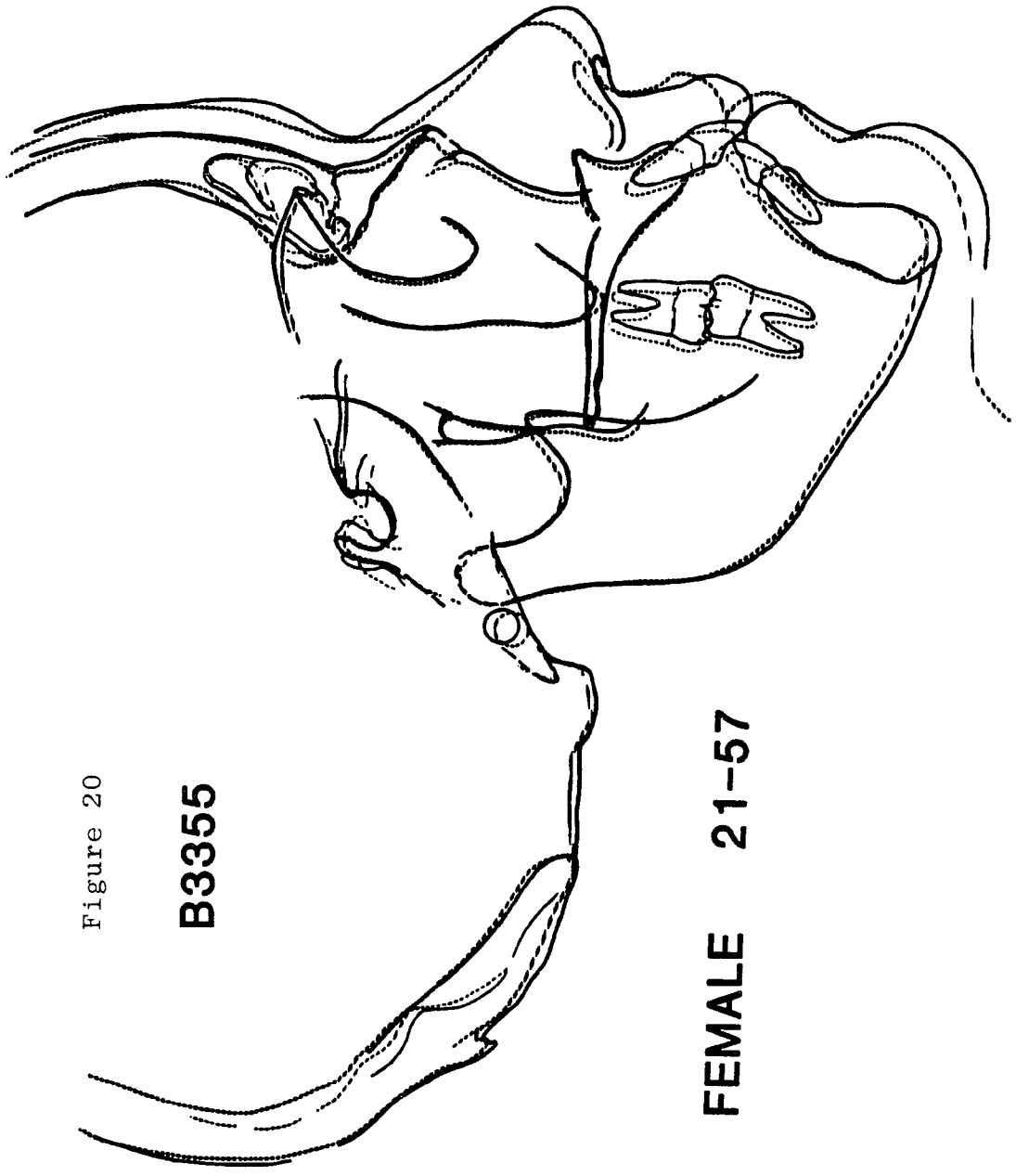


Figure 20

Figure 21. Superimposition, female age 34-83. An older female comparison which shows quite dramatic changes in upper, mid and lower facial regions. Magnification = 6.0 and 6.0.

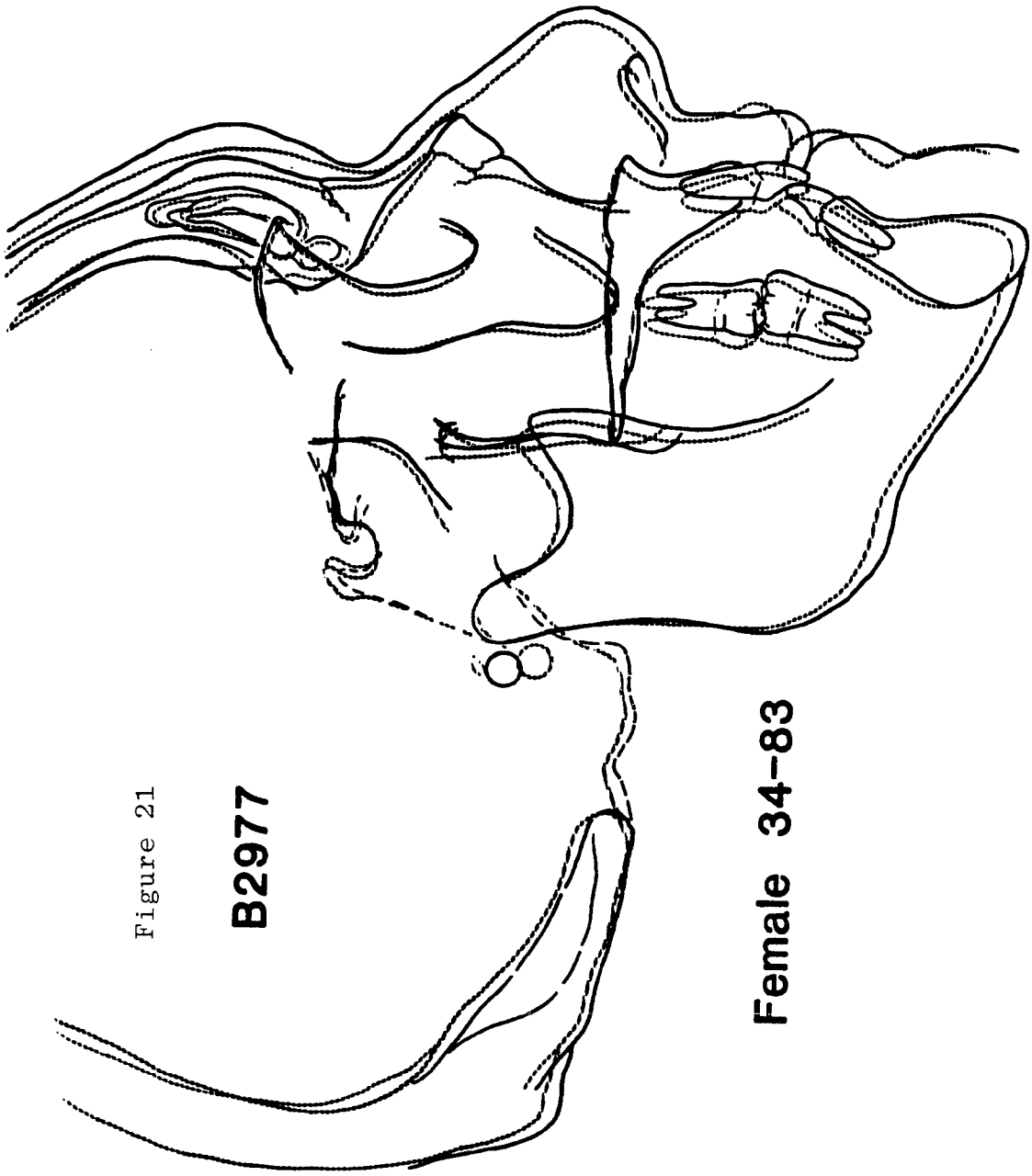


Figure 21

Figure 22. Superimposition, male age 17-27. An extreme example of the amount of change possible for the younger adult period. Magnification = 5.9 and 6.2

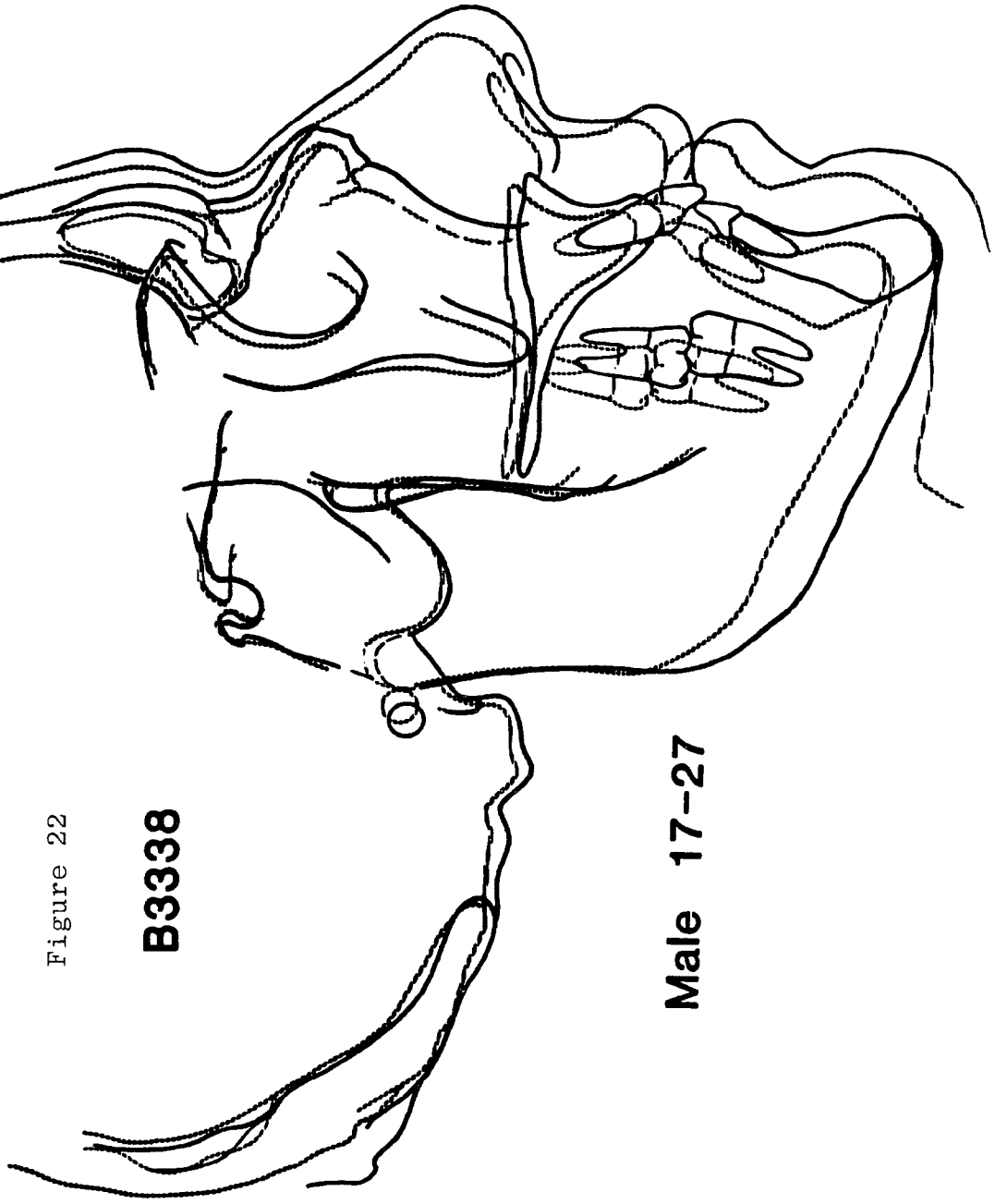


Figure 22

Figure 23. Superimposition, male age 21-52. A modest change is noted primarily involving anterior displacements of the lower face. Magnification = 6.8 and 6.6.

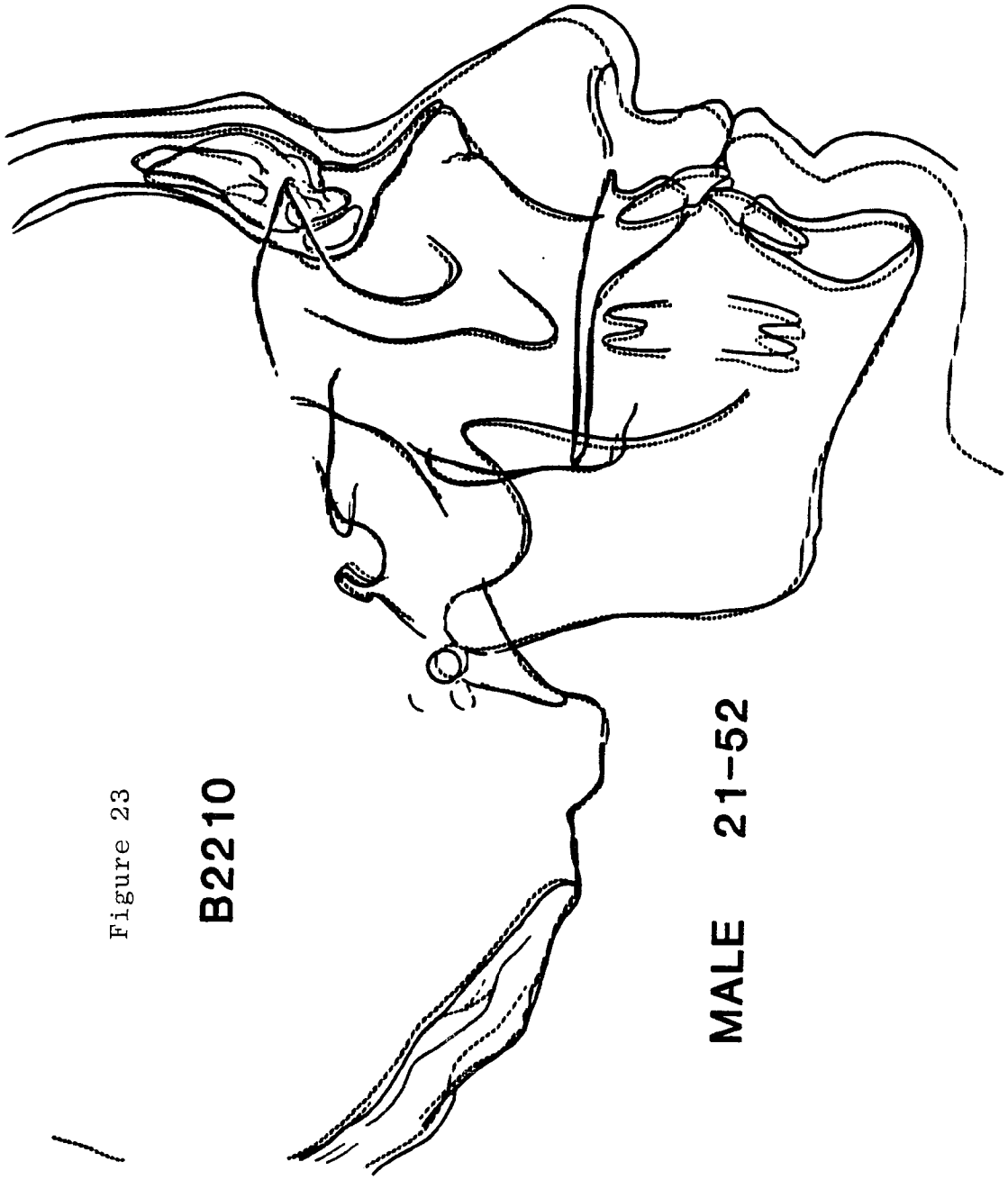


Figure 23

Figure 24. Superimposition, male age 17-30. The first in a series of three figures demonstrating the overall change. Note in particular the mandibular change. Magnification = 6.4 and 7.0.

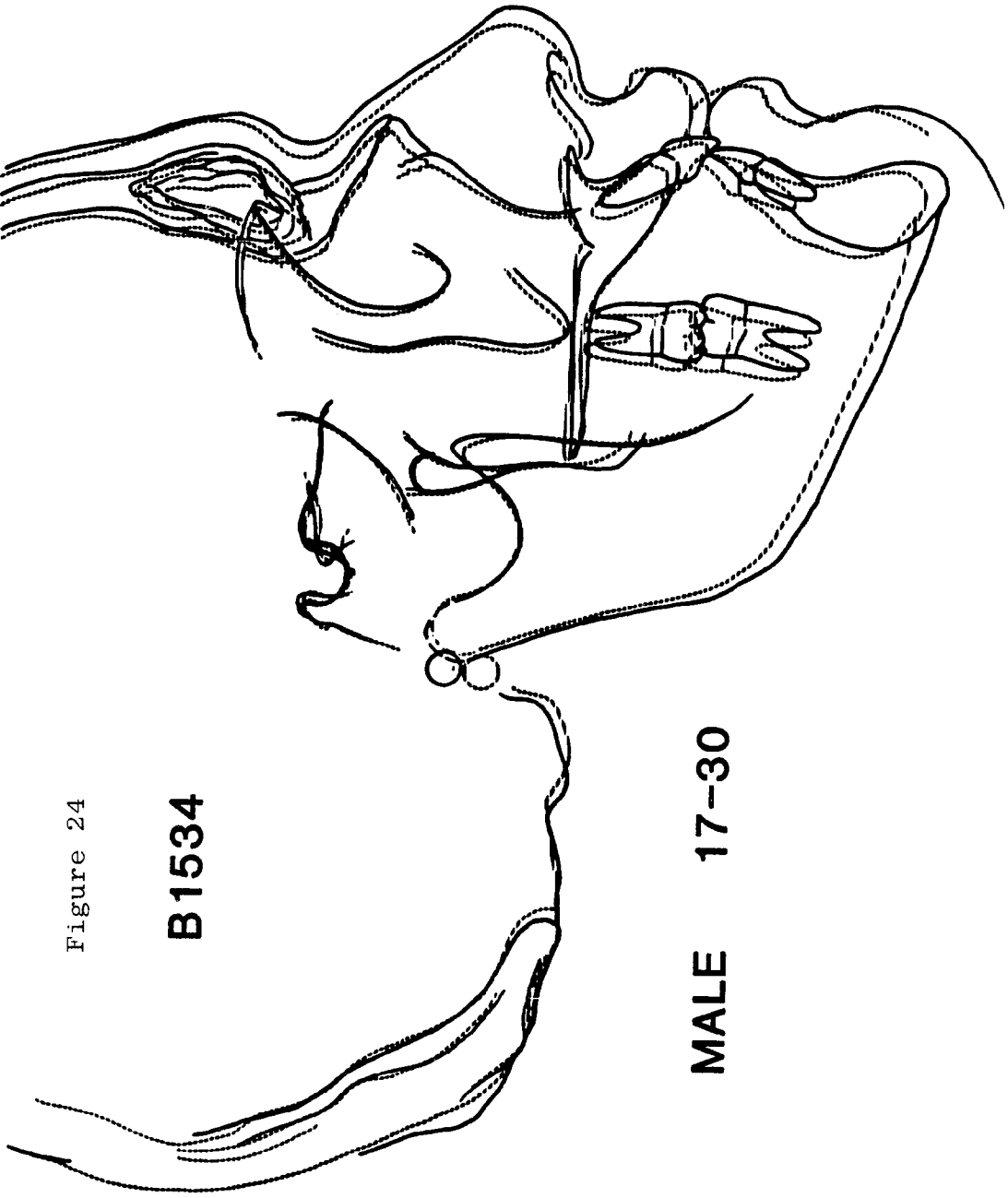


Figure 24

Figure 25. Superimposition, male age 17-19. The early span in a series involving Figures 24 and 26. Note the anterior mandibular alteration. Magnification = 6.4 and 6.6.

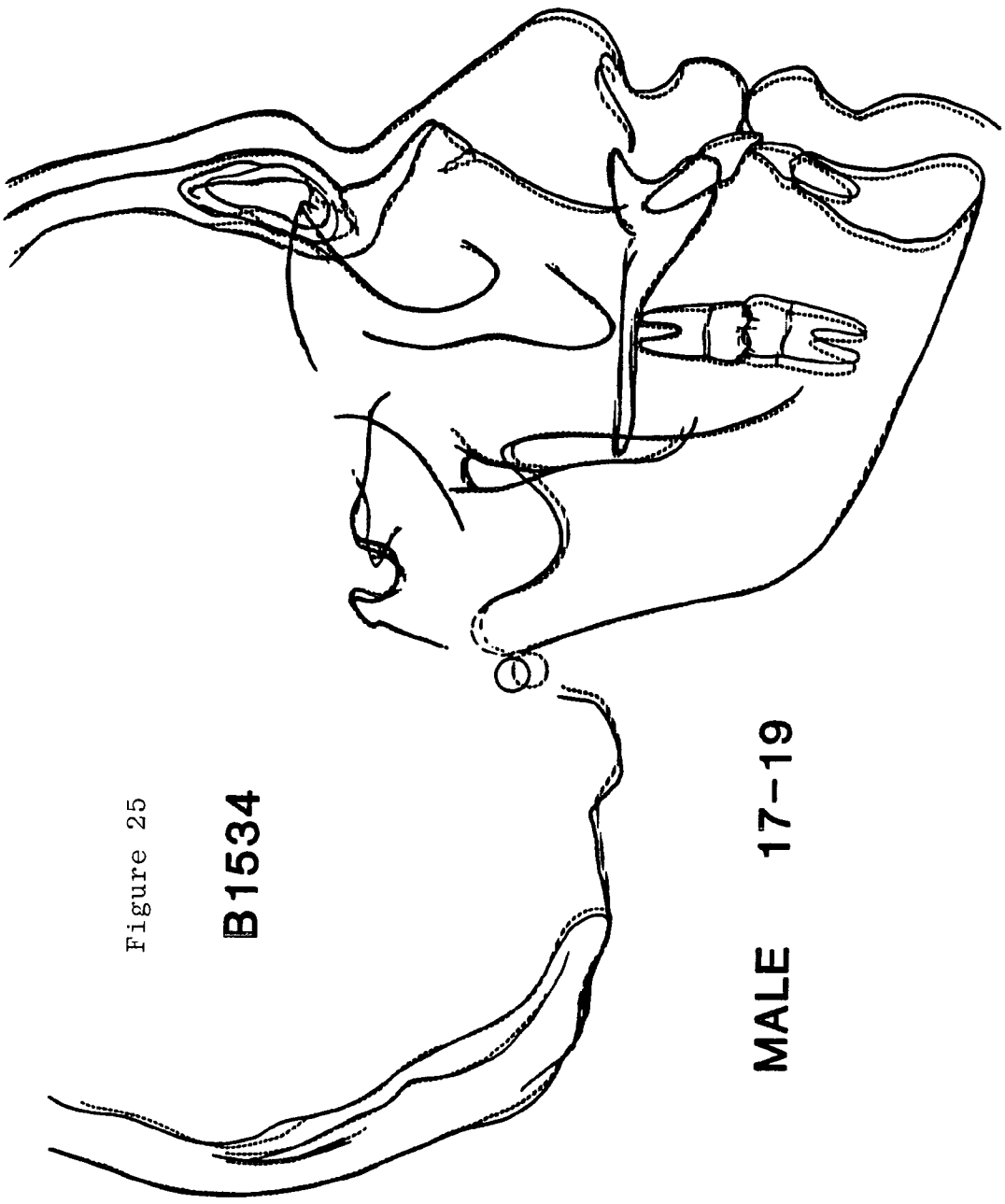


Figure 25

Figure 26. Superimposition, male age 19-30. A later age span in the series involving Figures 24-26. Note the vertical mandibular displacement. Magnification = 6.6 and 7.0.

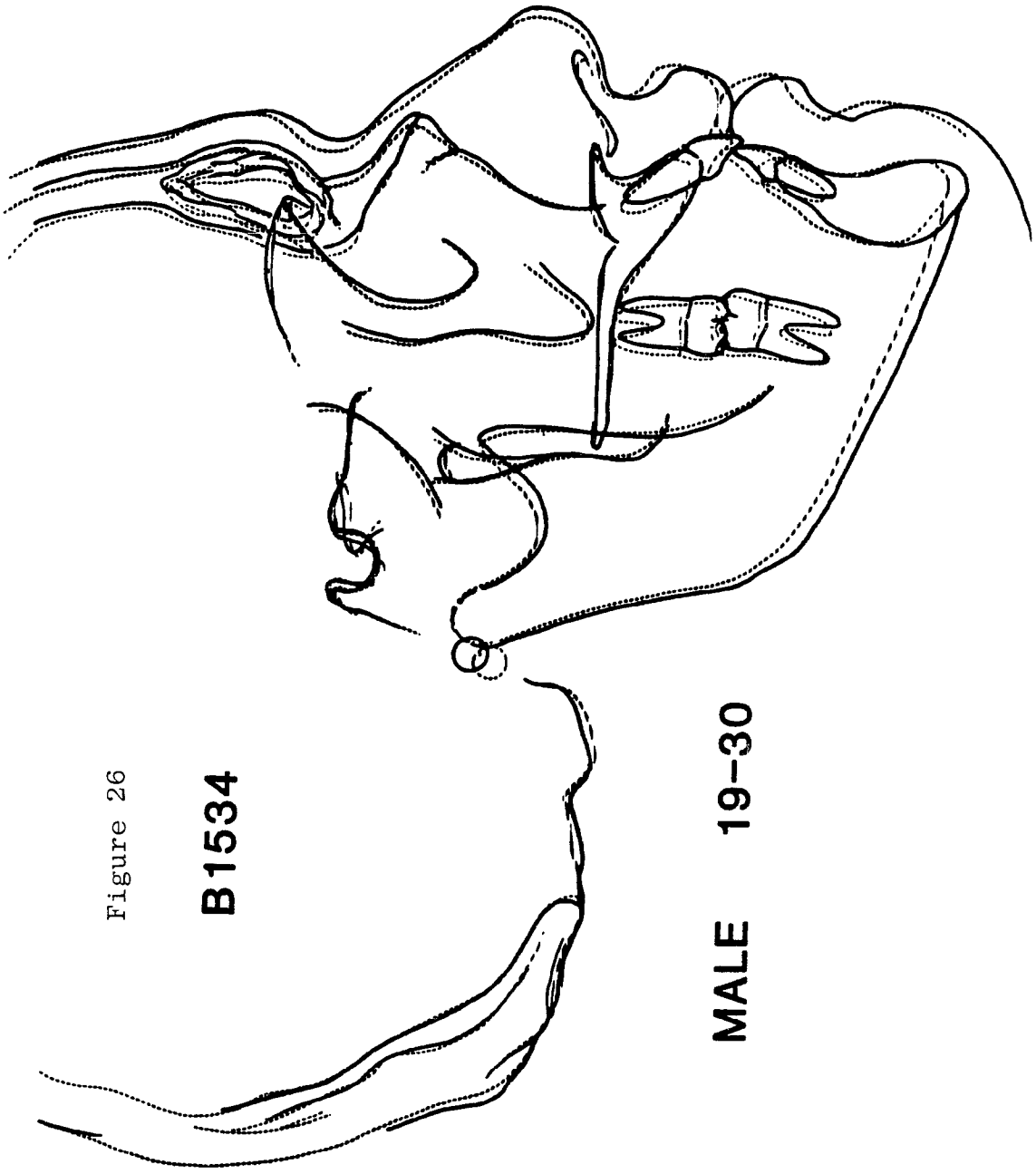


Figure 26

Figure 27. Superimposition, male age 17-49. The first in a series of three indicating overall change. The nasal region shows considerable change. Magnification = 6.5 and 6.6.

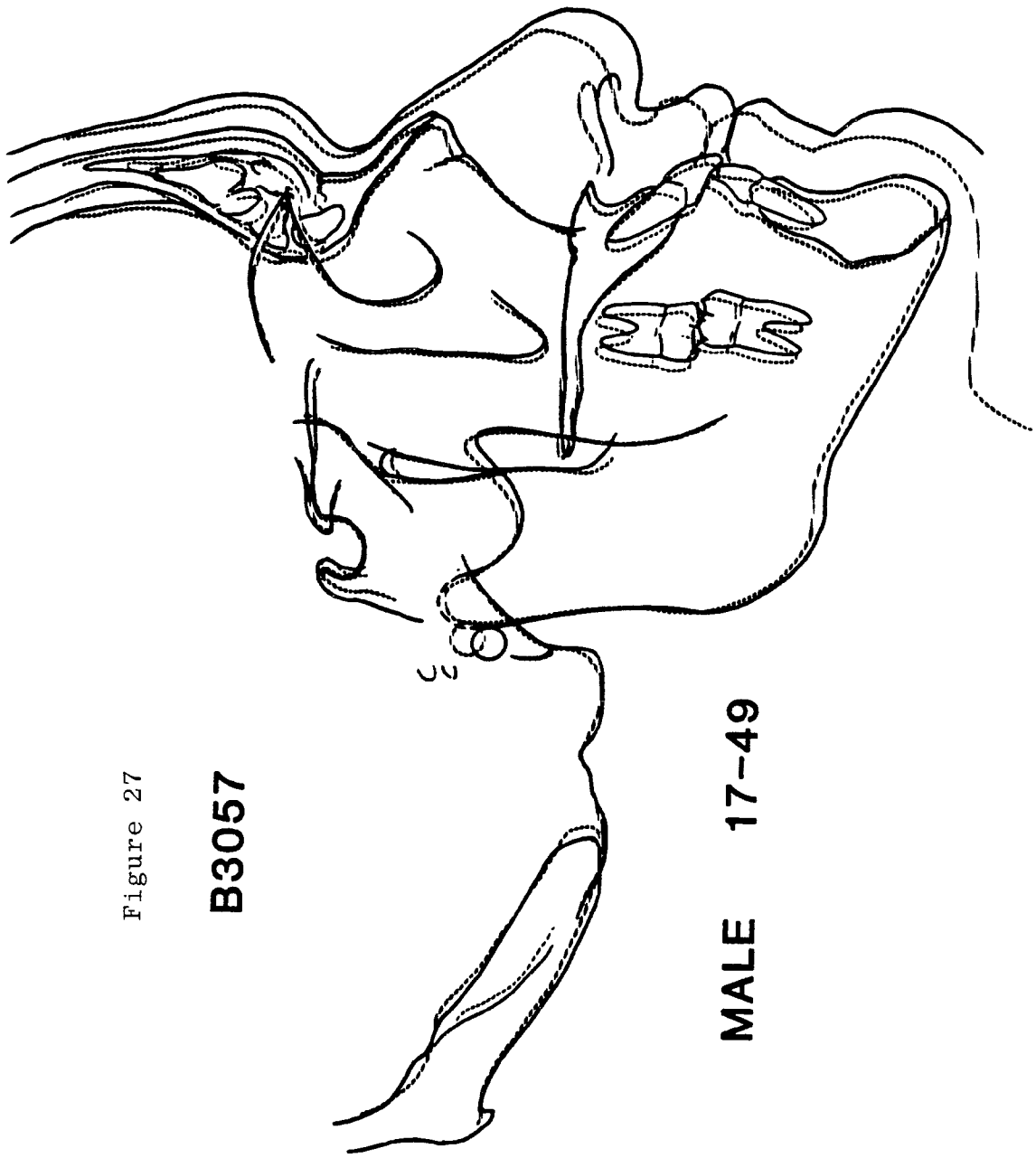


Figure 27

Figure 28. Superimposition, male age 17-20. The youngest age span involving Figures 27-29. Modest alterations are noted. Magnification = 6.5 and 6.7.

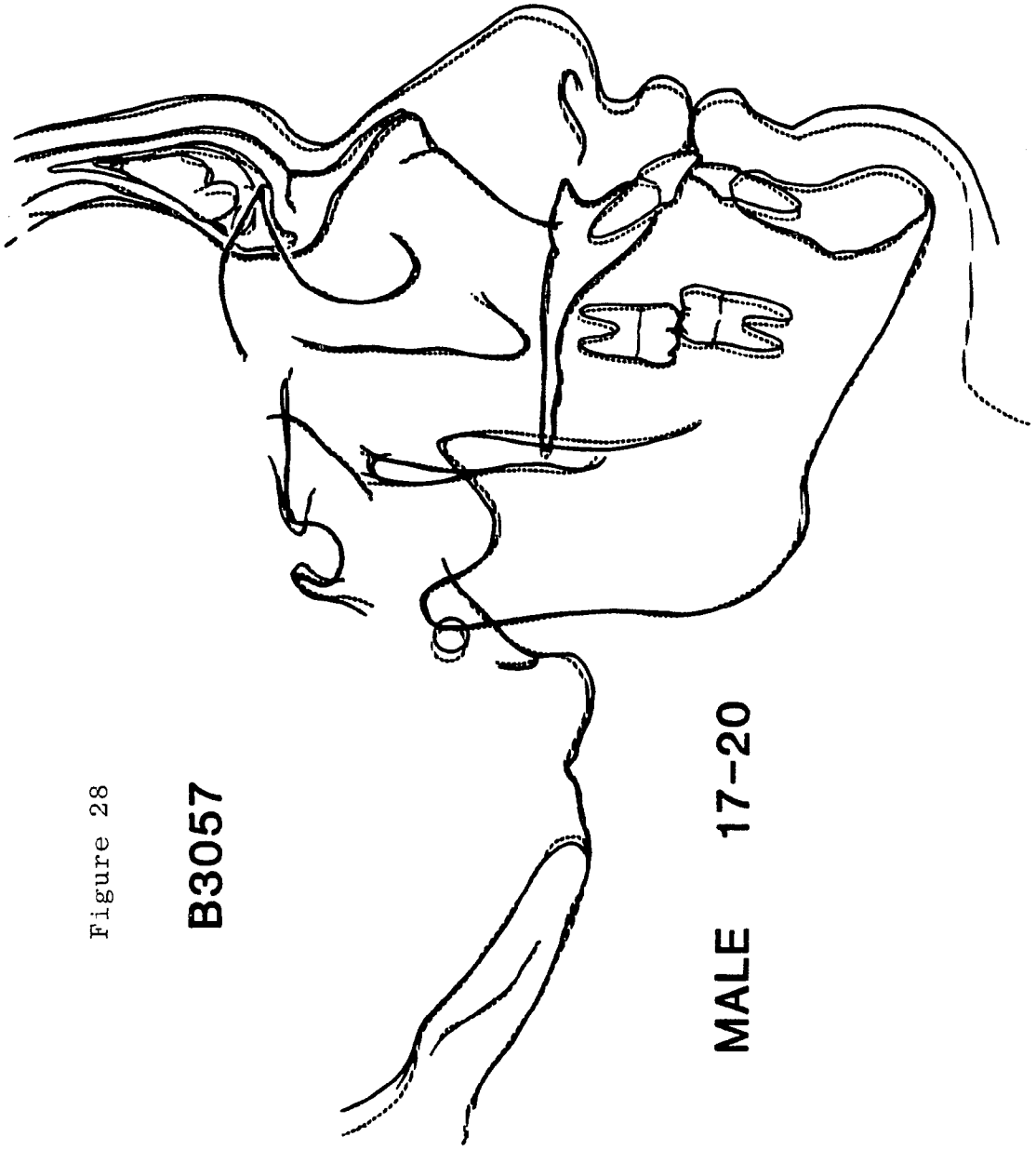


Figure 28

Figure 29. Superimposition, male age 20-49. The later age span involving Figures 27-29. Development of the nasal region is more dramatic during this period. Magnification = 6.7 and 6.6.

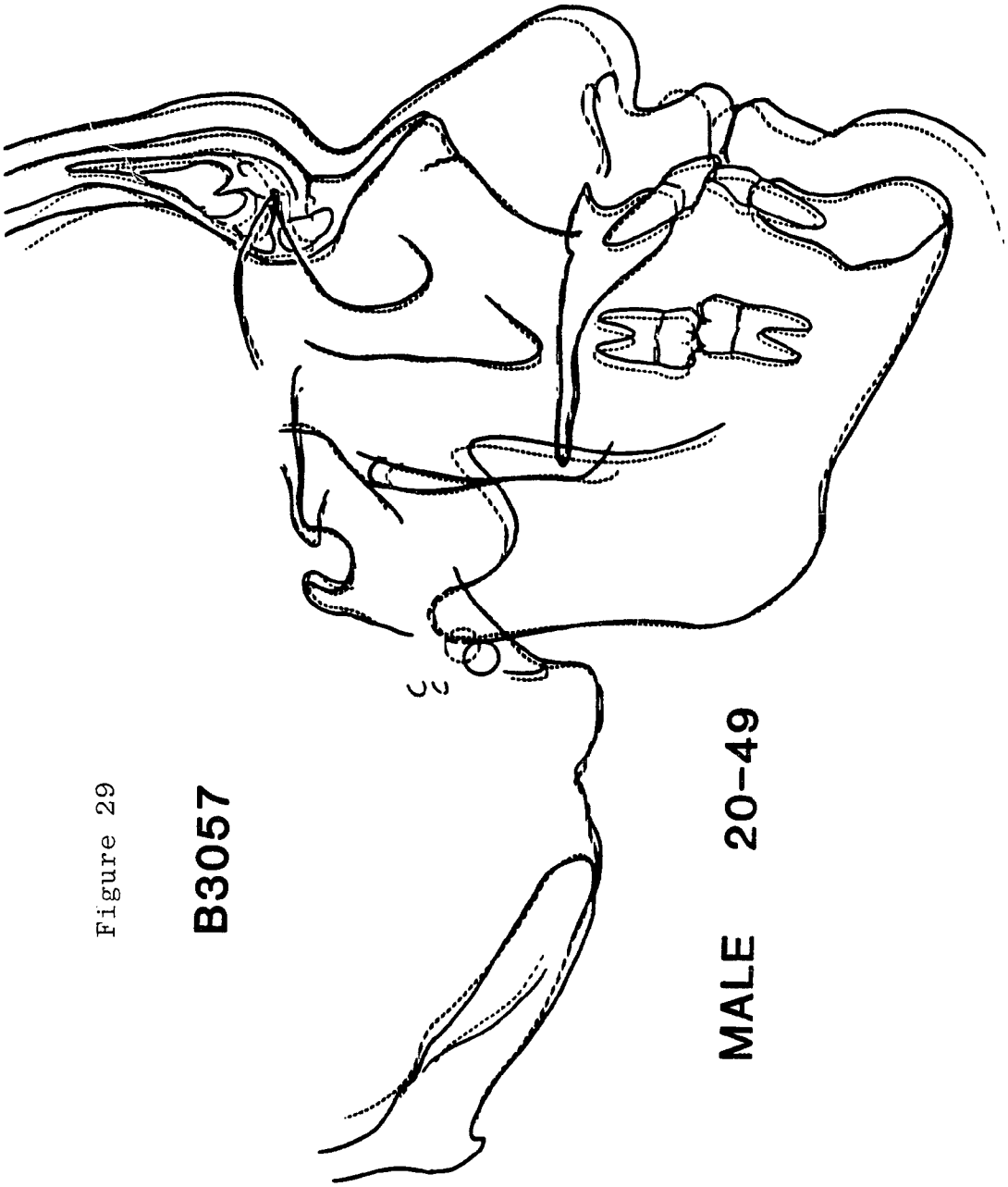


Figure 29

Figure 30. Superimposition, male age 17-55. Tremendous growth is evident here. This is the first comparison in a series of three. Magnification = 5.6 and 6.5 Treated case.

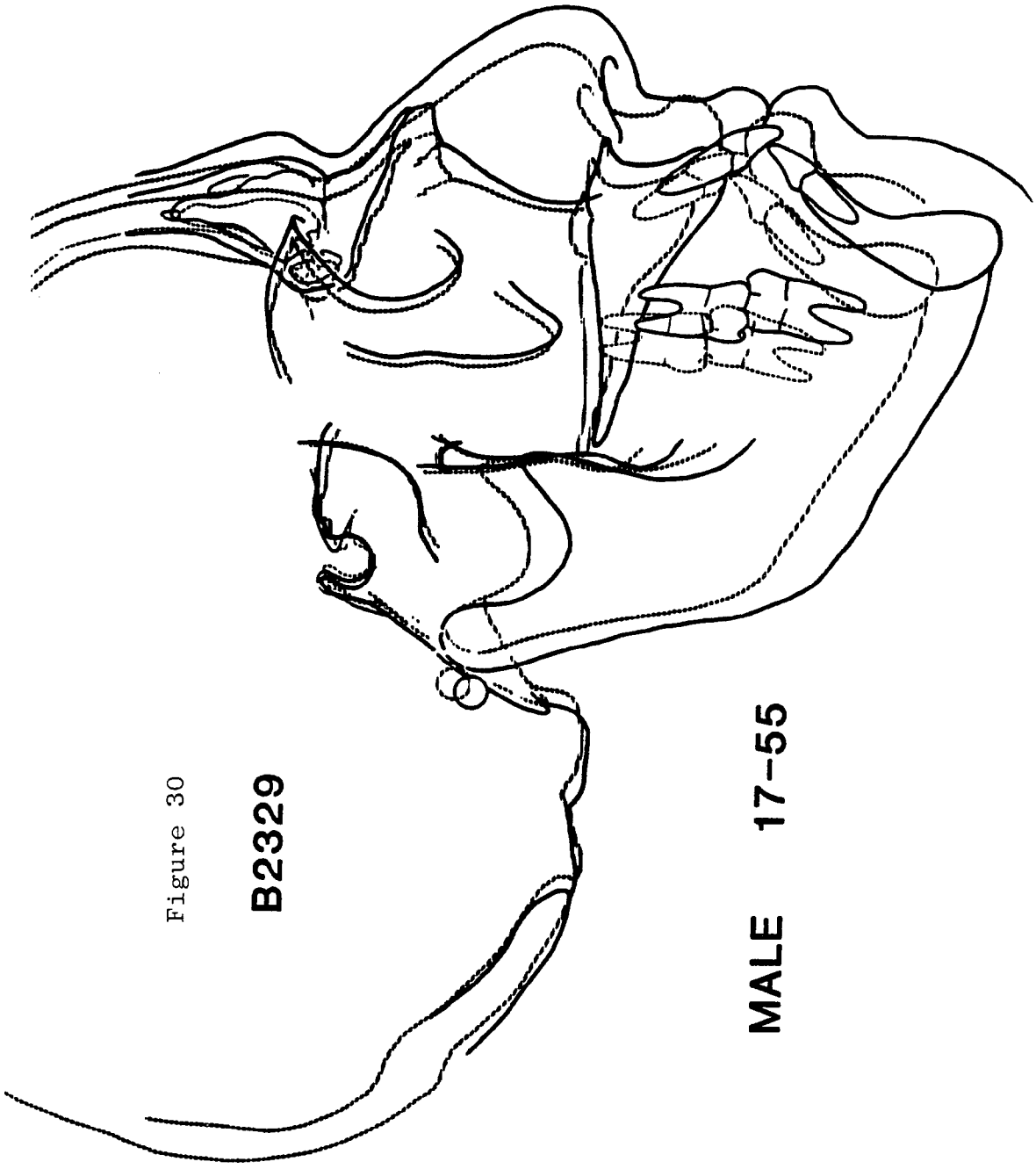


Figure 30

Figure 31. Superimposition, male age 17-20. The younger age span involving Figures 30-32. Horizontal and vertical change in a substantial amount is seen. Magnification = 5.6 and 6.0. Treated case.

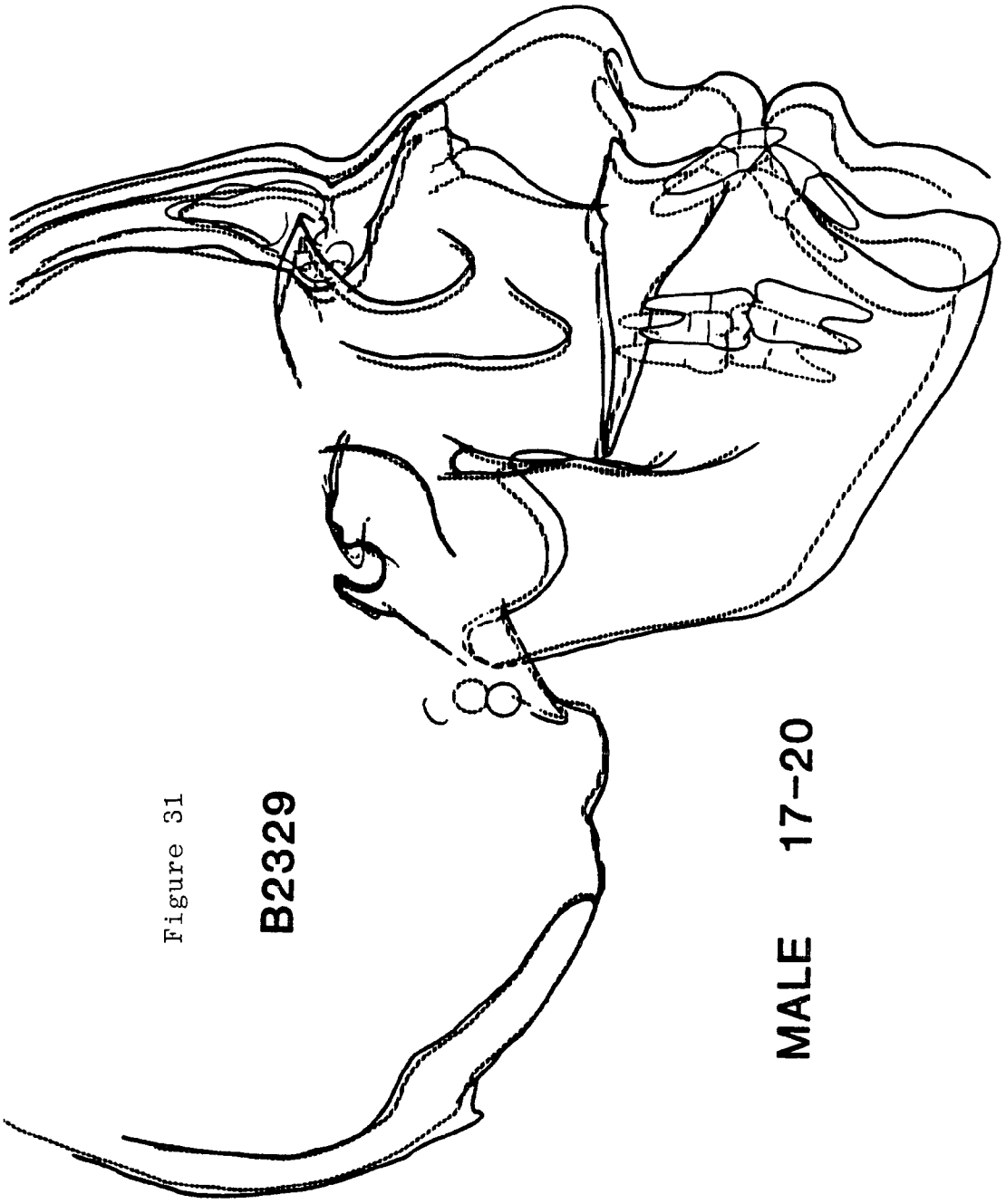


Figure 31

Figure 32. Superimposition, male age 20-55. The later age span involving the series shown in Figures 30-32. Mandibular change appears more vertical. Magnification = 6.0 and 6.4. Treated case.

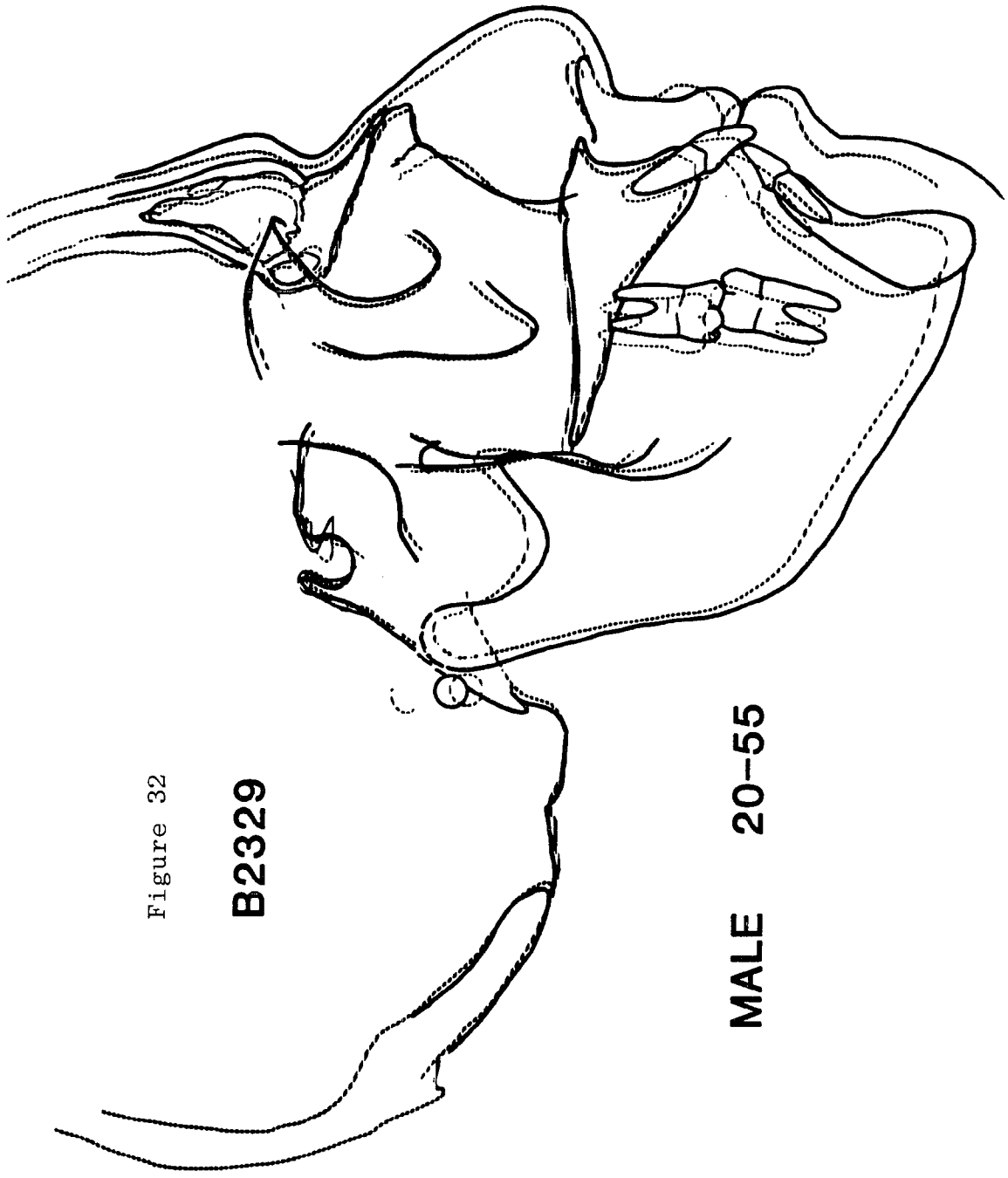


Figure 32

Figure 33. Superimposition, male age 17-59. The first in a series of three comparisons indicating overall change. Tremendous alteration is apparent. Magnification = 5.9 and 6.4.

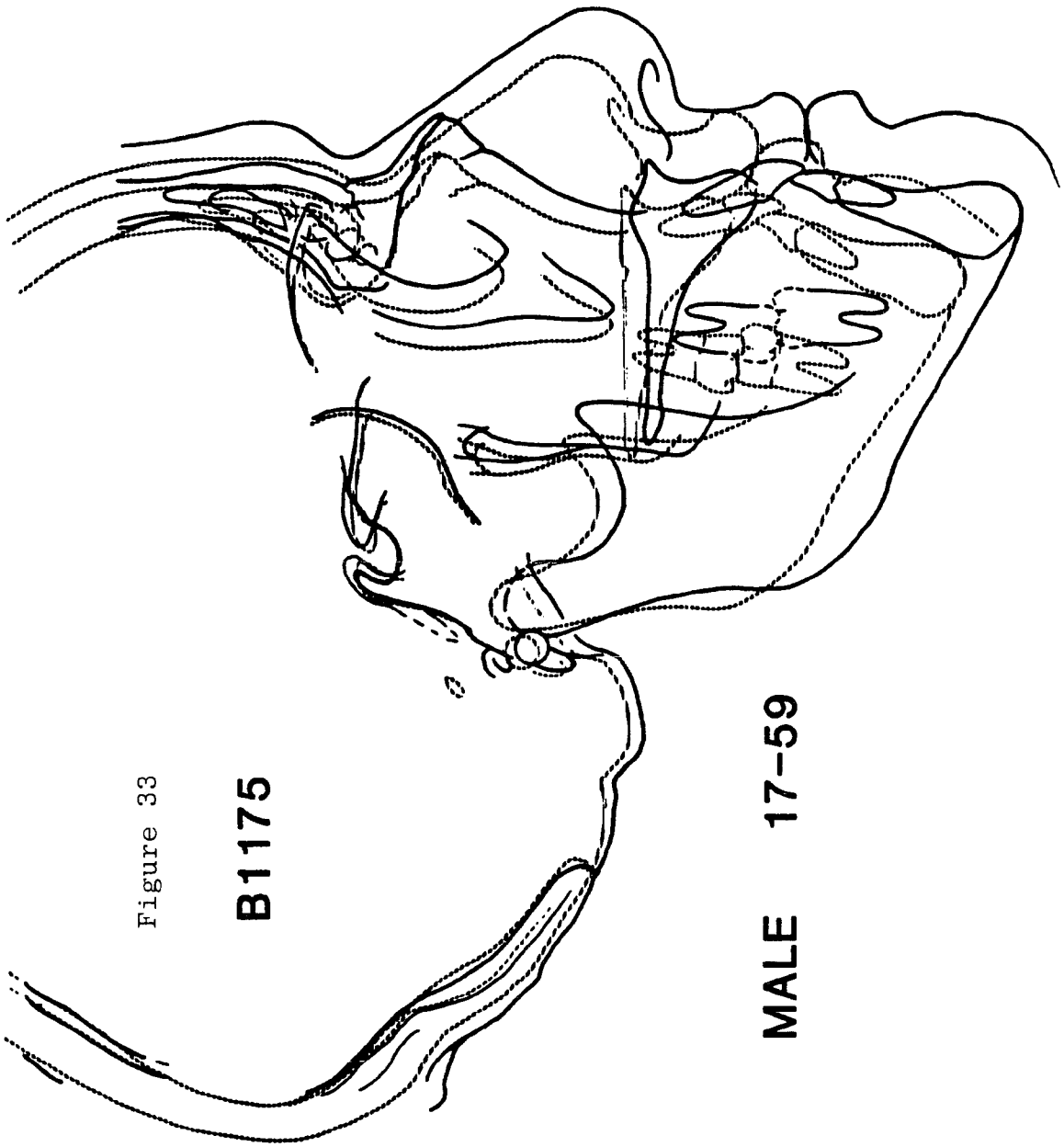


Figure 33

Figure 34. Superimposition, male age 17-25. The younger age span involving Figures 33-35. Tremendous change is apparent. Magnification = 5.9 and 6.4.

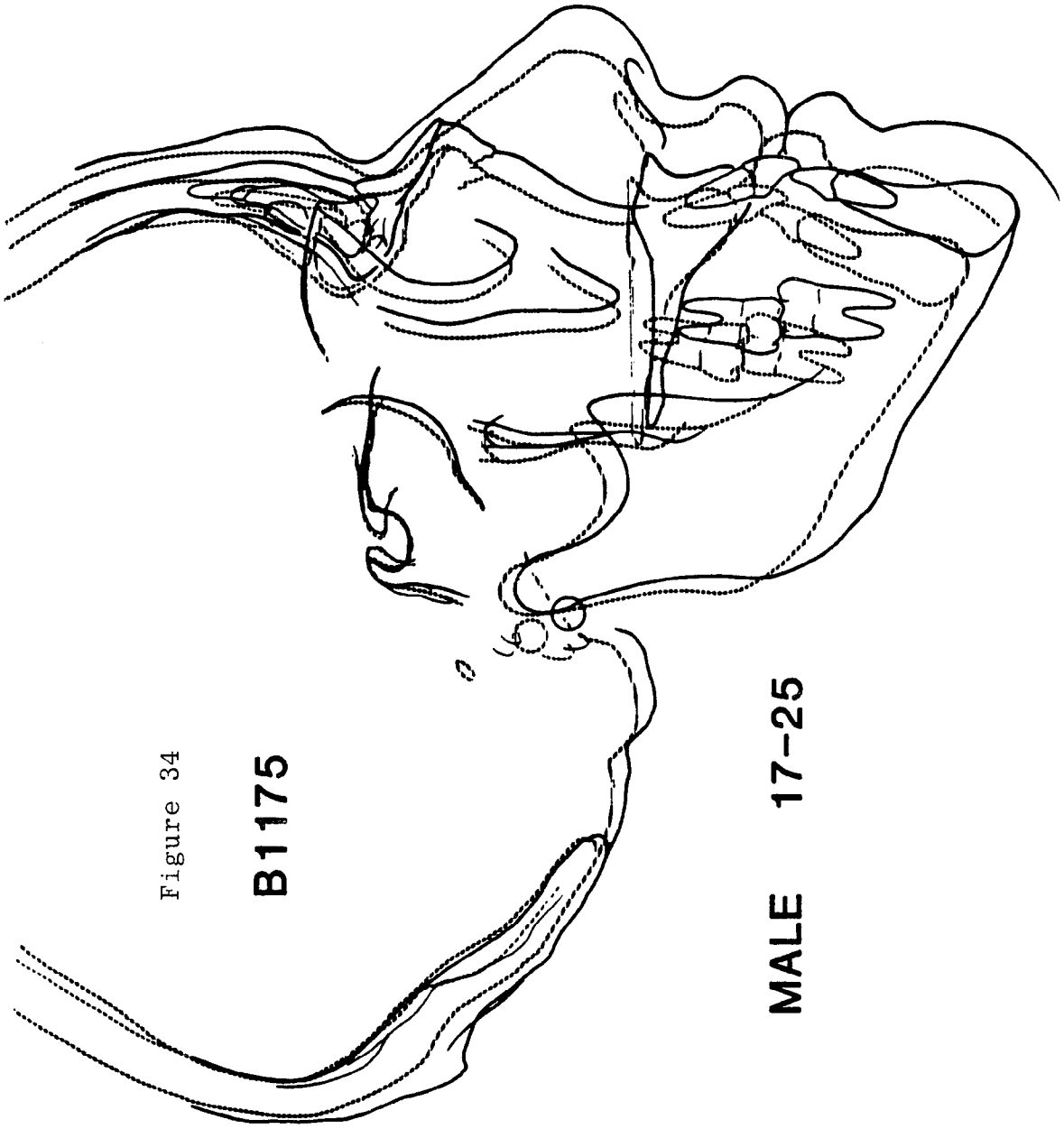


Figure 34

Figure 35. Superimposition, male age 25-59. In this later age span anterior displacement of the mandible and other subtle alterations are seen compared to Figures 33-34. Magnification = 6.4 and 6.4.

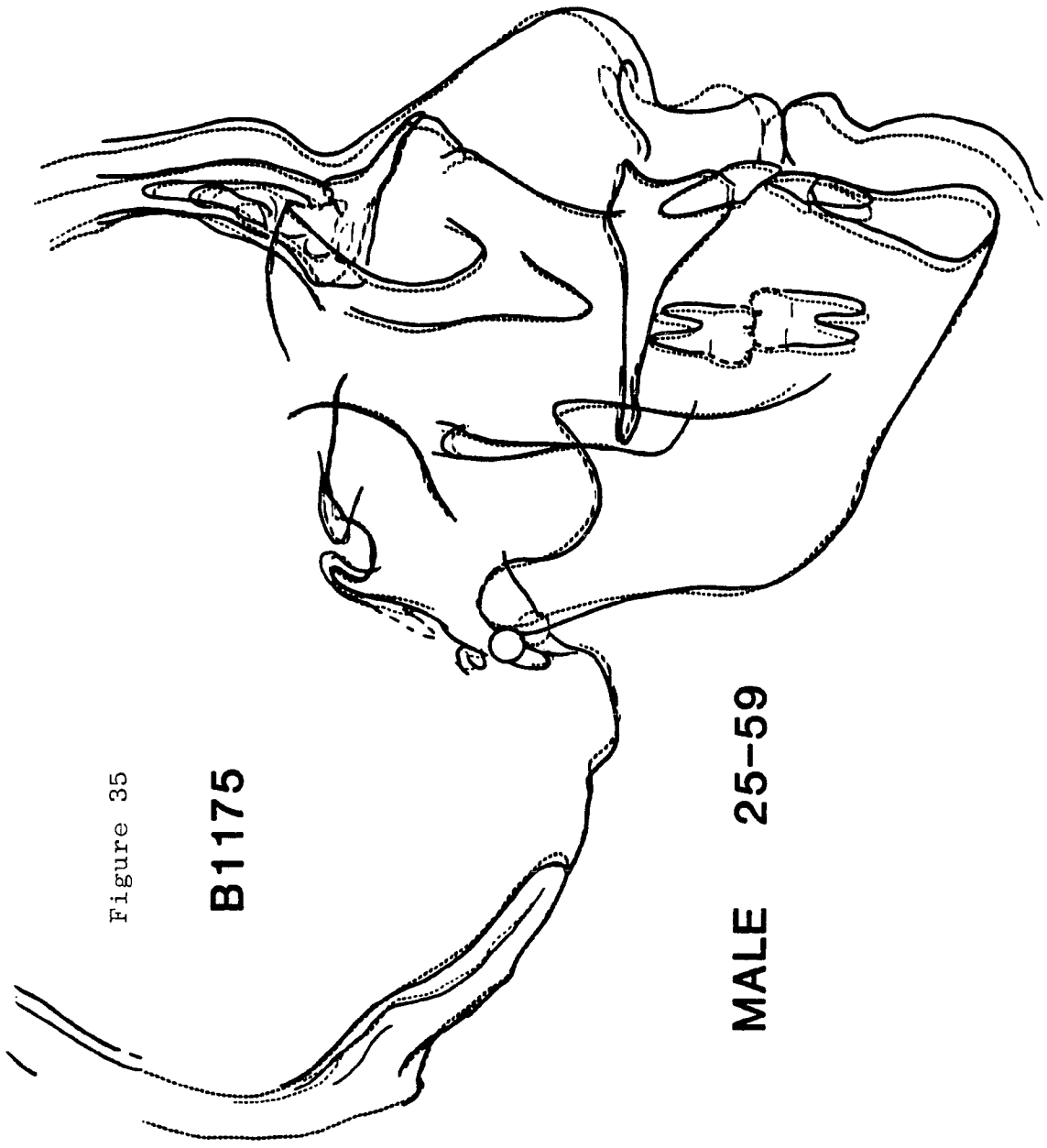


Figure 35

Figure 36. Superimposition, male age 17-58. Overall change in a series of three comparisons. Vertical alterations are seen. Magnification = 6.3 and 6.6.

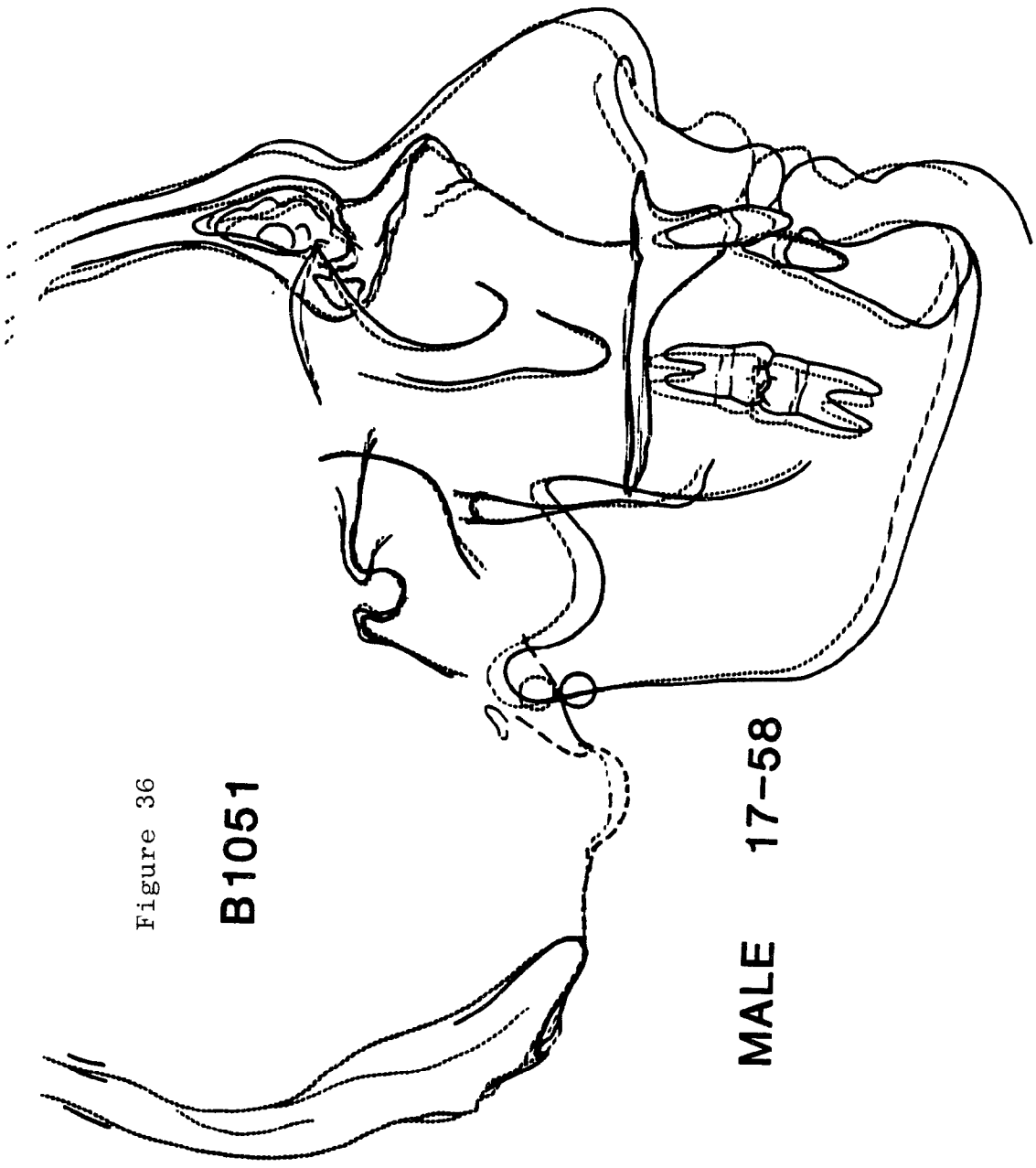


Figure 36

Figure 37. Superimposition, male age 17-26. The younger age span involving Figures 36-38. Vertical mandibular change is seen. Magnification = 6.3 and 6.7.

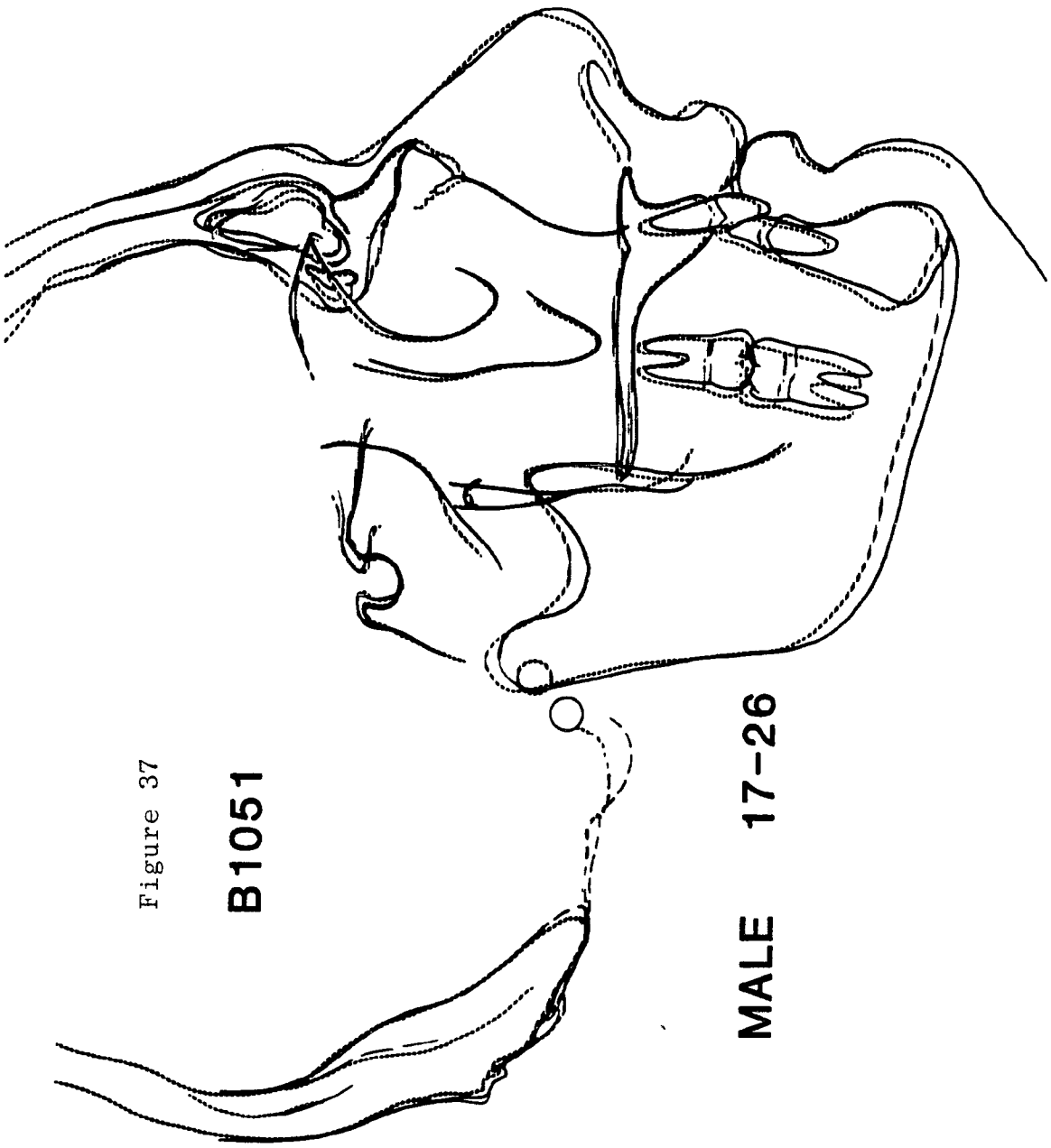


Figure 37

Figure 38. Superimposition, male age 26-58. In this later age span involving Figures 36-38, considerable alteration is noted for the nasal region. Magnification = 6.7 and 6.6.

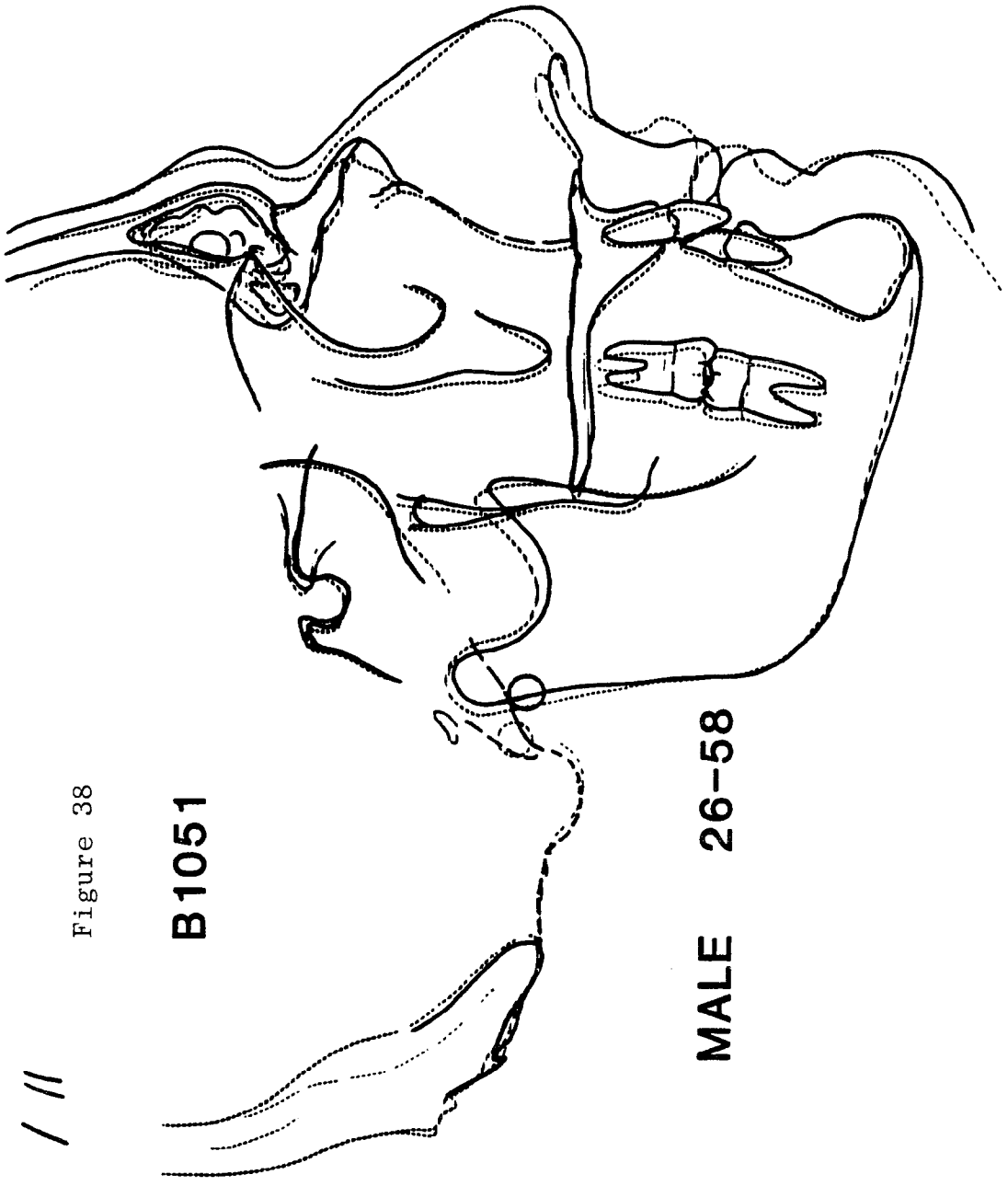


Figure 38

Figure 39. Superimposition, male age 17-59. The overall change noted in this comparison, the first of three, demonstrated considerable vertical change. Magnification = 6.3 and 6.4.

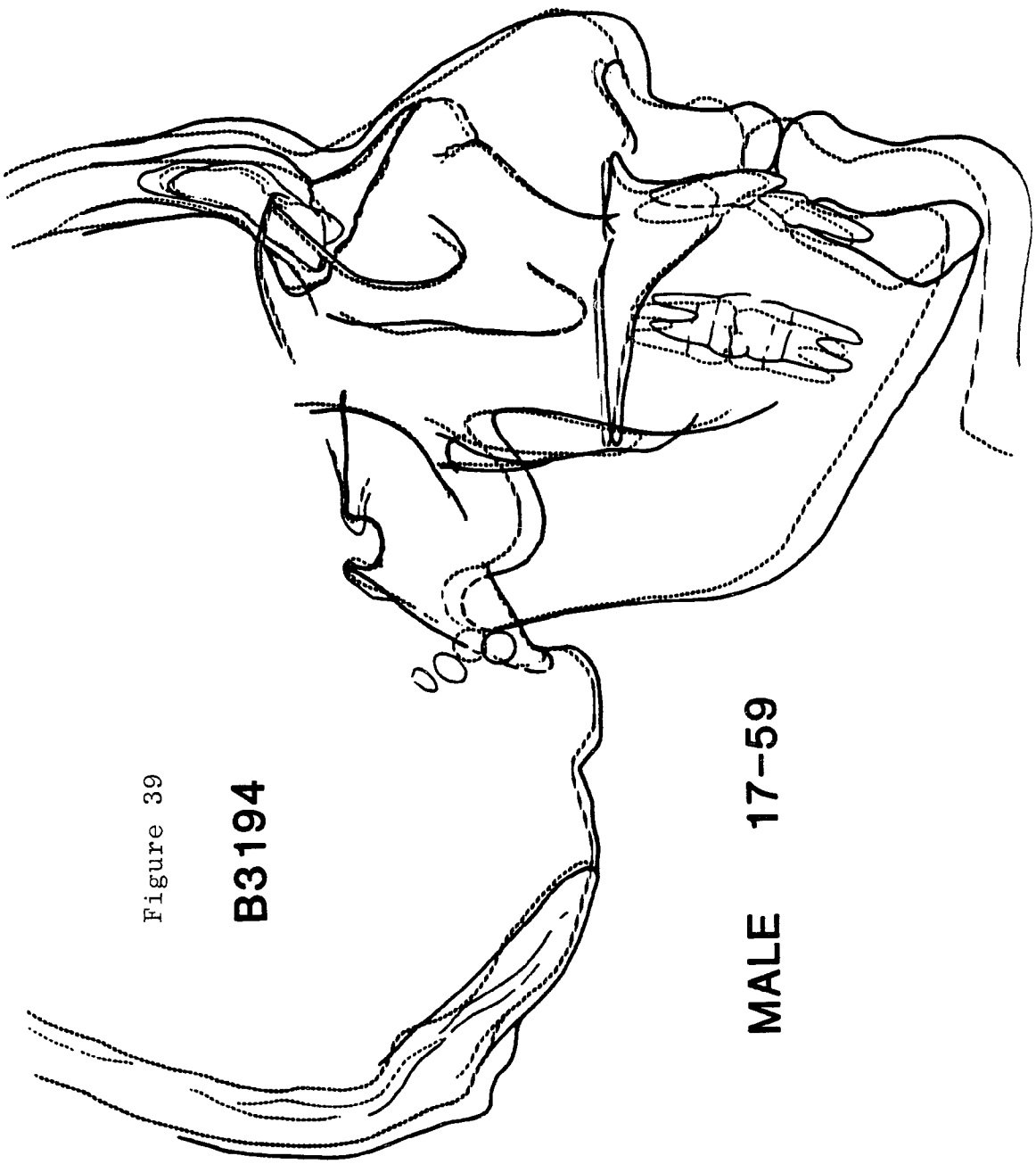


Figure 39

Figure 40. Superimposition, male age 17-27. The younger age span shown here involving Figures 39-41 shows vertical change. Magnification = 6.3 and 6.5.

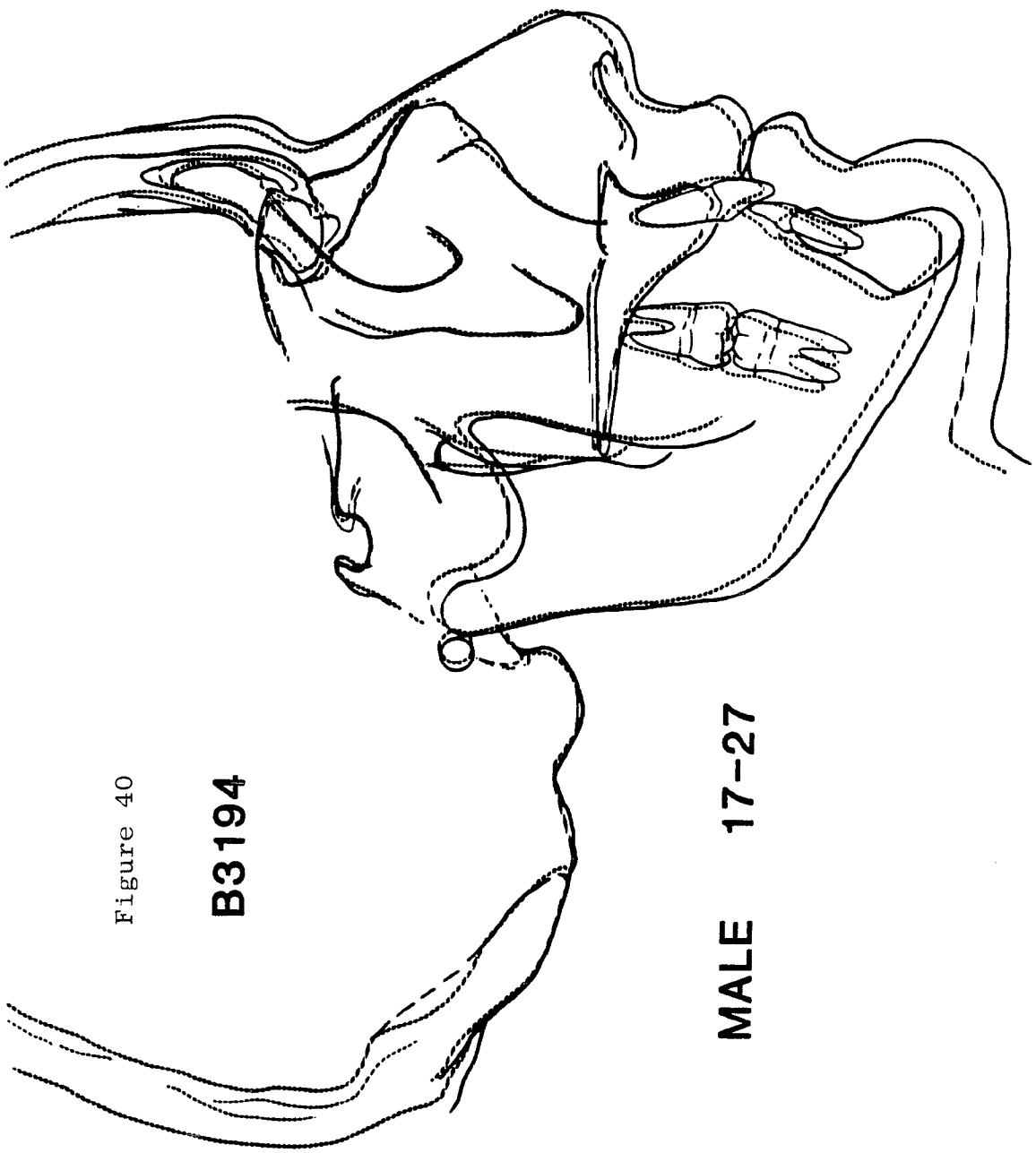


Figure 40

Figure 41. Superimposition, male age 27-59. In this later age span involving Figures 39-41, continued vertical change and midface alteration is noted. Magnification = 6.5 and 6.4.

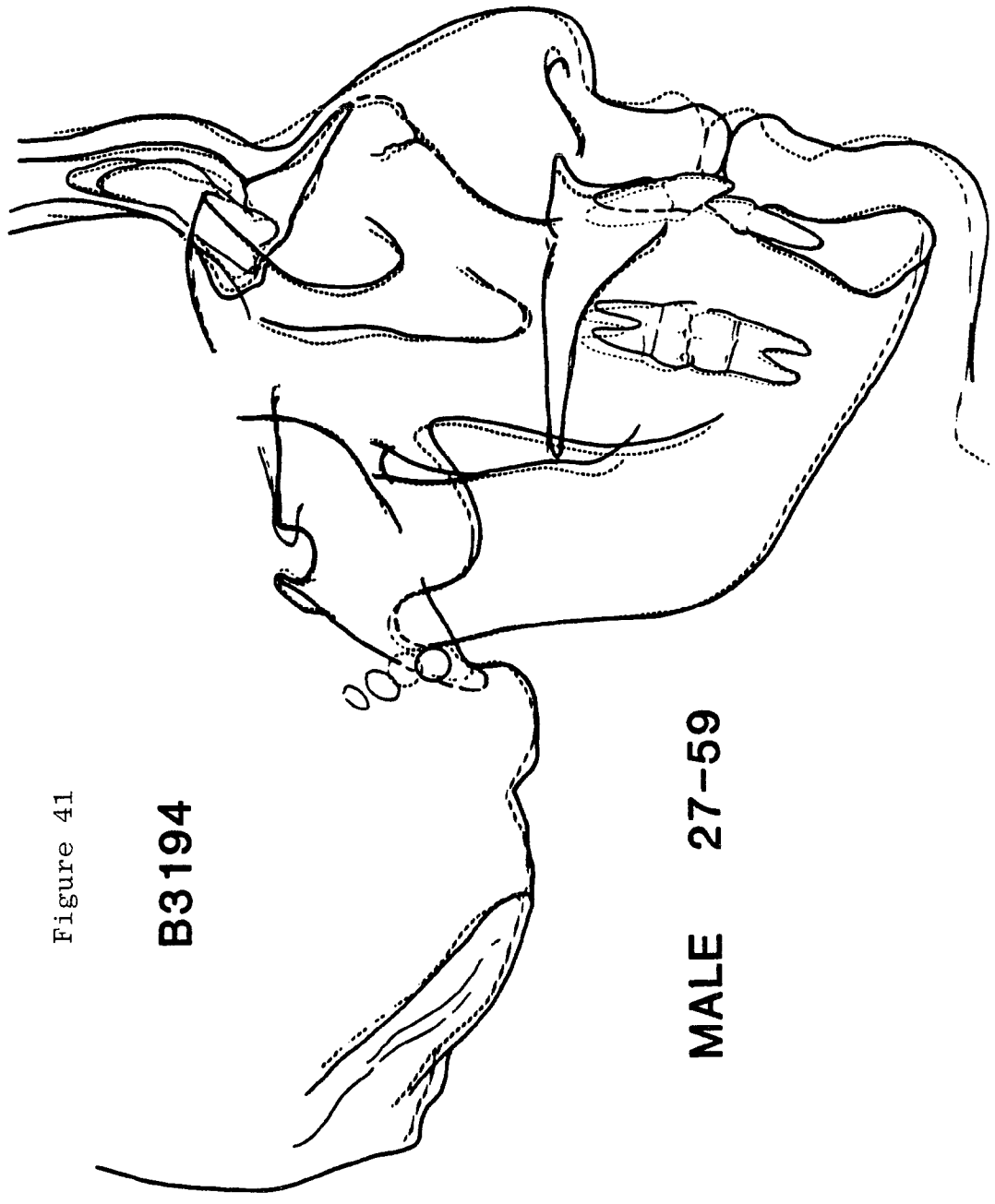


Figure 41

Figure 42. Superimposition, male age 36-77. Overall change in a series of three comparisons on an older adult. Modest changes are seen. Magnification = 5.8 and 6.6.

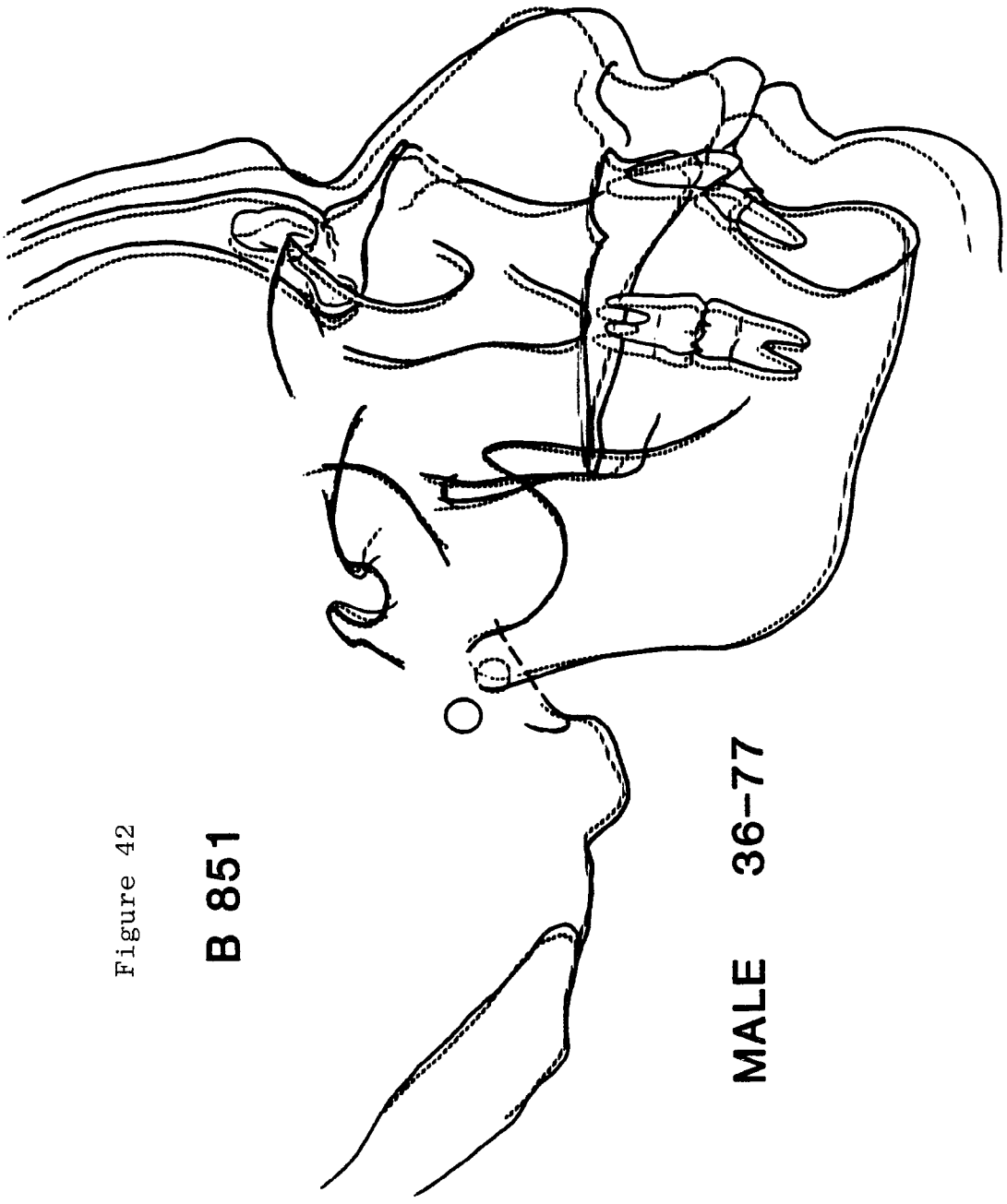


Figure 42

Figure 43. Superimposition, male age 36-45. The "younger" age span involving Figures 42-44. Vertical change is apparent as is midfacial change. Magnification = 5.8 and 5.9.

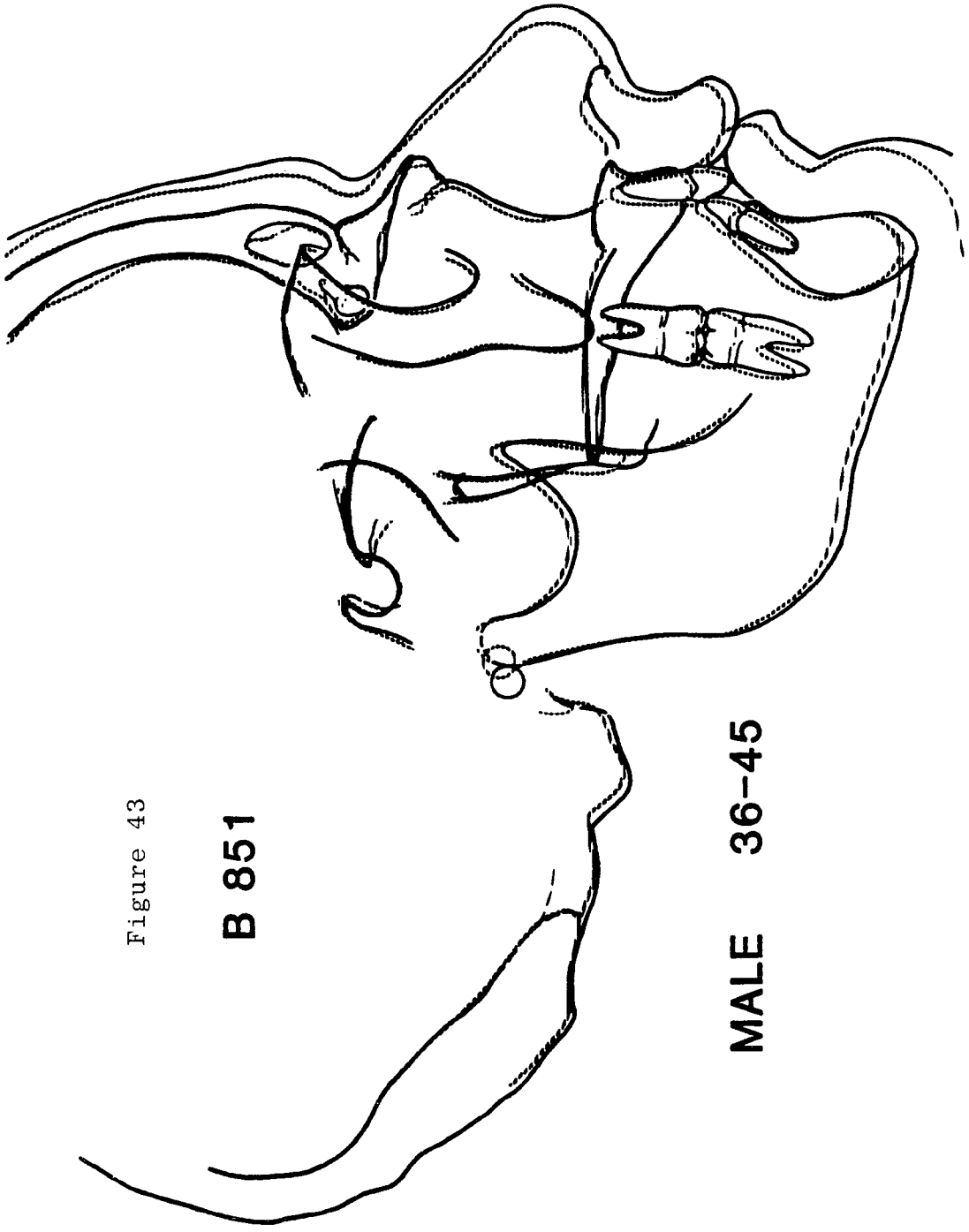


Figure 43

Figure 44. Superimposition, male age 45-77. In this "older" age span involving Figures 42-44, continued modest alteration has occurred. Dramatic soft tissue alteration is present. Magnification = 5.9 and 6.6.

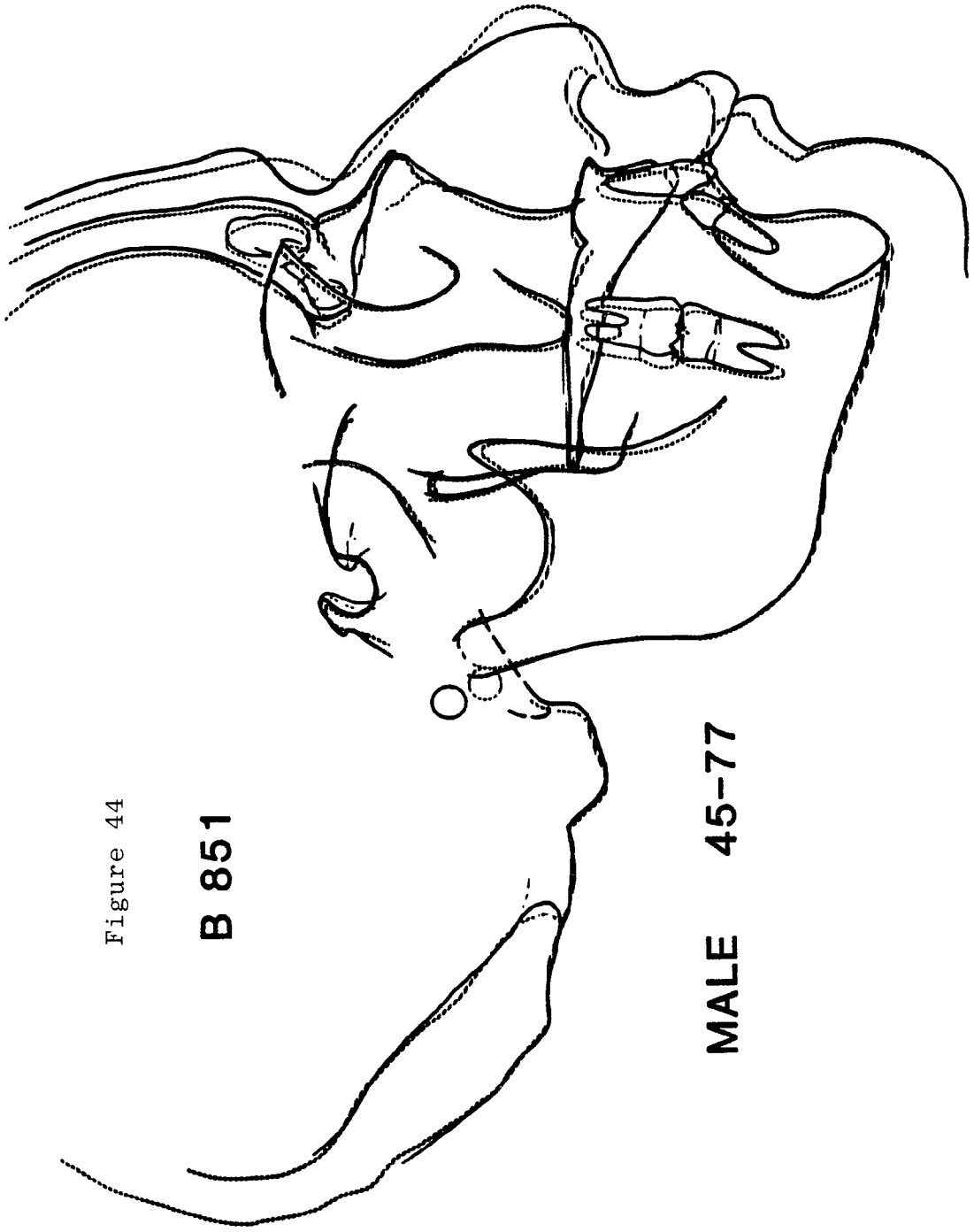


Figure 44

occurred, superimposition methods in the adult would be a moot point, however, as change was evident some manner of technique had to be decided on. Further, magnification data is presented with each illustration. Beyond that, each illustration was reduced to 74% of original to comply with format specifications. In all tracings the broken line indicates the value of the youngest tracing, and the solid line specifies the oldest age studied.

Measurements

For convenience all calculated descriptive and inferential statistics are presented in the beginning of Volume II, Appendix A. This was done to reduce the bulk of the report and for the convenience of the reader in viewing the calculations during the discussion.

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CHAPTER IV

DISCUSSION

Sample

The sample included in this study is a subsample of the Bolton Study population. Indeed, the original population was not selected randomly and thus the present study does not represent a random selection of people from Northeast Ohio. This may be beneficial in terms of applying these results to the present day, as seen below. The original population in general was characterized as of European, Sicilian or Negro ancestry, and from economically advantaged families (this was a result; not intended--see Appendix B). Further, in conjunction with and sometimes because of their participation in the Bolton-Brush studies, these people enjoyed good childhood health, had access to good health care, had access to good dental care, yearly exams screened for health problems which were immediately attended to, and had good nutrition. These people also had access to good education. For the most part in the 1930's these advantages were available only to the upper socio-economic strata. A random selection of people in the 1930's would have included some truly disadvantaged people. That the present study is biased with those "advantaged" in their youth, is important in terms of applying these results to today's children and adults, because the advantages available to a majority of the

original population are those now enjoyed by the majority of the population in general: access to health care, education, dental care, good nutrition, etc.

The present sample may be characterized as Caucasian of European ancestry, in good general health, and dental health, and people who are generally economically advantaged. A variety of vocations are represented with a tendency toward the professions (medicine, dentistry, law), management level positions or above, civic leaders and politicians.

Most of these people reside in the Cleveland area. In a surprising number of cases their parents are still alive (and in those instances many of the parents are still at the same residence). If the people did not reside in Cleveland, they tended to live in New England (perhaps due to schooling), elsewhere in Ohio, the far west coast, and Florida (possibly related to retirement). Residence distributions are shown in Figure 45.

The health of the individuals was good, with no active diseases of bone noted (Paget's, etc.). Mortality rates were generally low for the present group in regard to life expectancy. Most born in the 1930's had a life expectancy of about 62 years of age (Figure 46). The sample was generally more "alive" than expected. The largest cause of death was self-infliction, perhaps due to a sample biased toward the professions where suicide rates tend to be higher. Notably absent from morbidity and mortality records is a low rate of cardiovascular and cancer problems. However, as this

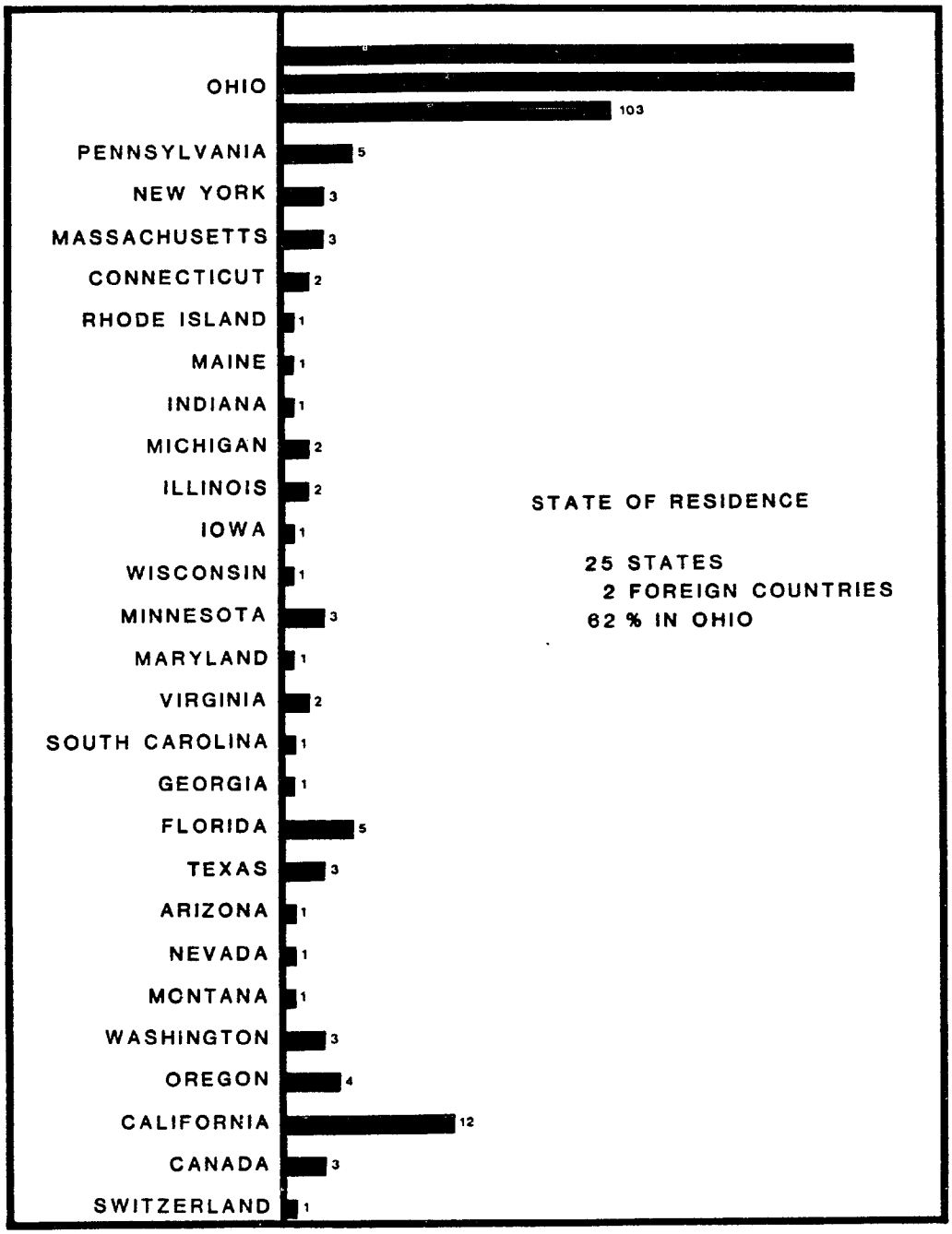


Figure 45. Residence distribution of respondents.

Figure 46. Life expectancy based on year of birth.

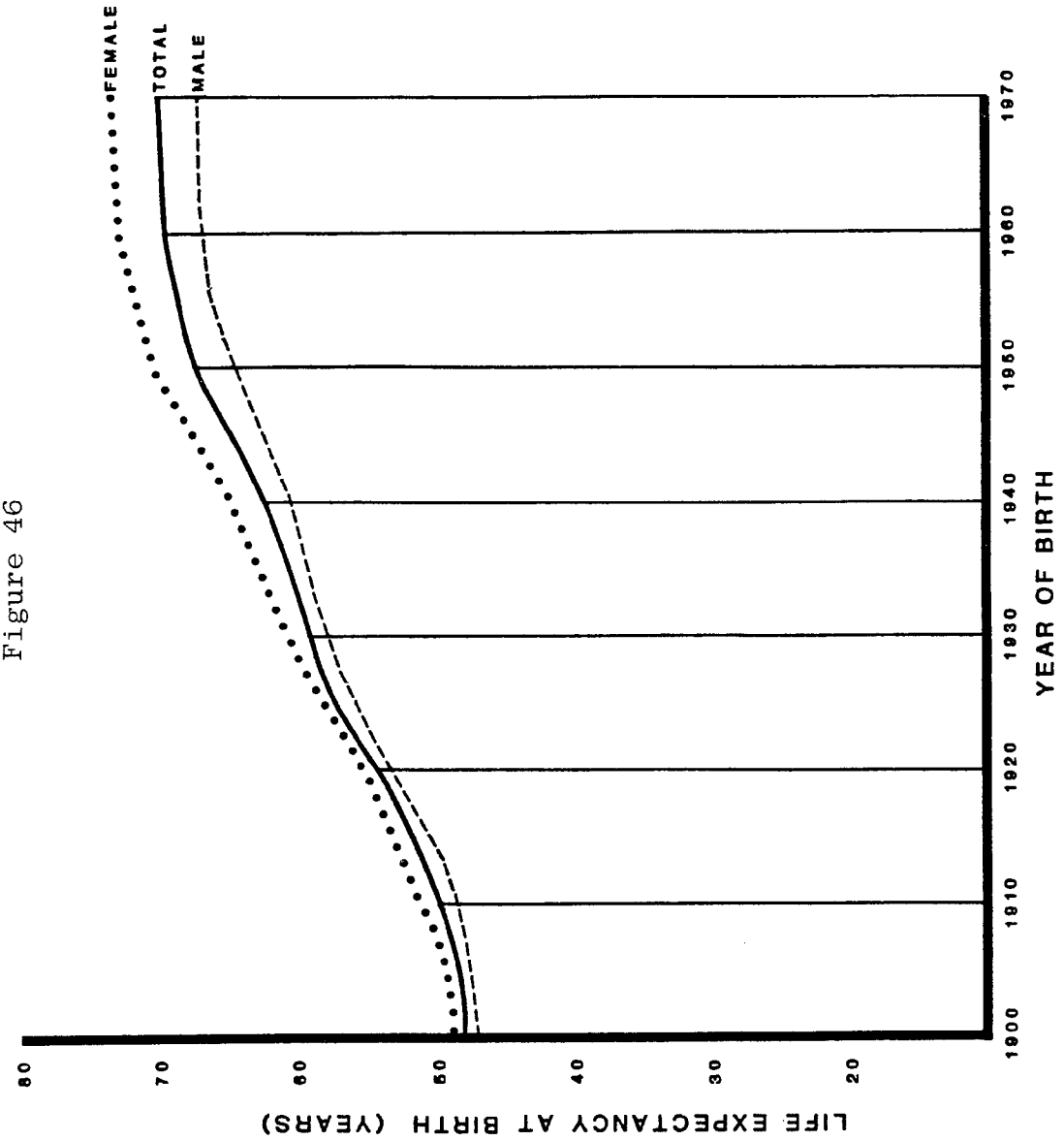

FEMALE
TOTAL
MALE
80
70
60
50
40
30
20
1900
1910
1920
1930
1940
1950
1960
1970
YEAR OF BIRTH
LIFE EXPECTANCY AT BIRTH (YEARS)

Figure 46

is a limited survey of the original population, further study is warranted in regard to the health of the population in general. Of particular interest, further, is the amount of radiation received and its effect on health. Although limited in nature, this study suspects that no health consequences were induced by the diagnostic levels of radiation that had been received.

The enthusiasm of the sample population in terms of returning the questionnaire and sitting for the examination was a pleasant surprise. Many expressed a feeling of responsibility to return, surprise at not being recalled previously, and several reported "My parents (still alive) made me come". The people apparently had good feelings about the previous study. Very few expressed radiation concerns; most preferred not to have dental impressions.

The dental health of the participants was good with only two cases involving complete dentures, two cases of a single denture, and one active case of periodontal disease (under care). The number of missing teeth was low (Figure 47) according to the National Health Survey, and in those cases prosthetic replacement was high. Most were receiving regular dental care, but most of the restorations were "old" by patient report. The gold restorations were in good condition, but the amalgams generally were not. The amount of active dental disease (dental and gingival) was inconsequential. That extractions were few is in contrast to the studies of Tallgren (1975), and Hummerfelt and Slagsvold (1973). In addition, even for those with a few missing teeth the vertical dimensions of

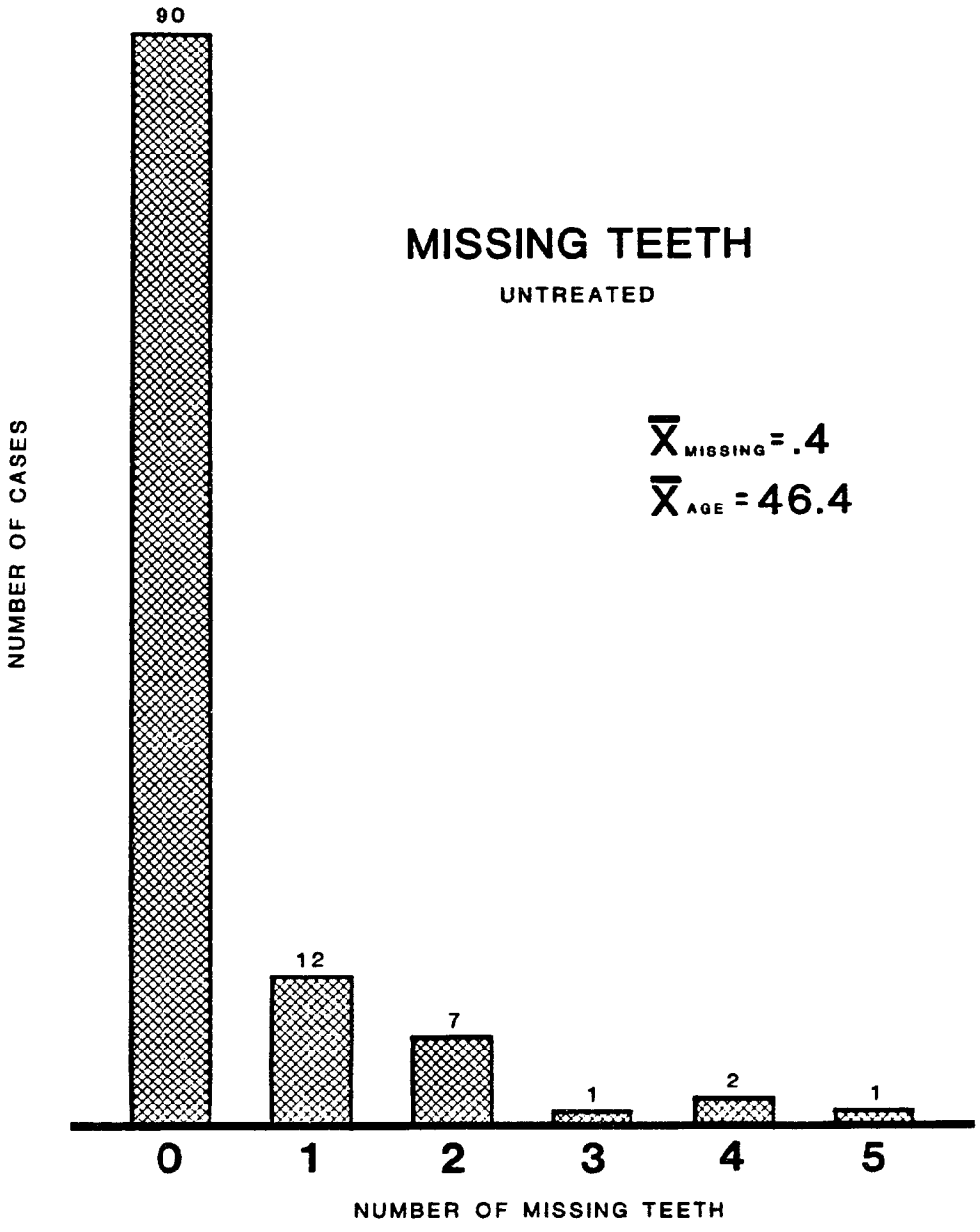


Figure 47. The number of missing teeth in the untreated sample. Excludes the third molar consideration.

the face should not be influenced (Bjork, 1947; Forsberg, 1976). Periodontal problems can cause tooth migration (Atherton and Kerr, 1963; Glickman, 1972; Goldman and Cohen, 1973) which could result in an error in assessing vertical dimensions. While this was judged not a problem in the one individual case, the case was deleted, as were all cases demonstrating a loss of more than three posterior teeth.

The decision to only include orthodontically untreated individuals for the main analysis does not imply that rather severe malocclusions are thus eliminated (as the bad ones were treated and the relatively good ones were not). In the 1930's the decision to treat or not was based largely on sex (females need orthodontics more than males), the ability to afford, and desire for comprehensive treatment (many could not and many did not wish it). Although including treated cases should present no problems for the present study (Forsberg, 1976), treated cases were not included in the main sample so as to exclude the variance induced by possible relapse in compilation of the data.

The largest problem with the sample was one of logistics: different starting ages, spans and final ages. This made statistical treatment difficult.

Technique

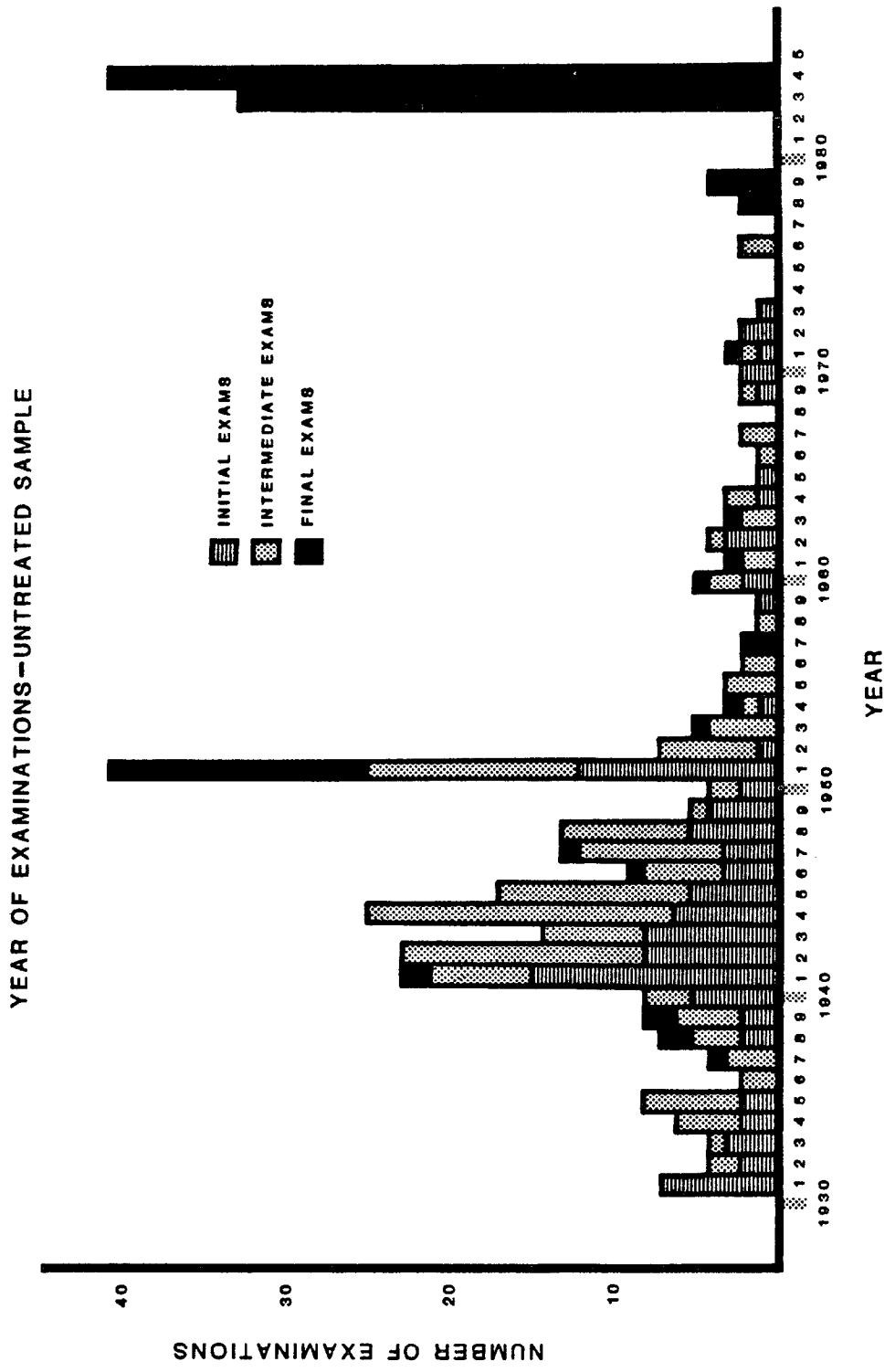
The cephalometric technique used in this study should be deemed less of a problem than in any previous study. Technically the same equipment used originally was used in the present study. Previous x-ray magnification is known and the procedures are all

standardized. Precision was an obsession in the early study as well as in the present recall study. Spurious enlargements and measurement reliabilities were tested for and deemed not generally a problem. Some of the people involved in the study were also available for consultation to insure standardization of technique. No time of measurement effect, in regard to the apparatus, was indicated. Results were consistent regardless of the year of examination (Figure 48) or the place of examination.

A lack of a headholder is somewhat critical in this regard. A three per cent error, which is easily imaginable without a headholder (determined by assessing the range of ML distances here: about 4.4 cm), could inflict serious problems where small amounts of change are likely. Determining appropriateness of correct head position on the basis of anatomic superimposition (Israel, 1973) denies the possibility of asymmetry which indeed does exist (White, 1982). When patient positioning error is confounded with imprecise magnification values (due to lack of a headholder; easily a 1-2% error), landmark location error, and measurement error, values derived are apt to be distorted, perhaps systematically. While a demonstration of differential change (Israel, 1977) does imply correctness of technique as opposed to simple technically-induced magnification, it cannot be considered proof. Distortions induced may be symmetrical or assymmetrical. What would have been considered more effective would have been demonstration of negative deltas as well as varying positive increments of change.

Figure 48. Year of examination for the untreated sample.

Figure 48


YEAR OF EXAMINATIONS-UNTREATED SAMPLE
INITIAL EXAMS
INTERMEDIATE EXAMS
FINAL EXAMS
NUMBER OF EXAMINATIONS
40
30
20
10
YEAR
1930
1940
1950
1960
1970
1980

Film series that were discarded from the present work because of obvious improper cephalometric technique (focusing rings substantially out of focus) speak also to this point. In these cases, while viewing the image for asymmetry, not much was discerned, however non-midline derived values, produced a somewhat distorted image of change different from that seen on previous correctly produced cephalograms in the series.

In essence, though the work of Israel may be based on biological effect, the interpretation is limited by technical difficulties.

Height

The possibility of variable height changes was to be expected on the basis of the literature in that such growth increases have been noted into the 30's and beyond, supposedly by continued apposition on the articular surfaces of the long bones (Pfeiffer, 1980; Buchi, 1950), changes in the vertebral column (Albrook, 1956; Erikson, 1976, 1978; Israel, 1973), skull growth (Israel, 1973), and a gain in fat on the scalp and plantar surfaces of the feet (Garn, 1981). Likewise decreases could occur on the basis of compression of the intervertebral disks. Indeed, variable height increases and decreases were recorded from early adulthood to later adulthood.

In examining the height change in all individuals where such data were present, two samples were constructed: one for whom the initial age was 17-18 and another whose initial age was

older (approximately 20 years in females and 23 for males). Females showed little change in height, with only a tendency for early gain and later loss. For the males, at younger initial ages, it was seen that significant height increases were occurring, but beyond 23 years of age the probability for height increases had diminished although a tendency remained. As individuals, however, it was clear that significant increases and decreases could occur to substantially affect height beyond 17 years of age (Figures 49-50).

A positive increase in the height of the vertebra (reported in later sections) would lead one to surmise that the statural consequence of aging is a net effect mainly involving vertebral elongation and disk compression due to such factors as weight changes and physical activity. A cursory examination of the participants anecdotally tend to bear this out, as runners (2 were marathon runners) were considerably shorter at recall while those leading a sedentary life were slightly taller. Part of the net effect may also involve the effects of physical activity and occupation on the long bones. Prives (1960) and Buskirk et al. (1956) found long bones to become longer in regard to increased physical work. Skull growth and fat deposits also obviously play a role in changes in stature.

Weight

For all individuals in whom weight changes were known a rather substantial consistent weight gain was recorded from young adulthood to middle age. The exceptions to the consistent gain of

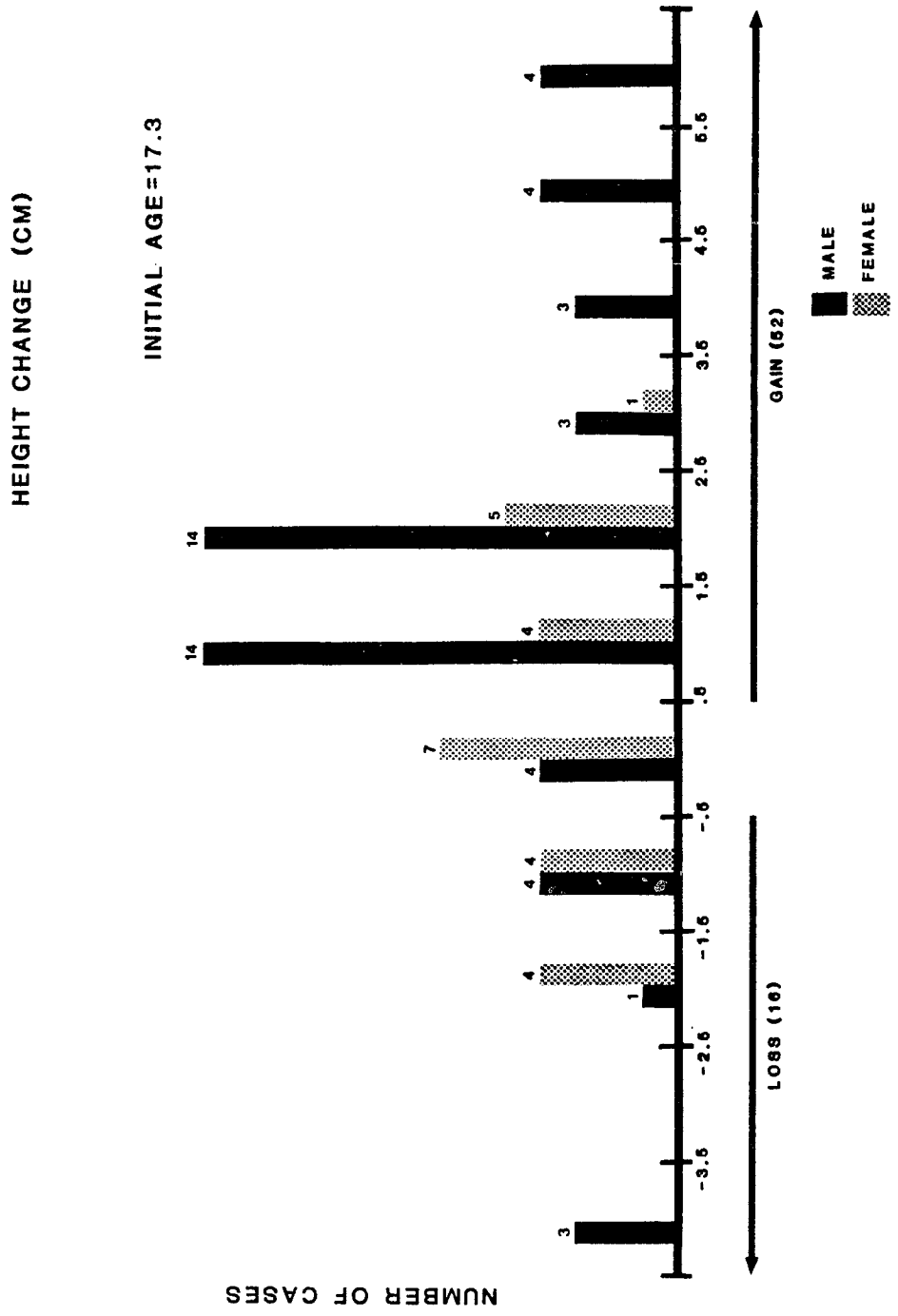


Figure 49. Height change considering spans formed with young initial ages.

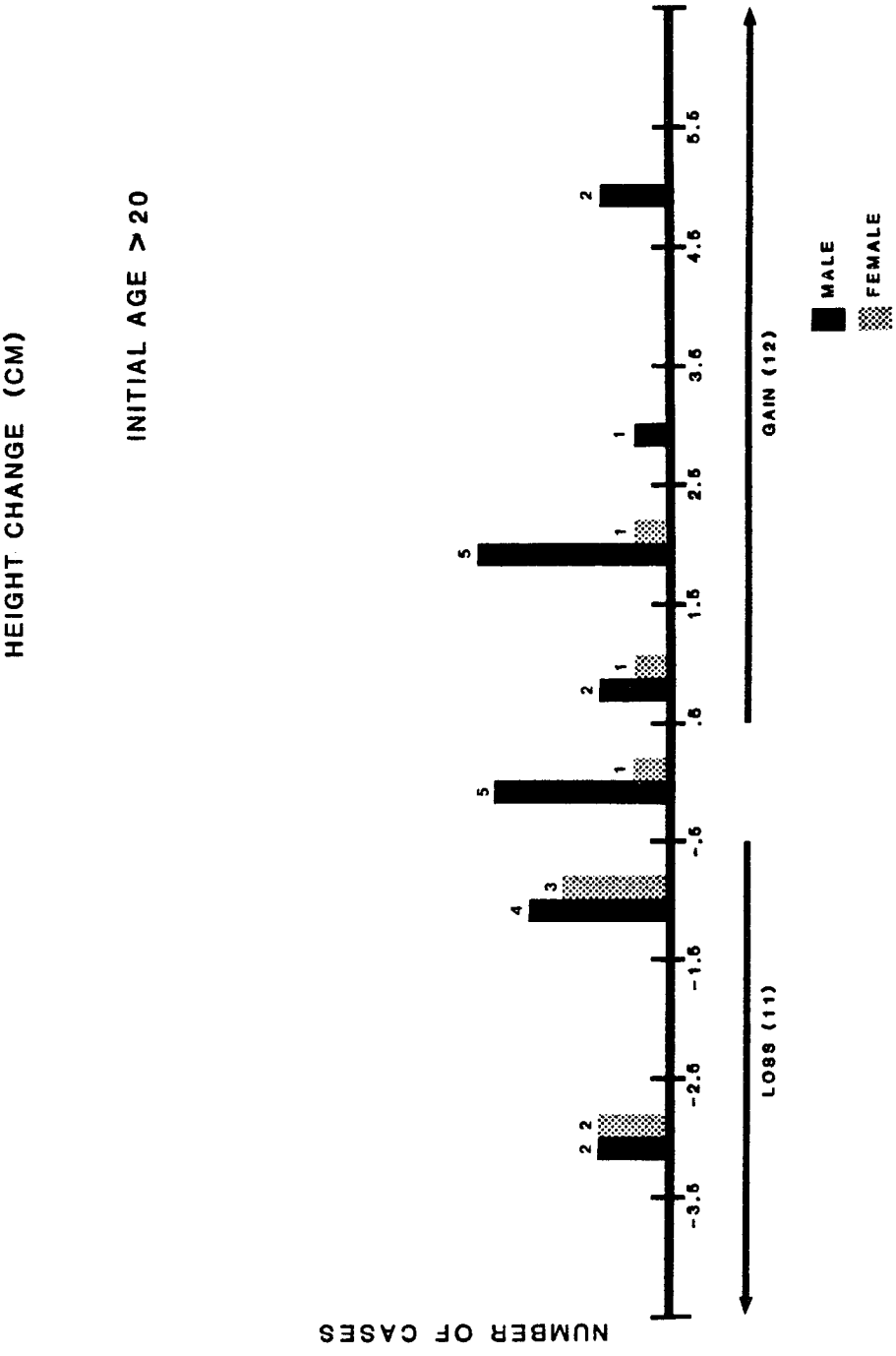


Figure 50. Height change considering spans with older initial ages.

weight involved mainly females where the effects of diet control are likely involved. A very few individuals would have been considered obese (Figure 51).

In the present study an increase in weight through time is consistent with the findings of Susanne (1978) and may have a bearing on height and on vertebral morphology changes. It is fairly easy to assume that an increased load on the vertebral column due to an uneven distribution of weight, along with a decrease in muscle tonicity, might induce a change in the cephalic-caudal dimensions of the vertebrae in order to structurally compensate for the weight and a "spreading" intervertebral disk.

Angle Classification

The Angle classification of the untreated sample is presented in Figure 52. A range of malocclusions was present, although the vast majority are Class I. It should be noted that Class II classification includes Class II subdivision cases, Class II division 1 and division 2 cases.

T.M.J. Examinations

In this present sample, a surprising finding involved the general lack of significant T.M.J. symptoms. In only two cases (untreated) were active symptoms involved (reciprocal clicks with myofacial pain). A few people related some past distress which apparently had spontaneously disappeared. In another case (serious dental sample--upper denture, lower partial), the patient was

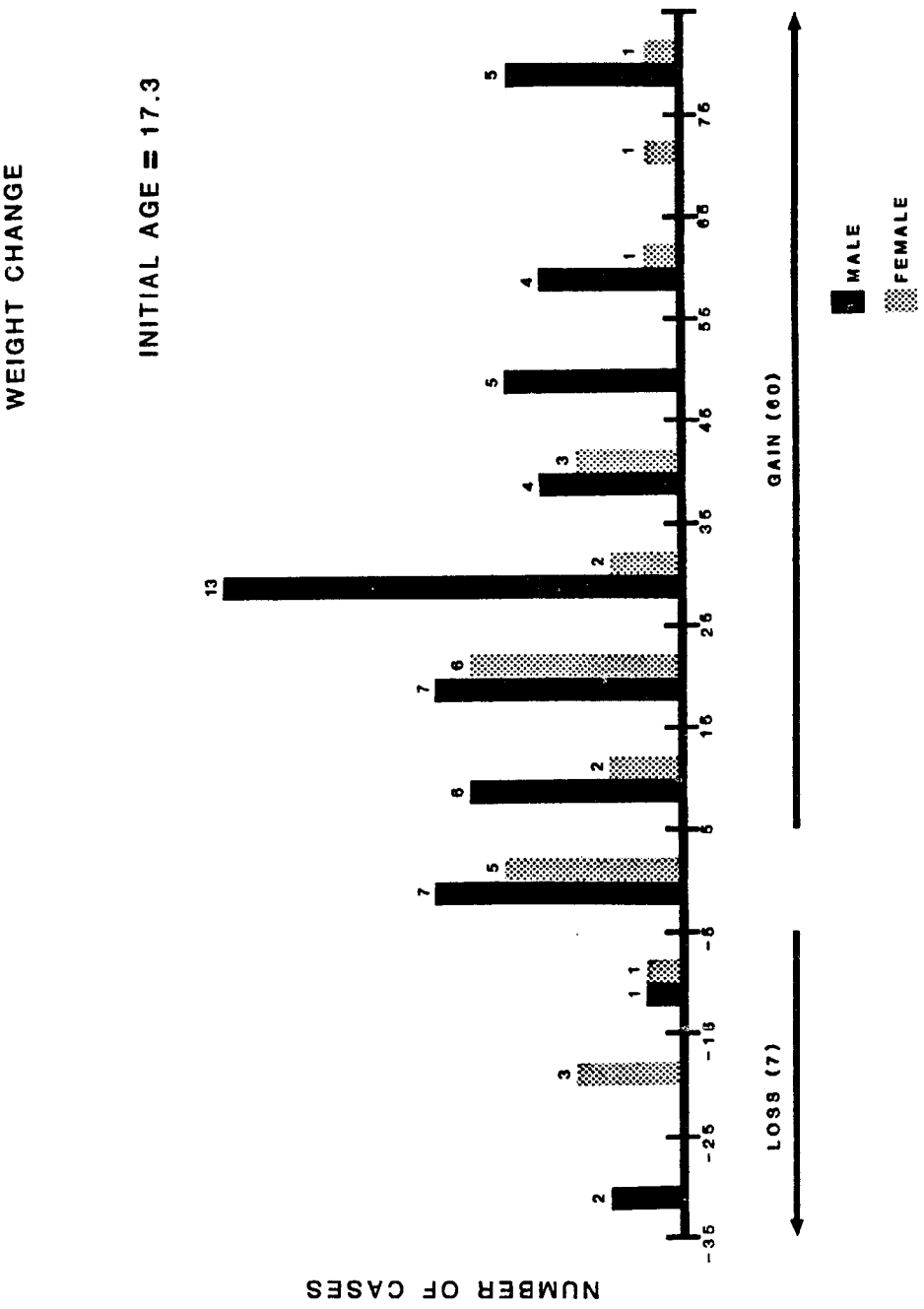


Figure 51. Weight change for all individuals where data was available.

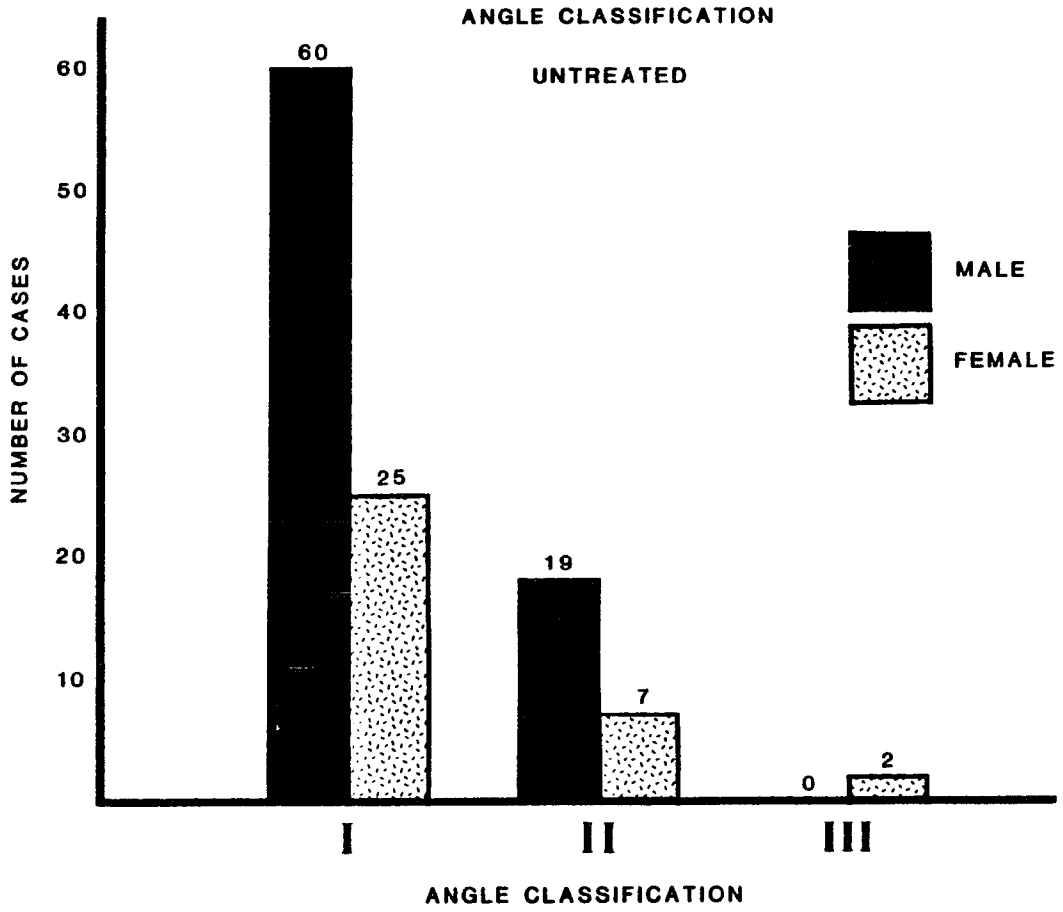


Figure 52. Angle classification for the untreated sample.

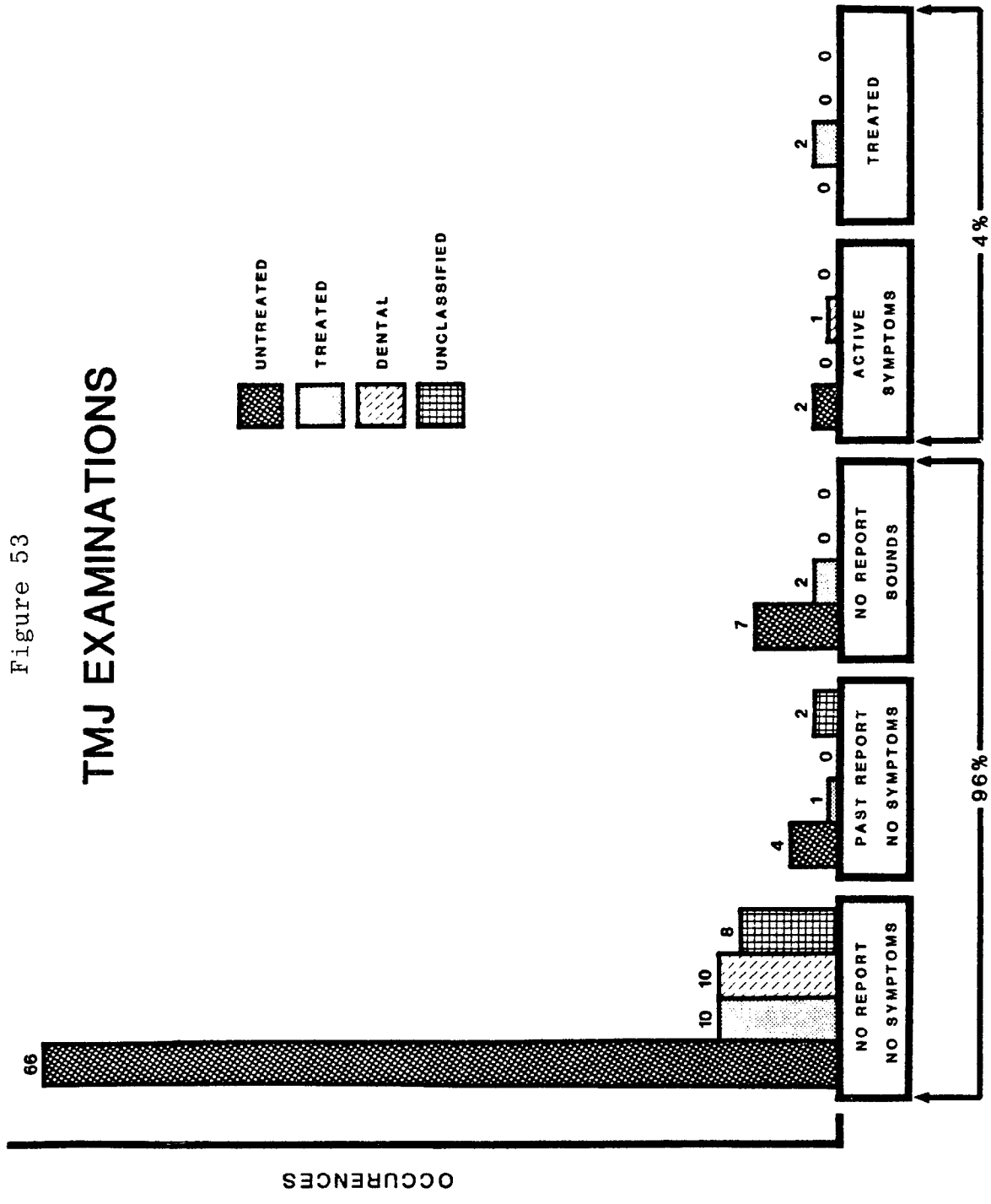
obviously suffering from T.M.J. symptoms (crepitus, myofacial pain, limited opening), and was obviously in need of a new prosthesis (patient in Class III occlusion). A few other participants exhibited some clicking ranging from very minor to extremely loud, but these conditions were in no way debilitating (Figure 53).

In all, only 4% of the sample showed any evidence of T.M.J. symptoms. None of the people exhibited "text book normal" occlusions and interferences were consistently noted. In addition malocclusions (easily justified as needing treatment) were present in nearly all cases. Some were very severe involving skeletal and dental factors which would be considered undesireable from an occlusion standpoint. Few could remember any past "occlusal adjustment". In the cases where symptoms were present versus cases which had no symptoms, it was impossible to understand how the occlusions were contributory or non-contributory to TMJ symptoms, except in the one case where no stable natural or artificial occlusion existed (treated sample).

It may be thus appreciated that apparently the condyle has a remarkable ability to adapt to the most deleterious occlusion if given time. Also, this group as young adults would have been treated with various occlusal treatments, as judged by their young adult models, in the name of preventing future problems, it is interesting to note they did not have the treatment and they did not get the problems. This would speak for less done in the name

Figure 53. TMJ assessment. 96% of the sample presented no debilitating TMJ symptoms.

Figure 53


TMJ EXAMINATIONS
UNTREATED
TREATED
DENTAL
UNCLASSIFIED
OCCURENCES
66
10
10
8
NO REPORT
NO SYMPTOMS
4
1
0
2
PAST REPORT
NO SYMPTOMS
96%
7
2
0
0
NO REPORT
SOUNDS
2
0
1
0
ACTIVE
SYMPTOMS
4%
2
0
0
0
TREATED

of prophylactic prevention on the basis of prediction of problems, and more for treating symptoms only as they exist.

The lack of T.M.J. problems in the untreated sample in no way implies that treated cases are those which develop T.M.J. symptoms. This was not studied and should not be inferred. On the contrary, of the 13 treated cases examined, two had T.M.J. symptoms (successfully treated).

Third Molar Status

Apparently the standard of treatment regarding third molars in the 30's and 40's was much different than the standard today. Often, impacted third molars were variably extracted, left impacted, unilaterally extracted leaving two impacted, etc. Since there are commercially available schemes (Rocky Mountain Data Systems) for determinating whether third molars should be enucleated very early (preadolescence) which are most likely based on predicting the space available for third molars at say age 18, it becomes increasingly important to understand what adult craniofacial changes may occur. If the adult continues to "grow" as in adolescence, space might become available for eruption of the third molars at ages beyond 18. With continued deposition on the posterior aspects of the maxilla and resorption of the anterior border of the ramus, tooth eruption might proceed. In some cases in the present study, this appears to have been the actual situation. Also, anecdotal reports by the participants relate third molar eruptions in the thirties and forties.

However, it was also found that impacted third molars can become "more" impacted or erupted out of bone totally (but still submucosal). In view of these conflicting end results and considering continued adult change, the question of third molar impactions and eruptions during adulthood will be scrutinized (at a later time) more intensely to investigate if determinents of the conditions for favorable eruption can be discerned. Suffice it to say third molar prediction schemes are by ignorance presently incomplete and should be viewed as a "guess" for a cost.

Gross Anatomic Changes

A few gross anatomic changes were evident. Continued enlargement of the paranasal sinuses occurred with age. The frontal sinus was obviously enlarged and observed to be located more anteriorly; remodeling in conjunction with the facial changes. The maxillary sinus was clearly enlarged and pneumatization near Basion also occurred. Suture obliterations were common. Further, sphenoid bridging and pituitary calcification occurred as did calcification of the falx cerebri. None of these conditions were seen generally except for the sinus enlargements.

Frontal Cephalogram

Although not assessed quantitatively in this study, obvious changes occurred with age. These changes include frontal sinus enlargement, obliteration of the radiographic image of the sutures,

a thinning of the parietal bones, and occasional calcification of the falx cerebri. This also speaks of adult change as both an internal and external osseous alteration (Figure 54).

Faces

In this group, faces were fairly characteristic for the conventional descriptions of the aging effects. Various descriptions given by Baselevich (1958), Wissler (1927), Hooten and Dupertuis (1951), Stoudt et al. (1970), Damon et al. (1972), Parot (1961), and Howells (1970) were noted as applying in varying degrees to the present study. Faces were also compared to previous photographs (which existed in small numbers). The faces appeared somewhat larger with increased size especially noted for the nose and ears. Size increases were apparent for ear length, ear breadth, and thickening of the lobe. The nose appeared more broad, longer and with a more downturned tip. In older participants the eyes appeared sunken with drooping bags and deep supraorbital creases. The eyelids occasionally demonstrated arcus senilis (lipid deposition) and reduced thickness.

The eyebrows had become thinned with grey hair predominating, and the hair had lost its sheen and velvet character to become more coarse-appearing. The hair on the head was diminished in density, and what existed was at the least patched in grey.

The skin was notably more wrinkled. Irregular horizontal lines were seen on the forehead; radiating "crows feet" at the

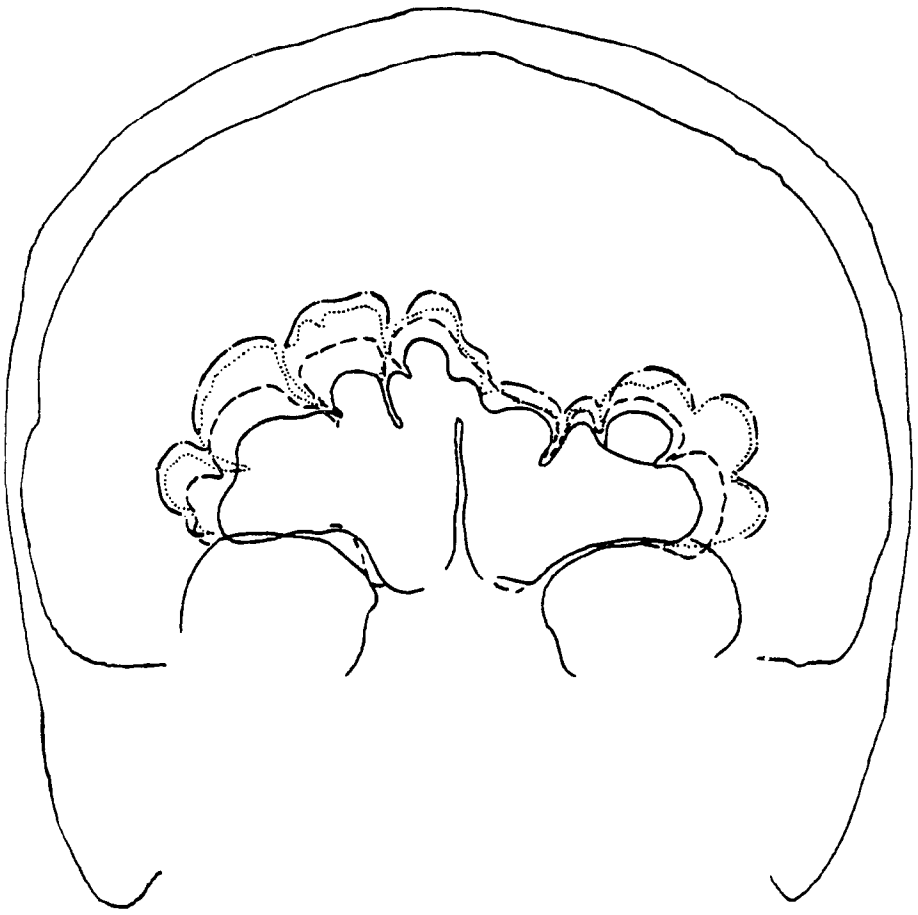


Figure 54. Enlargement of the frontal sinus on a selected case as seen on the posterior-anterior cephalogram. Solid line = 17 years; dashed line = 21 years; dotted line = 36 years; dash-dot line = 52 years.

lateral corners of the eyes; vertical creases had developed between the eyebrows; and deepening nasolabial grooves were seen extending from the sides of the nose past the corners of the mouth down toward the chin. The lips showed an occasional vertical wrinkle as did the sides of the face as "jowls" developed on either side of the jaws. In the neck both circumferential and longitudinal wrinkling occurred. As age proceeded, wrinkles among the oldest individuals seemed to coalesce to give the skin the appearance of a patchwork of crumpled paper. However, in spite of the changes of aging so visibly seen, a clarity of thought was also apparent (Figures 55-56).

Quantification of Adult Growth

The numbers in parenthesis following statements refer to calculation numbers as shown in Appendix A. Unless otherwise noted all measures are based on the "untreated sample".

With the naturally occurring biological changes apparently occurring throughout the body, and with the ability of the unnaturally occurring biological change mechanisms intact (orthodontics, acromegaly), it is perhaps illogical to suggest that the craniofacial complex with its elaborate system for sensation of environmental change would be in a complete state of dormancy and non-adaptation throughout the post-adolescent ages. It is thus expected that skull dimensions would be altered in some way during post-adolescent aging in spite of thoughts to the contrary and in spite of the biases present in the literature which indicate little or no relevent change.

Figure 55A. Female faces. In this frontal view series ages from left to right are 6 years, 11 years, 14 years, 60 years.

Figure 55A

Figure 55B. Female faces. From top left clockwise includes ages 60, 14, 11, and 6 years.

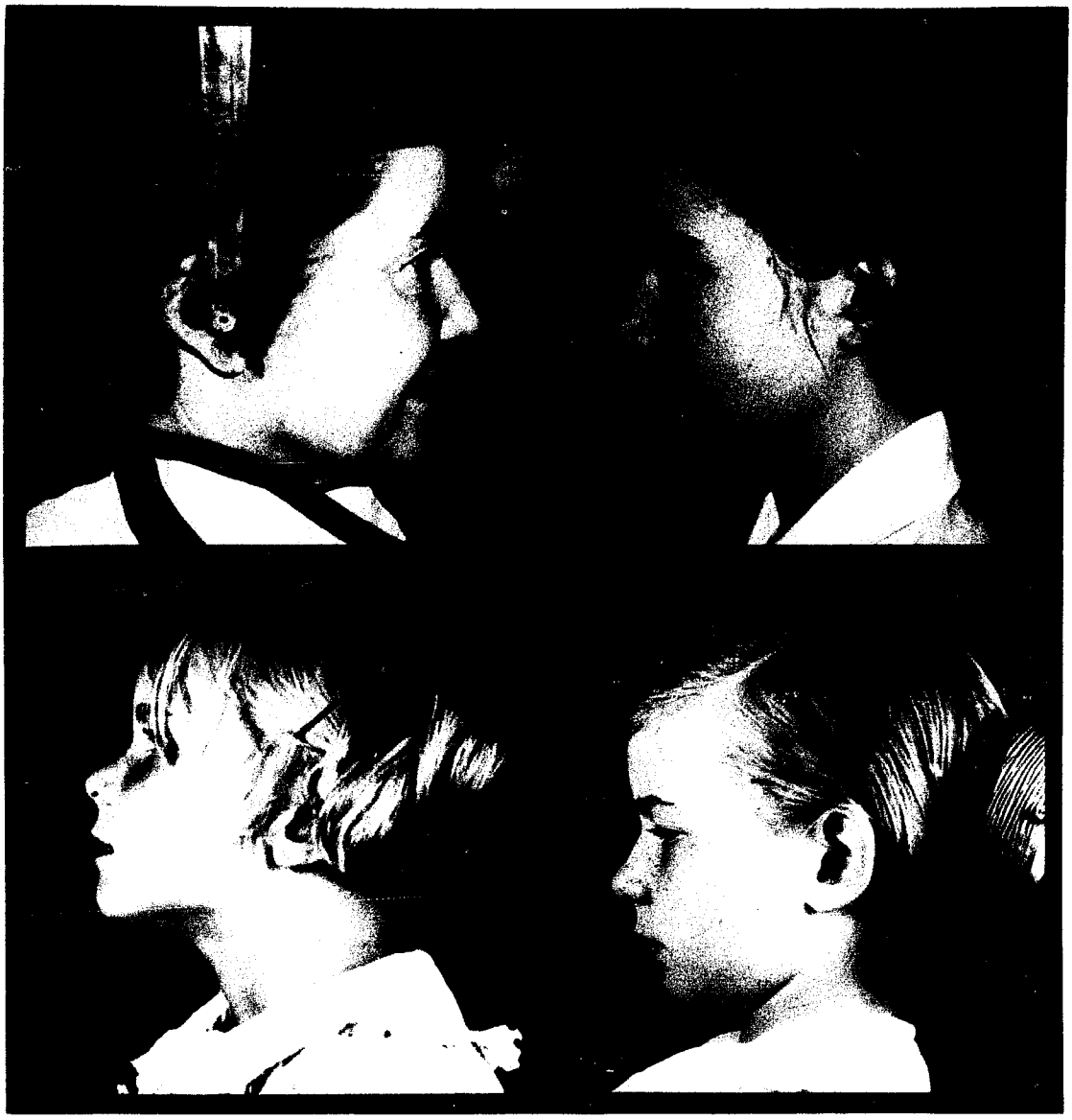


Figure 55B

Figure 55C. Female faces with similar views taken at age 57 and age 4. In spite of 54 year span the head posture and facial expression are strikingly similar despite tremendous facial change.

Figure 55C

Figure 56A. Male faces. From young adulthood to age 65.

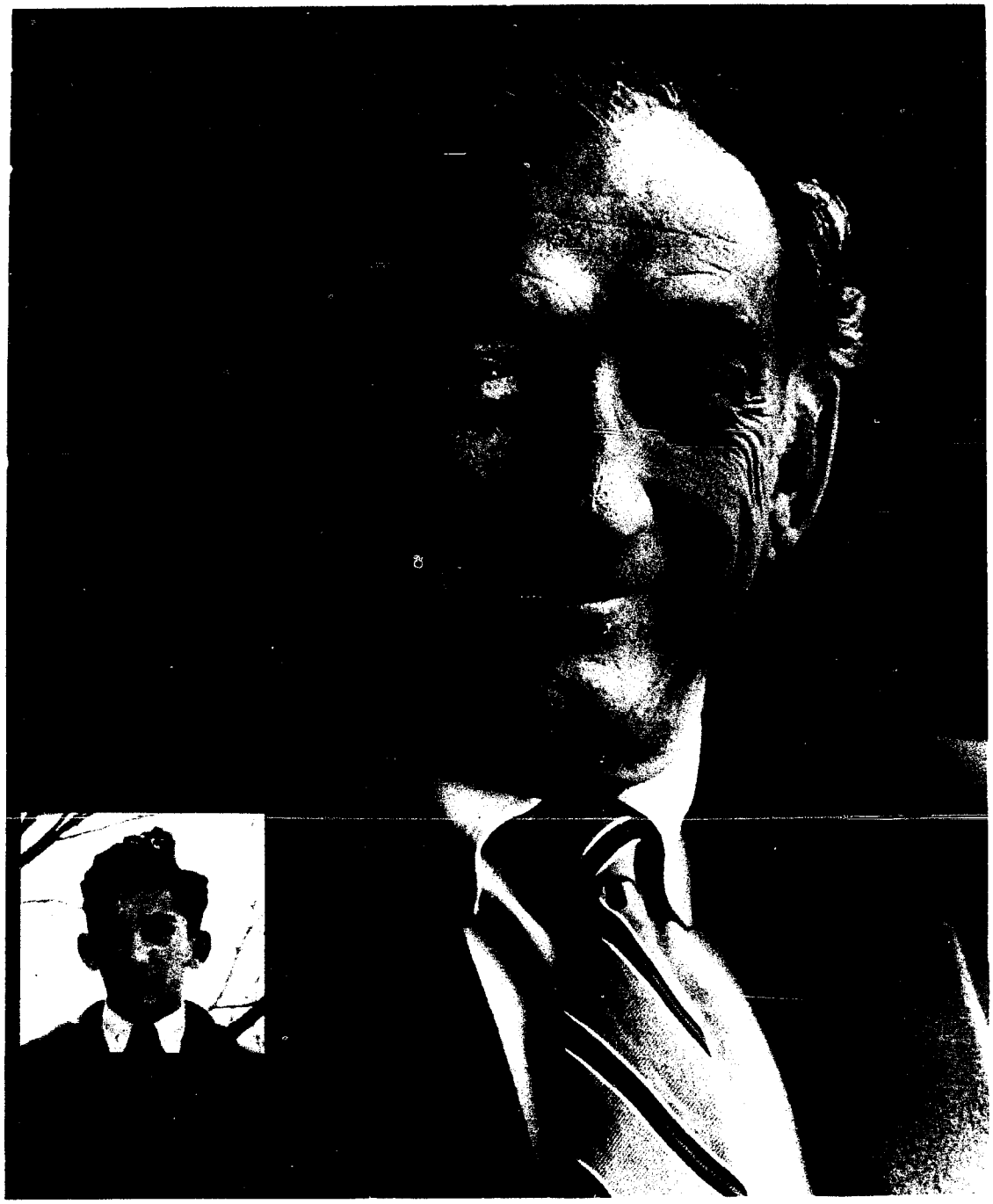


Figure 56A

Figure 56B. Male faces. Top row from left, approximate ages 50, 60, 70. Bottom row from left, ages 64 and 42.

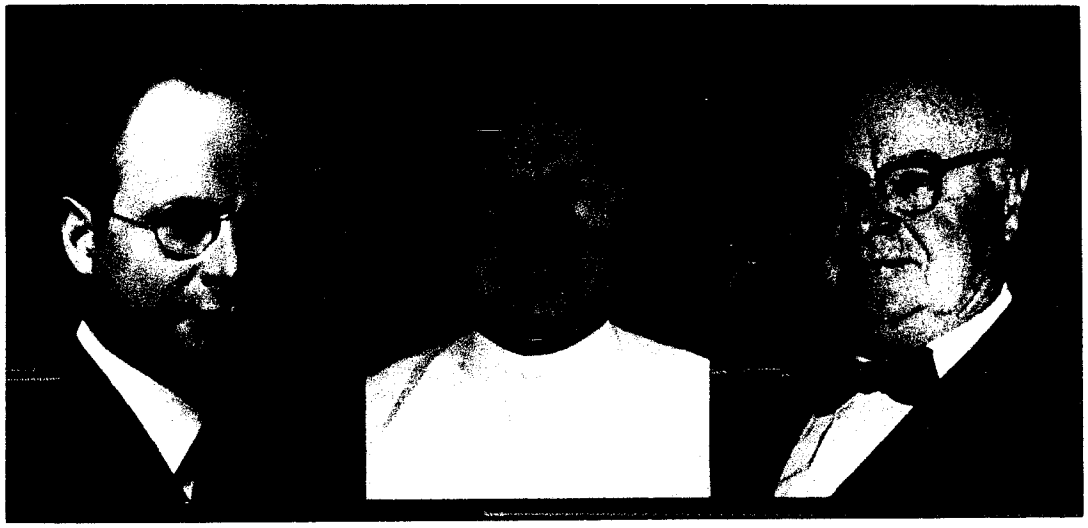


Figure 56B

Presence or Absence of Craniofacial Change

In order to evaluate the data overall, because of the multiplicity of starting ages, age spans of different lengths, variable final ages, and variable availability of intermediate exams, it is perhaps best to consider the period of adulthood with a series of questions in regard to the possibility of gain versus no gain for each period. This discussion involves the untreated sample.

Growth after 17?

Considering only the first 139 calculated values, and considering the values calculated for initial films (age equals 17 or greater) and final films (age equals 25 or greater), it is virtually impossible to deny the existence of adult enlargement (N=113). Some 64 of the possible 70 distance measures are enlarged significantly and, in addition, 48 of the possible 69 angular values have also become significantly altered. Considering only the male portion of the sample (N=34), 63 of 70 distance measures and 38 of 69 angular values changed significantly from initial to final. While late-maturing males may be felt to account for these findings, in assessing the female population (N=34), surprisingly, 59 of 70 distance and 40 of 69 angular values demonstrated a significant change. Two points should be made in this regard. While surely "late-maturing males" (say into the early twenties) are a factor in analysis of growth from 17 years of age on, "late-maturing female" characteristics were never considered to be a factor prior to the

study. Growth of the female was not suspected beyond about 16 years of age, but the data suggests differently. This will be commented on later.

Another point to be made was that both distance and angular values were changing during the period of the study. This suggests that both enlargement and shape (as well as position) alterations were occurring. In a sense "differential growth" appeared to be demonstrated. This is perhaps contrary to the views of Israel where a simple enlargement of the skeleton was suggested.

By nature of the definition of "growth" so often applied to adolescence, the definition of "growth" thus also applies to these adult changes. However, so as to qualify the nature of the change during the adult period the term "adult extensive conformational adaptation" is used to better envision and qualify the actual nature of the changes occurring. This is done in spite of the fact that changes appear to simulate in aspect (perhaps not in magnitude), by definition, the "growth" of adolescence. The composite male and female changes from initial to final exams are illustrated in Figures 57-58. The amount of change in this age period is considerable.

Growth after 25?

In order to investigate the effect of late maturing individuals on the data, the sample was reformed several times to delete some individuals at each step. In assessing the age period of 25 years and beyond, only those individuals were included who had

Figure 57. The composite female constructed on the basis of calculations 1-139. Regional anatomy is added to the initial landmark locations. The center of the open circle is the initial landmark location, while the center of the solid dot represents the final landmark location. The figure is 6% enlarged over actual size, but unreduced for format specifications. The reader may measure a "favorite" relationship from this drawing with reasonable accuracy.

Figure 57

COMPOSITE FEMALE

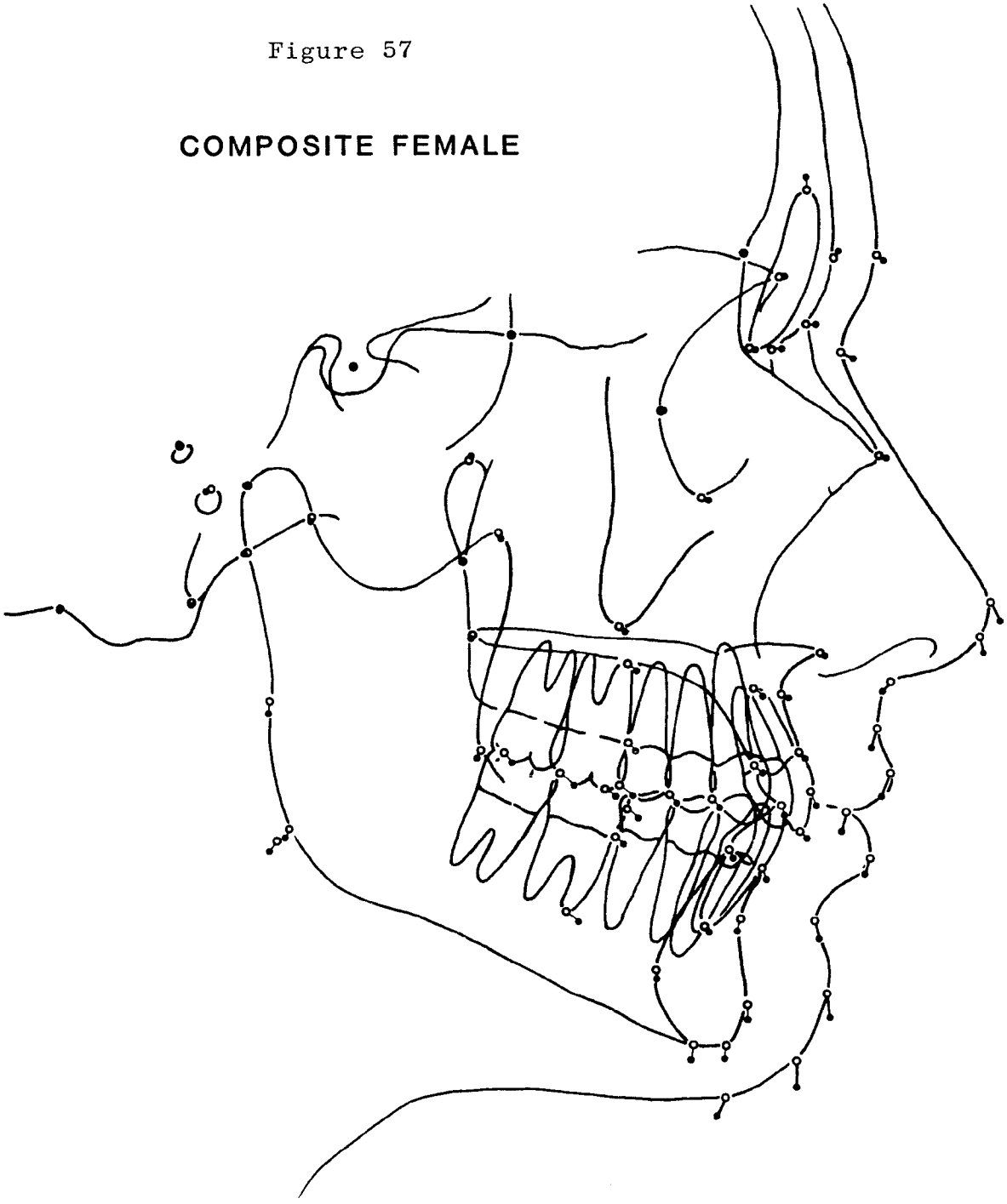
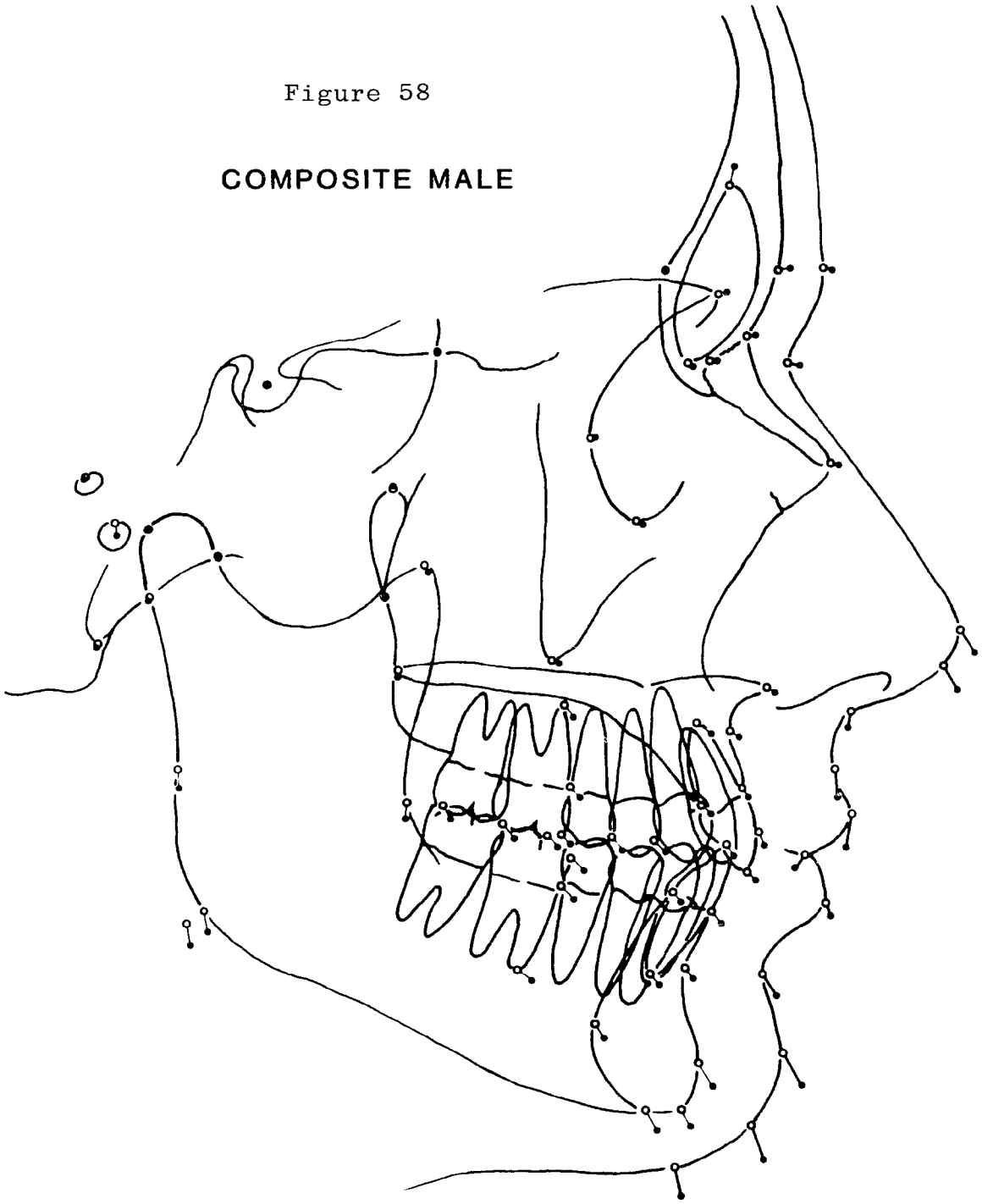


Figure 58. The composite male constructed on the basis of calculations 1-139. Description as in Figure 57.

Figure 58

COMPOSITE MALE



exams taken at 25 years of age and older (no spans formed using ages 17-24). This in essence would fairly well delete the late maturing individuals so as to describe "adult change" rather than adolescent growth extensions. Males and females were pooled (N=56).

In this structure of the data 60 of the 70 distance measures and 32 of the 69 angular values were significant. This again suggests that adults continued to change beyond 25 years of age. However, it might still be argued that the presence of some late maturing individuals, particularly males, were effecting the results, although this argument would be weakened.

Growth after 30?

Again the sample was restructured to only include those individuals who had spans starting at 30 years of age and beyond (N=27). The results of the significance tests would again speak toward continued adult change. Some 56 of 70 distance measures and 28 of 69 angular measures were significantly changed. Late maturation as an extension of adolescent growth would not logically be considered a factor with these spans.

Growth after 35?

The data was again restructured to investigate the age period of 35 years and older (N=10), and in this instance 43 of 70 distance measures and 19 of 69 angular measures were significantly different from initial to final observations.

Growth after 40 years?

Although this subsample was quite small (N=4), some 22 of 70 distance measures and 11 of 69 angular values were significantly different from initial to final. Thus, as the result of this test and the previous tests, it became fairly clear that instead of a concept of late maturing individuals as an extension of adolescence effecting the results (surely they affect the results), rather the more correct concept may be that in the adult period people are continually maturing. That is to say that no one is "late" but rather everyone is "continuing" to change and that maturation (in a final sense) of characteristics occurs throughout the adult period of life with some characteristics continuing to evolve to an unclear final age, perhaps death.

It may be stated that in young adults, particularly males, late maturation of some of the participants can influence the figures for the total sample and as such what it termed adult growth might be delayed growth in a few "late growers". This is surely occurring, but again inspection of the later spans (initial film in the 30's) speak to the whole of the situation. Growth changes are apparent at all times. However, further study at the very old ages would be necessary to comment on the possibility of a plateau effect of growth or a senile degeneration as noted by Todd (1925) and Hrdlicka (1938). At present this later concept is only suspected but not proven.

Male-Female Characteristics

The value of the present sample was quite apparent during the comparison of male-female differences. Being adult in nature, subtle but consistent changes were noted which, contrary to studies of the adolescent, were not "confused" with tremendous quantitative and qualitative change, maturity differentials and the like. Also, in adulthood the process of androgeny has been assumed to be essentially complete and in a sense the sexes are "dimorphed" (not a real word). The permanent features which characterize the biological nature of male and female organism differences are not evolving but have evolved to a considerable extent. Because of these factors, a clarification of the characteristics of sexual dimorphism seemed much easier to accomplish.

The value of being male or female was tested in several ways, and distinct dimorphic differences emerged. Although general individual characteristics will be discussed in later sections a scrutinization of the calculations 1-139 gave evidence that females were generally smaller than males. A two-sample T-test was used to test the differences between the male population's initial and final records and the female population's initial and final records. In this way the absolute differences between populations at any period of the adult time were tested for. In this test, considering the first 139 values, 70 of 70 distance measures were and 8 of 69 angular values were significantly different. The meaning of this is fairly clear in terms of two aspects of sexual differences. At both the initial and final exams males were larger than females and it

appeared that some configurational relationships differed between the two sexes. Wei (1968, 1969) and Ingerslev and Solow (1975), however, felt that despite size no real difference in form between the sexes is present. In this regard a larger face height for males has been shown, as well as a decrease in anteriorposterior distances for the mandible in females (Hellman, 1927; Buchi, 1950; Thompson and Kendrick, 1964; Lasker, 1953; Wunsche, 1953; Baer, 1956; Sarnas, 1957; Tallgren, 1957; and many others). It should be remembered, however, that the first 139 calculations are based on distances from Sella and angular relationship to Nasion-Sella. Therefore, significance means that overall differences are seen and do not speak of differences for localized regions within the face, as for example in the size of the mandible. Such differences will be evaluated and described in later sections.

Also, as mentioned previously, male and female subsamples were formed, and a paired T-test was used to test differences from initial to final exams. In this instance the males or females might or might not each become larger or smaller through time for a calculation even though there may not be a significant sex difference in absolute size. With these two tests it was then possible to decipher rational relationships such as "females were becoming larger with age for a certain characteristic, whereas males were not, but females were still at all times smaller than males". In this

regard, for the first 139 calculations, males demonstrated significance for 63 of 70 distance and 38 of 69 angular values; for the females 59 of 70 distance measures and 40 of 69 angular values. Thus, it is apparent that both males and females are changing with time, but, except for size, only 8 measures indicate a possible configurational alteration (statement based on the first 139 calculations only; male versus female comparison). Thus, in essence two aspects of male-female differences may be studied with this data: whether they grow and whether they are different in their absolute values.

It is usually suggested that sexual dimorphism involves selective areas of the craniofacial skeleton (Figure 59). However, size may be the major factor involved in several of these areas. Indeed size is a factor as seen in Figure 60. However, shape may be more indicative of the differences between males and females. In scrutinizing calculations 1-139, using this particular orientation, dimorphic angular features include the position of the lower molar root apex, anatomic porion, the glabellar area (soft tissue glabella), glabella, the internal aspects of the frontal bone, the area around the orbit (supraorbitale, lateral rim of the orbit) and the nose area (tip of nasal bone). This is to say, according to the present analysis (calculations 1-139), females are really small males except for the angular features noted. It would be expected that any other calculations involving these landmarks would likely demonstrate sexual dimorphism. This will be seen in discussion of the remaining calculations, as will be additional dimorphic features when

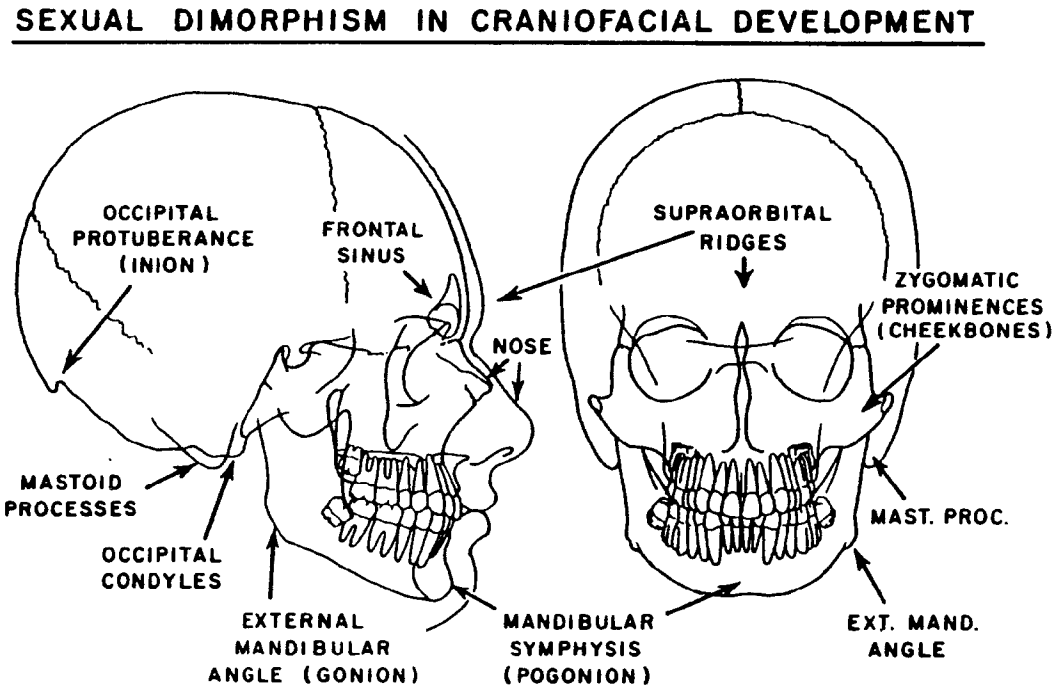
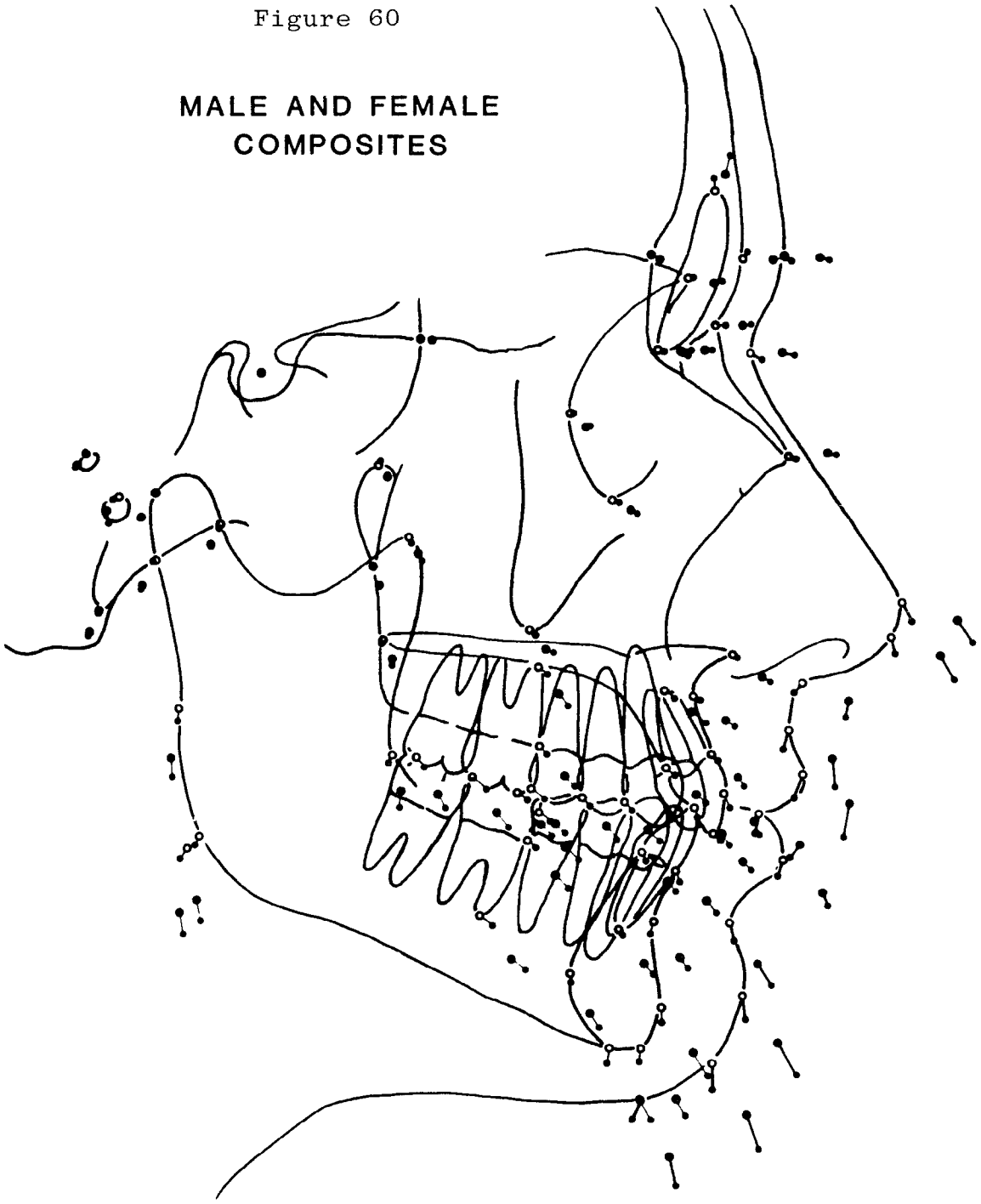


Figure 59. Common sexual dimorphism features. Illustration as adapted from the Bolton Study.

Figure 60. An overlay of male and female composite drawings. Background anatomy is provided by the female drawing. Female landmark locations are signified by the open dot to the solid dot. Male landmarks are signified by the large solid dots connected to the small solid dots. Size differences between the sexes are evident.

Figure 60



localized regions are scrutinized. Suffice it to say, for now, that the major features differentiating males and females involve the shape of the upper facial areas and size.

The percentage difference for size between males and females was calculated for selected measures (Table VII). These data suggest that males are approximately 5 to 9 per cent larger than females overall, depending on the measure taken. This is consistent with the findings of Forsberg (1976) who reported that males were 6% larger, but that females and the gonial angle was 3-5% larger in the female. A tendency also exists for stating, even though both sexes grow during adulthood, that males grow more as the percentage differences become larger at the final exams. This relationship was seen in general for all calculations taken. Males were larger to begin with in adulthood, grew more, and were larger in later adulthood.

The previous section raised the possibility of a "late maturing female" change, and it is appropriate to comment on this interesting possibility prior to the more in-depth analysis of the calculations that follow. During the tracing of cephalograms and preparation for digitizing, the tracings were superimposed by registering on sella and orienting along sella-nasion. While no firm conclusions could be based on this process as superimposition occurred before magnification of each cephalogram was accounted for, it was possible to observe the growth activity of the located points, especially when magnifications were known to be of a similar magnitude. In this way a general feeling for the relationships present could be anticipated, which would be later proven or dis-

TABLE VII

PER CENT DIFFERENCE BETWEEN MALES AND FEMALES FOR SELECTED MEASURES

PER CENT DIFFERENCE (MALE OVER FEMALE)

MEASURE	FINAL	INITIAL
SELLA-GNATHION (2)	8.6%	7.8%
SELLA-NASION (49)	5.5%	5.7%
NASION-MENTON (201)	7.5%	7.4%
PM VERTICAL-A POINT (184)	6.4%	6.0%
PM VERTICAL-B POINT (186)	8.6%	5.9%

proven.

This procedure became very interesting for the female part of the sample, especially when several films were available for a case (2-9 films were available for each individual) beyond the required initial and final. The general feeling derived was that females changed very, very little in early adulthood when viewing tracings for 17, 18, 19 and 20 years of age, but later in their twenties and thirties, females appeared to begin to grow again. An example of this is seen in Figures 18-20. While an in-depth examination of this aspect of adult growth was beyond the scope of the present analysis, superficial scrutiny of the female health history forms led to a hypothesis that the events noted in terms of a "re-starting" of growth were at least coincidentally related to events of pregnancy. The woman in Figures 18-20 had children at 22, 24 and 25 years of age.

This possible relationship may have a biologic basis. When it is considered that females become sexually adequate to bear children at puberty, this condition is related to growth; the female undergoes radical hormonal and other physiological changes during pregnancy; the female body systems support and apparently induce the fetus to growth at a time in its development when the fetus itself is apparently unable to fully initiate growth as its endocrine glands are not yet formed or functioning; if during pregnancy the female is responsive to her own hormones designed to stimulate growth of the fetus; then it is perhaps not illogical to suggest the female herself grows as the result of her own pregnancy. Anec-

dotal reports of an increase in shoe size (one of the last confining pieces of clothing now worn--as shown in studies by Hrdlicka) during pregnancy due to water retention and attendant swelling of the feet and a failure to return to the original shoe size long after pregnancy, are common.

While this aspect of female change may be an artifact of the sample as evidenced by trends seen in the calculated mean values given by age for females, and also because of the logical nature of the argument, this matter begs further clarification. A "female post-fertilization growth acceleration" may be possible. No such trend was seen for the male as the change noted during superimposition and data manipulation suggested a more continuous deceleration of growth through time which never finalized.

Another aspect of male-femaleness which was apparent upon superimposition (although less so than the above), but which, by nature of the sample could not be clarified in depth, was that males tended to grow in the same direction during early adulthood as they had grown during adolescence ("vertical growers" grew vertically, "horizontal growers" grew horizontally). In their twenties, however, together with the "restarted" females, all grew vertically. That is to say individual growth patterns were apparent in early adulthood, while a general growth pattern common to both sexes consisting of a more vertical change was present in the older ages. This finding is consistent with the calculated data, but the direction of growth could not be partitioned according to age because of the sample characteristics. Numerous examples of this are seen in Figures 17-44.

It should also be added that male-female differences are easily discerned for most measures when displayed as mean values by sex and age. In viewing each sex, it should be noted that a majority of the distance calculations for males are generally largest in the 31-50 age range. This should not be taken to mean males become smaller in the last age group. Although difficult to analyze, some secular trend may be affecting the males in this group so as to raise mean values. Included in this age span are generally the final films of former graduate students who represent a generation beyond that making up the original Bolton population. This factor does not affect the female population.

Treated Cases

Two samples were also formed besides the untreated group, not by design, but as the result of the recall examinations. If during the examination, the individual reported that comprehensive treatment had occurred the individuals were not included in the untreated sample. Because, in addition, a number of adult spans (treated) already existed on file, a sample was formed (N=28) and analyzed separately as to adult change and also to test whether morphology, treatment, or perhaps relapse served to differentiate treated cases from untreated cases. In previous adult studies treated cases had been included with untreated individuals, so these tests were also designed to test the wisdom of this approach.

The Angle Classifications (present status) that were determined in this group and the number of missing teeth are shown in Figures 61 and 62. It is clear that the majority of the cases were treated nonextraction. Several orthodontists (greater than 8) were involved in the treatments so techniques of treatment could not be considered the same in each case. All cases were analyzed according to examination data collected after all appliances had been removed. The proportion of males and females did not differ substantially from the untreated sample, but the treated group was younger in terms of final age.

Evaluation of calculations 1-139 revealed that significant growth had occurred between the initial and final examinations for 60 of 70 distance measures and 23 of 69 angular values. This is taken to mean that treated people also grow as do the untreated people.

Testing differences between the untreated sample and the treated group by means of a two-sample T-test for the initial and final films revealed there was a significant difference for 34 of 70 distance measures and 51 of 69 angular measures. This is interpreted as meaning there is a significant difference between treated and untreated samples. While this could be the result of age, sex, and angle classification differences between the two samples, it appears, rather, that the samples consist of quite different types of craniofacial configurations (angular values differed significantly). It may be that because of the somewhat different craniofacial configurations than that present in untreated people, the "treated"

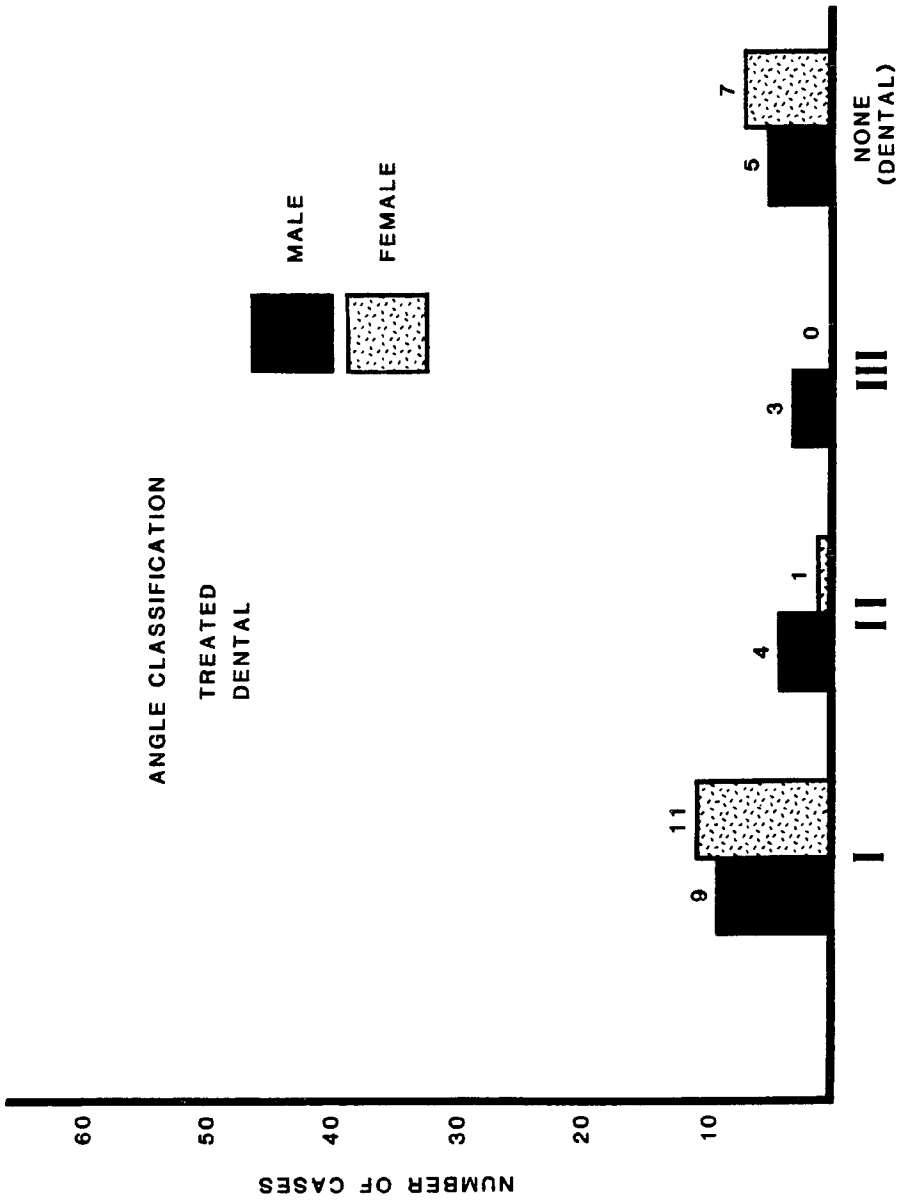


Figure 61. Angle classification by sex for the treated and serious dental problem samples.

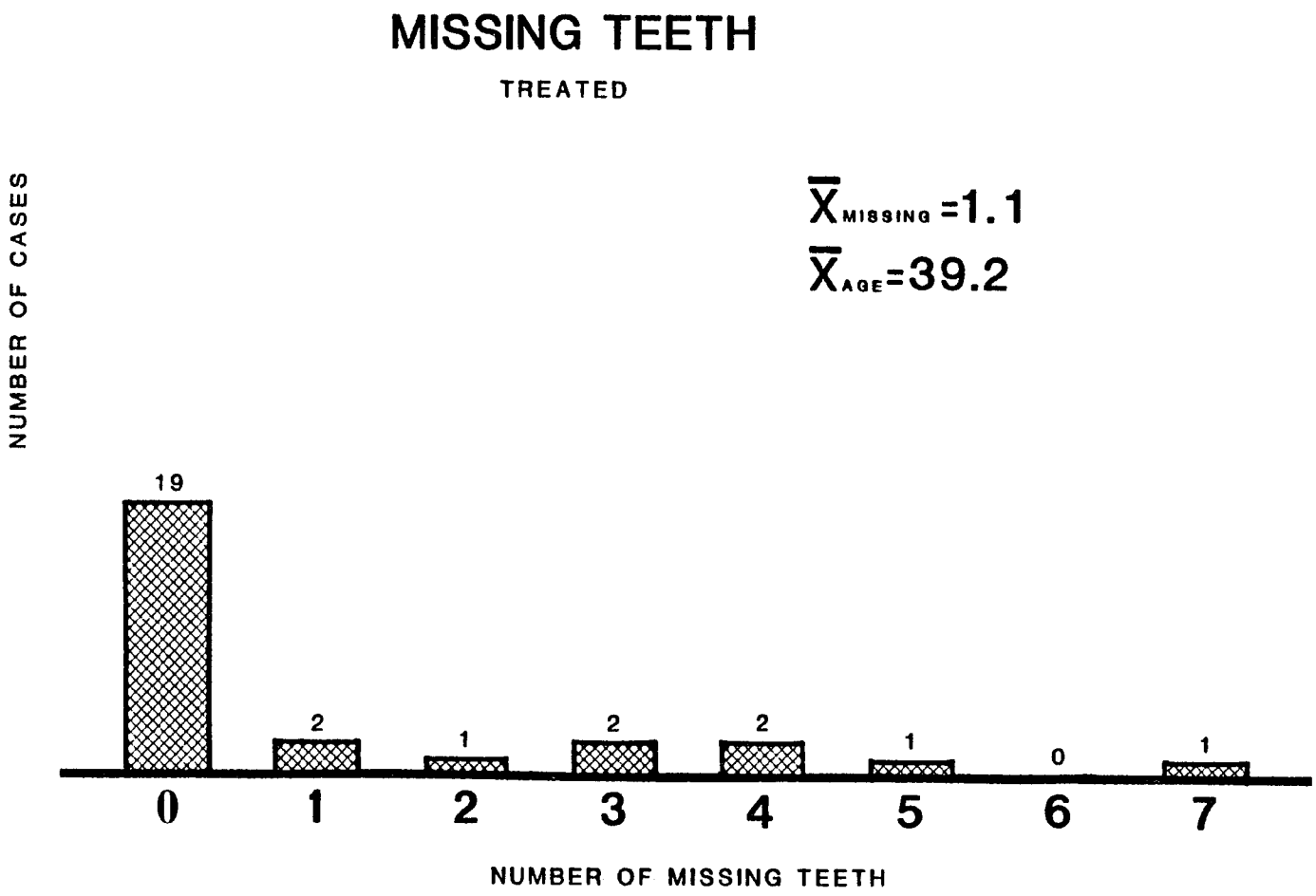


Figure 62. Missing teeth noted in the treated sample. Most cases had been treated by non-extraction methods.

people may have sought treatment, and/or that the family dentist may have recommended treatment, and/or the orthodontist may have recommended and carried it out. That is to say, these people may represent some sort of a "malocclusion syndrome" group which desired and received treatment because their craniofacial configurations were indeed different.

Because of the apparent differences exhibited by this treated group, it was not included in the primary sample of untreated individuals and receives further attention elsewhere in this report. A few comments as to the nature of this group, however, are in order.

Some characteristics of this group include differences in the length of the face (shorter) and the height of the alveolus (greater). However, the prime differences seem to involve the mandible, being more dimunitive in size and more posteriorly located. It is also clear that this group grew, but the nature of the changes appear quite different than those in the untreated group. This was perhaps most evident during the superimposition procedure where it was clear that several cases were relapsing. Relapsing is perhaps an inappropriate term, however, for it is often used in the connotation of a failure of treatment. Rather, the situation appears more to be a realization of prior growth trends. That is to say, the relapsing cases grew "poorly" before treatment, were treated, and then grew poorly after treatment during adulthood.

One case entered the adult period and then literally grew into a full Class II malocclusion as the maxilla grew more or less

normally in a continuous fashion, the teeth displayed anterior tipping, the occlusal plane tipped up posteriorly, and the chin fell behind as its growth did not pace that of the maxilla. Surprisingly the overbite did not increase with time. However, in Class II division 2 cases it did. Also, there was also a tendency for extremely upright upper incisors to further upright so that the root apex was clearly anterior to A point suggesting that fenestration of the labial plate had occurred, a finding that has clinical implications.

Post-treatment development of open-bite was observed in two cases and it appeared that osseous change was not, as expected, the root of the change. In this situation it appeared that an overdevelopment of the posterior aspects of the maxilla presented initially, but excessive adult development did not then occur in this region. Rather, anterior and posterior extreme eruption of teeth was observed in conjunction with considerable growth of the mandible in a vertical direction. An in-depth analysis of the long term growth of treated individuals as compared to untreated individuals will comprise a separate study (especially a Class II comparison of untreated and treated individuals). However, the significance testing is presented for all calculations (Appendix A) for the readers examination and interpretation.

Major Dental Problems

Another sample of individuals (N=12) was analyzed separately from the untreated (and treated) sample. These individuals were

untreated orthodontically but were not included because of failure to meet extraction criteria and/or had experienced substantial dental reconstruction. Very little of the restoration was recent. The sex distribution and sample characteristics are shown in Figure 61 and Table VIII. A paired T-test and two sample T-test were conducted to investigate whether this group grew and whether it was different than the untreated group. In regard to whether this group grew through time, in considering calculations 1-139, 31 of 48 possible distance measures (no tooth related measures were attempted) showed a significant change while 18 of 47 angular measures altered through time. It was clear that this group was also changing as in the untreated group.

In testing whether this dental problem group was different from the untreated (dentally healthy) group, 41 of 48 distance measures and 12 of 47 angular measures were different. This again could be due to sex and age differences; however, given that a number of the angular relationships were altered it is likely that some phase of tooth loss and reconstruction had a rather dramatic effect on the growth of the craniofacial complex. A superficial analysis of the differences include a dramatic alteration of mandibular position and morphology and an apparent dimunition of the growth of the anterior portions of the face in the dental group. In-depth analysis of the effect of tooth loss on adult change is beyond the scope of this study, but the results of significance testing for all calculations are presented for the reader's information.

TABLE VIII

CHARACTERISTICS OF SAMPLE WITH
SERIOUS DENTAL PROBLEMS

MAJOR DENTAL PROBLEMS

ID	DENTAL CONDITION
B285	FULL MOUTH RECONSTRUCTION
B1999	MULTIPLE UNRESTORED POSTERIOR TEETH
B2030	9 MISSING TEETH, EXTENSIVE BRIDGEWORK
B2595	7 MISSING POSTERIOR TEETH
B2652	4 MISSING ANTERIOR TEETH, BRIDGEWORK
B2747	10 MISSING POSTERIOR TEETH
B2757	MULTIPLE EXTRACTIONS,PARTIAL DENTURES
B3042	FULL DENTURES
B3438	FULL DENTURES
B3484	UPPER DENTURE, LOWER PARTIAL DENTURE
B4171	UPPER DENTURE, LOWER PARTIAL DENTURE
B4604	UPPER PARTIAL DENTURE

Vertebra

Measures taken on the third cervical vertebra for the untreated sample indicate a significant increase in height (211) and width (212) after adulthood had been achieved. In height (211) mean trends indicated this increase continued during the later ages at least for the females, although group tests failed to demonstrate a significant trend in the latter ages beyond 25. In width (212) anteroposterior dimensions indicated a significant increase continued beyond 25 years of age. Vertebral canal width (214) showed a significant decrease for males and a non-significant decrease among females, with the effect also seen in the group tested beyond 30 years of age. In total width of C3 which encompasses the body, canal and spine, significant increases were noted in all ages studied, indicating a continued enlargement of this vertebra through time.

In terms of anteroposterior change, several mechanisms may account for the changes seen here. Adaptive deposition of bone may be occurring on the external surface of the body and the posterior aspect of the cervical spine, or deposition may be occurring on all dorsoventral surfaces (thus including the posterior aspect of the spinal canal). Either combination could lead to the changes noted here.

These changes would also logically be expected if one were to envision the cervical vertebra being responsive to weight changes (Table IV) and muscular changes. In terms of weight,

the addition of weight usually unequally distributed could in effect place sufficient stress on the vertebrae to initiate an adaptive alteration so as to broaden the body of the vertebrae. Likewise postural muscular alterations of the cervical muscles with age would be expected to influence the osseous morphology of the cervical spine. The narrowing of the spinal canal is more difficult to interpret. The change in height is consistent with overall height changes in Figures 49-50.

Sexual dimorphism was extremely apparent in all dimensions noted here, with females consistently smaller in absolute terms but not in growth behavior. Both sexes were apparently adjusting to continuing demands placed on the system.

Since there was no real reason to suspect that orthodontic treatment and severe dental problems would have a substantial effect on the vertebrae, all subsamples were grouped and retested for initial to final change (Table IX). The results noted are consistent with the previous description for the untreated sample.

Another measure of spinal aperture (foramen magnum) which might be expected to be responding to different adaptational forces, was the measure taken from Opisthion to Basion (213). In this regard a significant decrease was noted for the males but not females (significant sex difference). This is also seen in Table VII. In males, apparently what occurs is a remodeling anteriorly at Opisthion (104, 34) and inferior remodeling at Basion but with no change in angulation (36, 106).

TABLE IX

VERTEBRAL CHANGES FOR POOLED SAMPLE

VERTEBRA (C3)

INITIAL AGE 20.0
FINAL AGE 46.5
N 306

(UNTREATED, TREATED AND DENTAL SAMPLES)

DISTANCE	SPAN	MEAN	SD	MEAN DELTA	DELTA SD	PROB.
63-65	FINAL	14.0	1.6	.6	1.0	.000
	INITIAL	13.4	1.4			
64-66	FINAL	16.8	1.6	.7	.9	.000
	INITIAL	16.1	1.4			
38-40	FINAL	38.8	3.8	-.2	1.8	.106
	INITIAL	39.0	3.8			
66-67	FINAL	16.7	1.5	-.2	.7	.002
	INITIAL	16.9	1.6			
64-68	FINAL	49.2	3.5	1.3	1.3	.000
	INITIAL	47.9	3.4			

An Interpretation of the Findings

Using all calculated values the following is an attempt to provide a logical statement as to the relationships present in the craniofacial complex of the individuals in the untreated sample. Calculation numbers used to justify the statement are given in parenthesis. Viewing the composite male and female drawings (Figures 57 and 58) will also assist in following the discussion.

Cranial Base

Overall the cranial base appears to be relatively stable (107, 106) except at its extreme extensions. The occipital condyle area appears to be changing slightly with age as the region involving Bolton point moves slightly downward (35) and forward (105) especially in the male. Although the effect is slight, it is apparently significantly consistent across the ages and apparently can effect cranial base orientations (230) notably Frankfort plane. A size difference (sella to Bolton point) between sexes is also noted (35) being larger in the male. This too may reflect a change in functional demands placed on the area in regard to the vertebral column and muscular action.

In regard to two calculations (179 and 192) with Bolton point and basion measured to nasion, both measures demonstrated significant changes with age, however it is difficult to signify what is actually occurring: anterior movement at nasion or posterior movement of basion and Bolton point. A combination of movements is most likely.

As discussed in regard to the foramen magnum, basion appears to continue to elongate in a fashion conformate with its original direction (106, 36) so as to remodel downward and backward without a change in the cranial base angle (106). A non-change in this angle also is useful in assessing whether other angular values utilizing a cranial base orientation are changing (230, 229). Again a size difference is noted for the distance from sella to basion (36), being smaller in the female.

For machine porion, apparently in the male, porion is more inferiorly located with age. This may be related to the increase in ear size anecdotally noticed in the present study and a possible alteration in the orientation and morphology of the ear canal which can be visualized on dry skulls. This effect apparently continues well into the twenties. A sex effect is again noted here for the distance measure from the cranial base but not angular values (40, 110, 161). This event may seriously disturb some of the common cephalometric orientations if the posterior extent of the Frankfort plane is moving inferiorly with time, unless orbitale is moving coincidentally, which apparently is not the case (229). Anatomic porion, on the other hand appears to be fairly stable except for a slight but consistent elevation in the female (41) continuing into the twenties. A sexually dimorphic effect in both angular and distance measures is present (41, 111) with the male anatomic porion located farther away from sella and at a more acute angle to nasion-sella than in the female.

The anterior cranial base from sella to the endocranial surface of the frontal bone demonstrates remarkable stability except for a slight significant change from sella to the ethmoid registration point and PM vertical plane into the twenties, for the male. This may be accounted for by slight remodeling at any of the areas involved in the measures (42, 112, 181, 43). A size effect attributable to sex (42, 181) is also noted for the ethmoid registration point but no angular sex differences are seen. On the other hand when nasion is included in the cranial base measures, the picture is altered from continued stability to continued change and it becomes very evident nasion is moving forward (180, 183, 49) across all ages in a consistent manner.

Two aspects of the frontal bone were scrutinized in the present study: the behavior of the external tables at the endocranial and ectocranial surfaces in the glabellar region, and the behavior of the frontal sinus. As might be expected based on previous studies these areas undergo considerable change with age.

In regard to the endocranial surface of the frontal bone, this area appears to be relatively stable in terms of the distance from sella (43). No significant changes were noted at any age, but a sex effect was present in regard to distance from sella. Positionally, the interior prominence relocates superiorly with age in the male (113). Anteriorly the ectocranial surface continues to develop significantly (some 9%) through and beyond 30 years of age (85, 44). The position of the prominence also apparently changes with

age (114) with the prominence located more inferiorly with age especially in the female. Overall, sexual dimorphism is easily demonstrable in these dimensions with less robusticity noted in the female and an altered location of the prominence. The prominence in the female is more superior, ectocranially and endocranially.

The frontal sinus also continues to develop dramatically with age. Positionally, the upper and lower extreme aspects of the sinus are apparently moving forward and apart with age (219, 115, 117, 45, 47) with the more dramatic increases noted in the upper extension of the sinus into the frontal bone and much smaller increases noted for a lower extension anterior to the nasal spine into the nasal bone region. This age effect continues well past 30 years of age (210). Curiously, however no sexual dimorphism was seen in any of the appropriate measures (210, 117, 115 and not 45 or 47 which include overall size differences), although mean trends indicate males were generally larger in regard to sinus size. These conformational changes are most likely partly due to the continued adaptive growth of the nasal region as the face remodels in a forward direction as the nose increases in size with age. This behavior will also be seen in general terms for the entire midface.

Midface

The posterior aspects of the midface are relatively dormant in activity although a number of subtle changes are present. Measures taken from sella to the pterygomaxillary fissure show some

upward and forward movement of the superior aspects into the thirties (57, 126). Pterygomaxillary inferior is moving downward for the male but not in the female (55, 124). The relationship of sella-nasion to the PM vertical plane is somewhat complex in nature with slight subtle changes not occurring in the sample when young spans are present, but rather when the spans are limited as to starting age above 25 years of age. This is interpreted to indicate changes in this angle do not alter early, but at later ages in adulthood. A slight decrease in the mean values are seen for the female; conversely for the male perhaps as the result of late male growth at the ethmoid registration point or resorption at PTM superior. Regardless of this minor alteration PM vertical remains a stable reference throughout most ages.

The position of the posterior aspects of the palate, however exhibits continued change into the thirties. Measured from several viewpoints (54, 163, 205, 162) increases are seen indicating downward movement. Sex differences apparently reflected size only. The posterior nasal spine also apparently remodels posteriorly while moving inferiorly (123). In spite of the movement of posterior nasal spine inferiorly and posteriorly, consistent change of angular relationships for both sexes between cranial base planes was not seen (231, 248). A notable exception to this statement involves males who showed a consistent change between the palatal plane and sella-nasion and the PM vertical plane. Both measures indicated the

posterior aspects of the palatal plane was lowering more than the anterior aspects of the palatal plane. In spite of this change no sex effect was noted, only a male age effect. This notation of a development in the male of the posterior aspects of the midface (55, 124, 231, 248) so as to effect a posterior counterclockwise rotation is a consistent finding throughout the measures as will be seen.

Consistent with the descriptions noted for the facial aspects of the anterior cranial base the distance relationships of the fronto-maxillary nasal suture continue to show continued forward movement anteriorly with no angular change (48, 118) in relation to the cranial base. The tip of the nasal bone behaves likewise moving anteriorly at all ages (50) elevating slightly in the male (270) with age. A non-significant trend in the female was for a decrease in the elevation of the tip of the nasal bone (270). Sex differences are noted in terms of the angle of nasal bone elevation (270, 119) being greater in the male.

The characteristics of the orbital region were measured from several aspects. Orbitale moves consistently forward from sella throughout the ages and was farther forward in the male (52). However in relation to sella-nasion no age or sex alterations in angulation were present (121). Orbitale was farther from the palatal plane during young adulthood but this was probably more the result of palatal movement (168). Further it is interesting to note that other measures denote the remodeling of the orbit forward (167) so as to increase the height of the orbit (170). The lateral

orbital rim apparently is moving forward during the twenties (51, 182). Supraorbitale is also moving forward into the twenties with males larger than the females (46). No angular change in supraorbitale was seen; however, a sex effect was noted with supraorbitale located more superiorly in the female (116, 169). In this regard the "tilt" of the orbit brings the top of the orbit farther anterior in the male and more upright in the female. An upward remodeling of supraorbitale was seen, but only slightly (169). The results of the movements of the orbit are consistent with the idea of a "gnomic" figure with little change in shape, but only size, as the structure move forward (170).

The key ridge is moving forward at all ages (53) and exhibits considerable difference in size according to sex. The angular relationship shows males demonstrate a slight elevation with age (122), as it moves forward. This results in an increased dimension with age from sella-nasion (165) and relative stability with the palatal plane except in the male (166) which may be related to the marked counterclockwise, downward shift of the posterior midface in the male.

Anterior nasal spine demonstrated anterior and downward movement in the twenties (12, 199, 164, 203). An angular change in the position of ANS relative to nasion-sella occurred in the twenties and thirties (82). This may be related to a slight downward deflection of ANS noted during tracing, but the meaning of this later change is not clear.

Downs point A is continually moving away from the cranial base during aging (11, 159, 184, 193) and the effect of sex on size is consistent with males being larger. However, the angular relationship between the cranial base and A point remains stable (81, 226, 228). This would suggest that the maxilla is coming forward consistent with anterior movement at nasion. Downs point A, in relation to the nasion perpendicular (based on machine porion) shows some age change in males. This is probably based on a male change in the position of machine porion noted earlier. The age effect disappears when anatomic porion is utilized (197, 195).

It is clear that the midface is not dormant in regard to age and sex differences. Only a few angular relations were altered with age, but size increases with age were a consistent marked finding. It is felt that this may be related to an increase in the nasorespiratory area due to increased physiological demands brought on by increased age and diminished pulmonary efficiency. While this demand theory is plausible, the cause to grow remains unanswered as an extension to adolescent growth inquiries. The effects seen here are summarized in Figures 63 and 64.

Mandible

With the foregoing changes noted in the cranial base and midface, since their additive changes influence the position of the mandible, it would be expected that the mandible would show a demonstrable configurational alteration. This is very much the case.

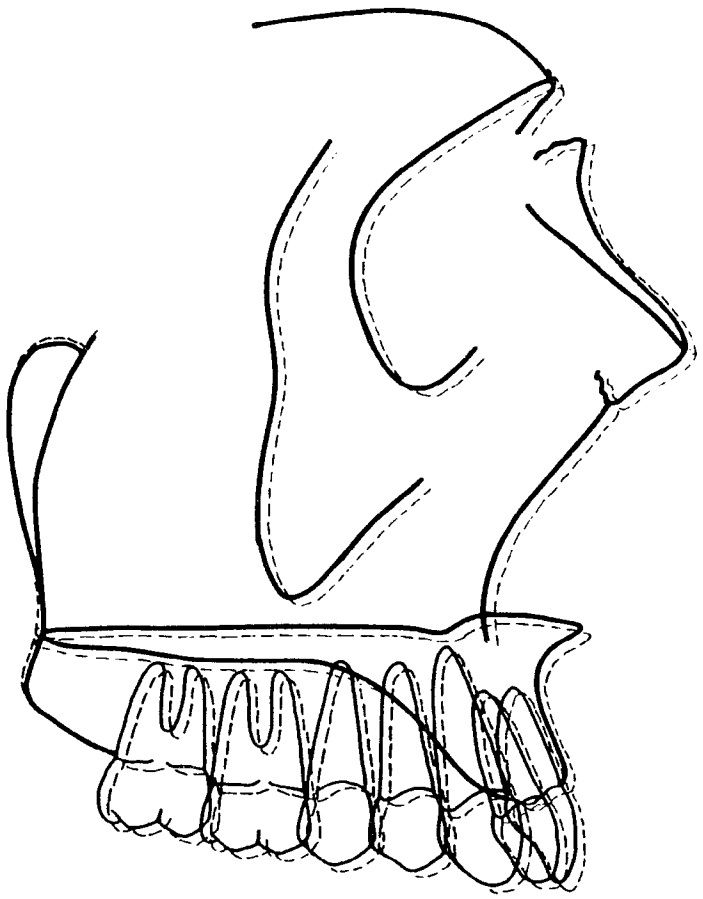


Figure 63. Maxillary positional change. The illustration provided indicates the general movements for both sexes even though they differ slightly.

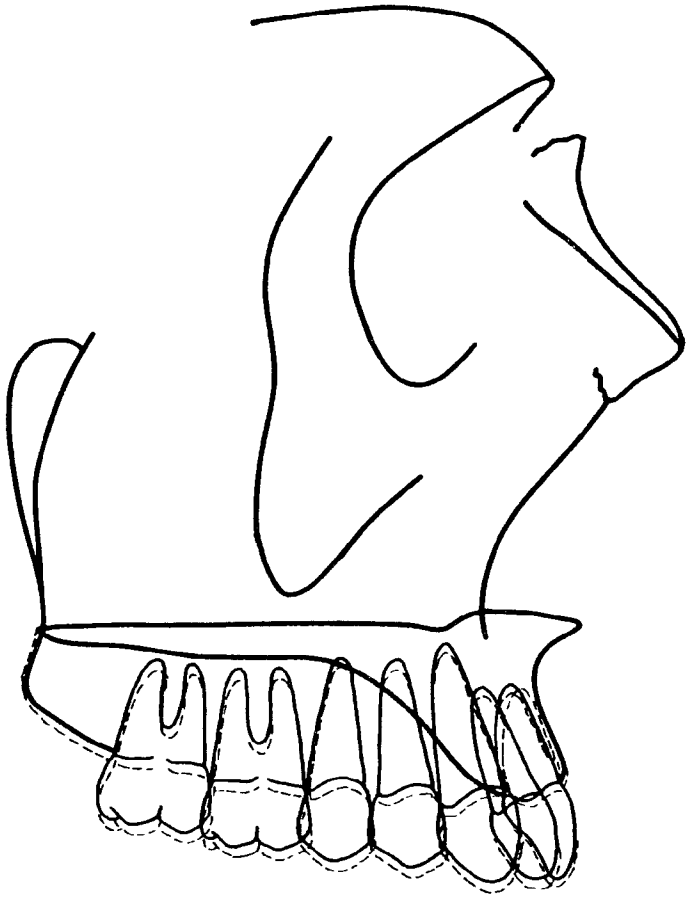


Figure 64. Maxillary dimensional change based on palatal superimposition. Slight increases are seen.

In regard to the position of the mandible it is clear the mandible undergoes considerable change. Menton is moving downward throughout all age spans (1, 200, 204, 201) for both males and females with males of course demonstrating larger absolute values. In regard to the position of menton, however, only females show a change in the angulation of menton, rotating clockwise through time (71). As might be expected gnathion (2, 72, 207) and pogonion (3, 73) behave similarly. Males demonstrate movement of pogonion away from the PM vertical plane (anterior that is), while females do not (187) except for a tendency. In regard to the nasion perpendicular (utilizing machine porion) this relationship also holds with one qualification. In females the mandible is apparently moving posteriorly or perhaps more correctly not moving as forward as nasion with age (198). This trend is also seen for nasion perpendicular to pogonion based on anatomic porion (196).

The activity of B point shows a size gain across the ages away from the cranial base with time (greater in the male), with an angulation change (clockwise) in the female (4, 74, 186, 194). Similar adjustments are seen for the lingual symphyseal point (17, 87). The apparent clockwise rotation of the mandible in the female and stability of the angular position of the male mandible, however, may be more complex when combinations of calculations are considered. It is clear that the mandible is moving downward in both sexes (1, 200, 204, 2, 3, 207, 4, 17, 194) and the angle of the points with the cranial base shows an increase (backward rotation) in the

female (87, 74, 73, 72, 71), but not in the male. But what is not clear is whether the mandibular chin points are moving more-or-less straight vertically (downward) or down and back (clockwise) in the female and anterior, down, and forward in the male. Several measures, however, tend to clarify this situation. In measuring from PM vertical to B point and pogonion, it is clear that in the male the chin points are moving forward and the female chin points are fairly stable (186, 187). This then suggests a situation where the male chin points are moving downward and forward and in the female more-or-less straight downward with age. This relationship also is understandable in terms of common cephalometric measures such as S-N-B and BO-N-Pog (225, 227). With these measures, the male shows a significant increase in angulation (225) thus implying that the chin continues to come forward at a rate more than the growth of the midface, however, in the female the opposite relationship holds (225, 227). The mandible is falling posteriorly in regard to these measures, but this is more apparent than real as it is clear that as the female chin moves down and not markedly forward (but not markedly posterior), as the midface moves forward, the angles decrease. Some clockwise rotation of the female mandible is possible though as will be seen (Figures 65 and 66).

Gonion also changes markedly in position through time across the ages as it moves downward (31, 32, 201, 206). Again male values are larger than female values for distances away from the cranial base. Mean trends also indicate this downward deflec-

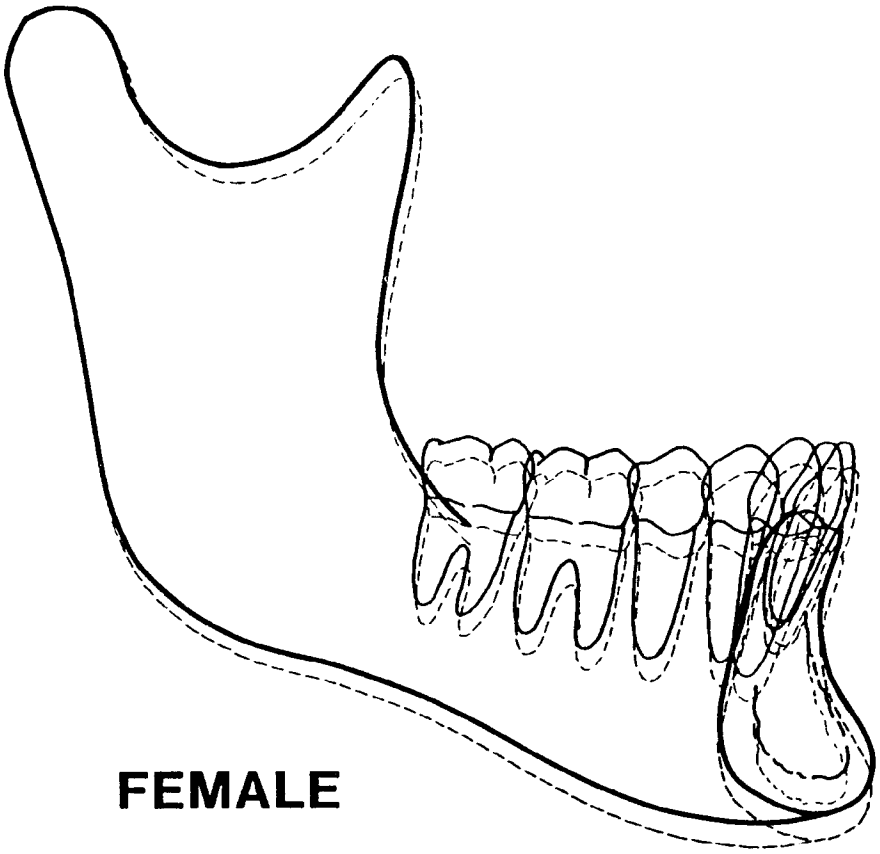


Figure 65. Female mandibular positional change indicating a vertical descent of the mandible.

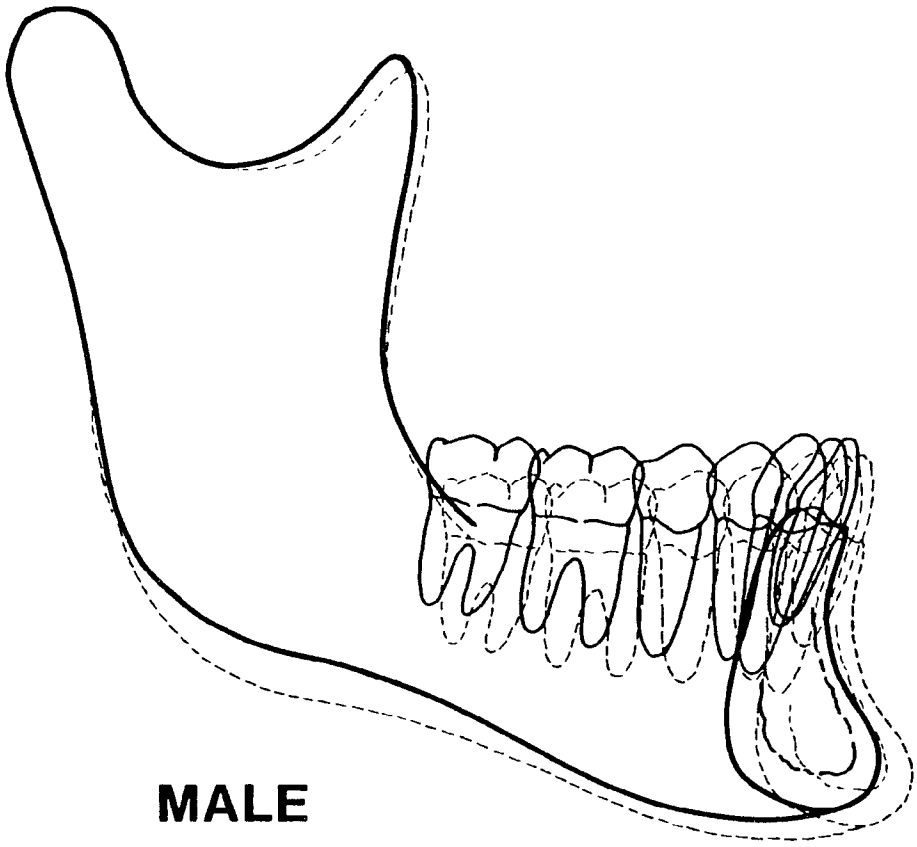


Figure 66. Male mandibular positional change indicating a continued downward and forward descent of the mandible.

tion is of greater magnitude for the male. While a downward trend is present in both sexes, it is also clear that gonion is also moving forward or backward depending on sex (185, 101, 102). The female gonion points show a posterior movement, while the opposite effect occurs in the male again expressing a posterior facial development in the male and a clockwise rotation in the female.

The anterior and posterior borders of the ramus are also moving downward, and it is interesting to note that the posterior aspect of the ramus is moving forward in the male but is quite stationary in the female. All the while, however, the anterior border of the ramus is moving posteriorly (30, 33, 100, 103). This would suggest anterior resorption of the anterior border of the ramus, which might have some bearing on the ability of the third molars to erupt and further amplify a counterclockwise rotation of the male mandible with age.

The coronoid process, which might be expected to be responsive to adult conformational alterations through growth, behaved similar to other mandibular points. The coronoid point moved away from the cranial base with time, but maintained its angular relationship (56, 125).

The relationship of anterior and posterior articulare demonstrated some curious changes. Anterior articulare was stable at the early stages of adulthood but showed a significant downward movement at the later stages of adult life (38); but an early change for

males in the angulation to the cranial base (108). In articulare posterior the same relationship generally held for the young stages of adulthood but with an early change for the females in the angulation to the cranial base (37, 107). Also, articulare posterior became located further from the front of the face with age (188). This later effect would suggest that if the mandible is located further from the cranial base with age and further from the front of the face, the mandible must indeed be of greater length with age. These results would also suggest that remodeling downward of the temporal bone around the condyle with age may be the appropriate thought especially for articulare anterior.

The position of the condyle in relation to sella proved to be quite stable in nature, and except for a sex effect in regard to the absolute distance between sella and condylion (39), little change was noted except for a somewhat more posteriorly located condyle in the female (109) with age. As with articulare posterior, condylion was located further from the front of the face with time (189, 62), again by default suggesting an increased dimension for the mandible.

In assessing the size and configuration of the mandible itself (Figures 67 and 68) this was indeed found to be the case with the distances of the effective length of the mandible, the body, and the ramus all increasing in length throughout all spans (141, 191, 140, 142, 143). In addition, a change in the gonial angle (133) was noted for males with the angle becoming more acute with time and much more acute than with that seen in females. These changes in

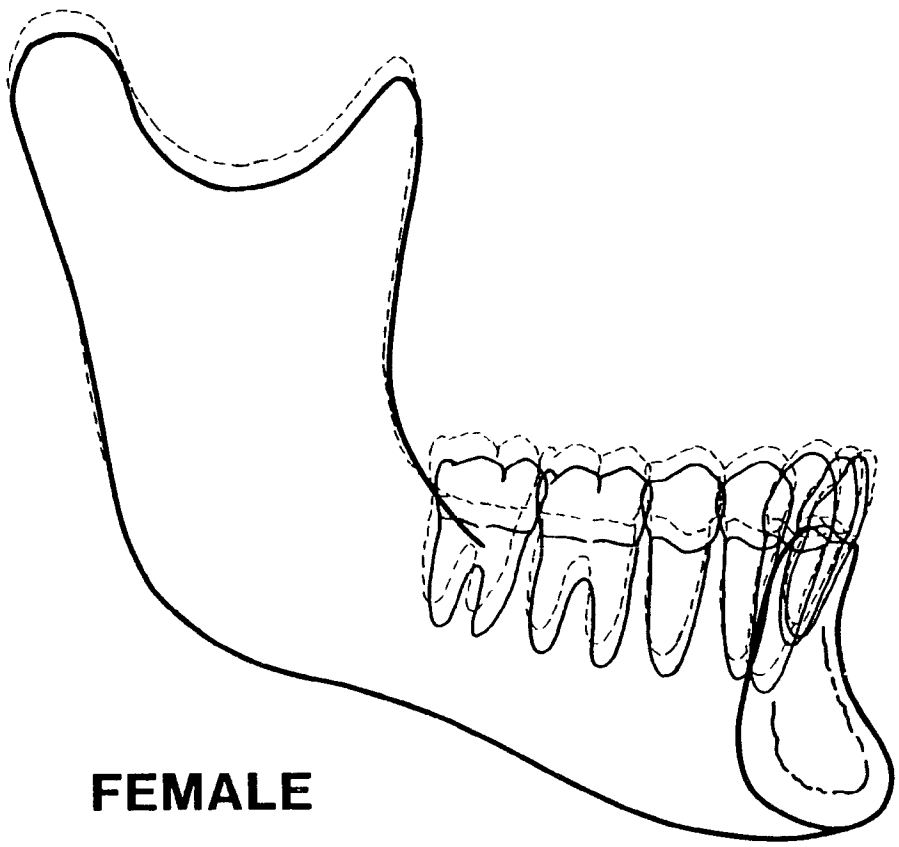


Figure 67. Female mandibular dimensional change.

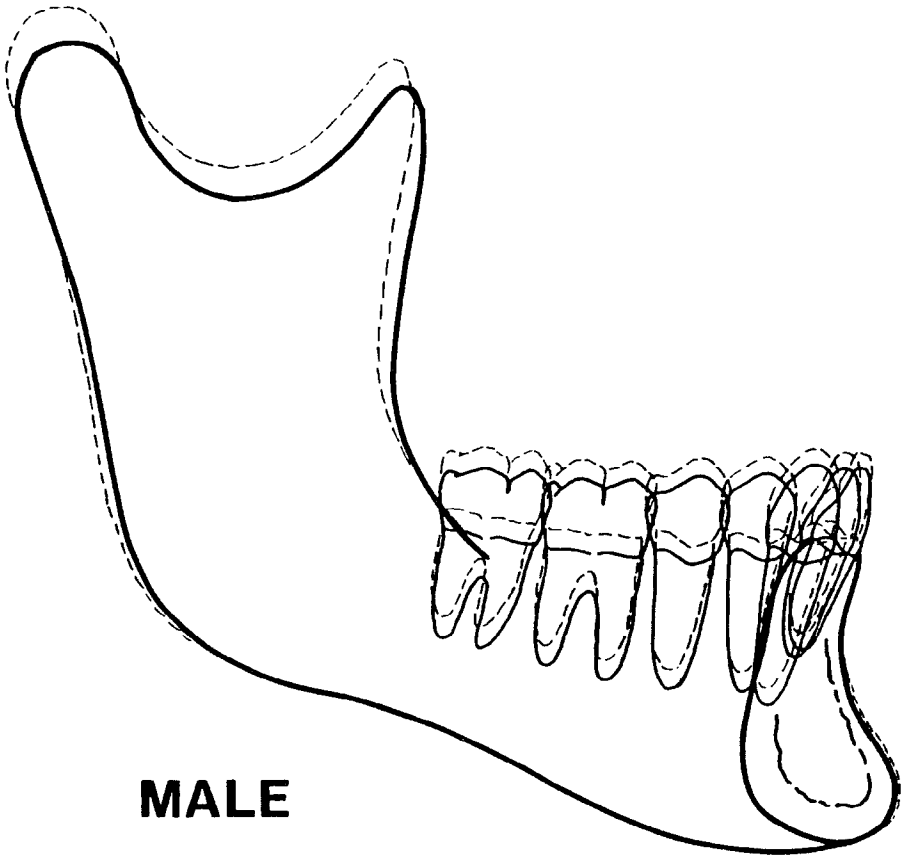


Figure 68. Male mandibular dimensional change.

mandibular length were not attributed to the development of the so called "chin button" even though significant increases in symphyseal width occurred in both sexes and chin prominence augumentation occurred in females (150, 151). In females they appear to have a less prominent mandible but a more prominent chin with age. Increases in the region of the body-ramus intersection were also noted, but only for later adult periods (146). On the contrary the width of the ramus (145) was decreasing significantly in males (tendency in females) apparently due to substantial resorption of the anterior border of the ramus (147) and lesser but significant, deposition on the posterior aspects of the ramus.

The coronoid process also appears quite labile and responsive to the apparent biomechanical demands placed on it by a mandible increased in size with age. The coronoid process moved forward and upward with time (144, 149) while maintaining the angular orientation (253) to the mandible proper. The masseter length relationship also increased with time especially in the male (208).

With manifest changes in the size and orientation of the mandible it would not be unexpected that common cranial relationships would also be altered with time. As might be expected in relation to sella-nasion, the Frankfort plane, palatal plane and the PM vertical plane, the mandibular plane displayed significant effects (or tendencies) indicating the mandibular plane was rotating counterclockwise in the male and clockwise in the female (235, 241, 247,

250, 234). This female trend was also seen for measurements involving the ramal plane (236, 242) and in relation to the front of the face (251).

The various growth axis measures were also consistent with the present findings indicating a counterclockwise rotation of the mandible down and forward in the male and a lowering of the chin and clockwise rotation of the mandible in the female (243, 244, 245), although these measures are surely influenced by the marked downward development of the face. The various indicies of intermaxillary protrusion also suggest this interpretation (254, 255, 160, 238).

In essence then, for both sexes the dimensions of the mandible are increasing. In the male more so, and more so in the area of the ramus so as to effect a change in the orientation of the mandible continually downward and forward. In the female however, even with the attendent increase in dimensions, as the chin would move forward the mandible would in effect be rotating backward so as to increase the anterior vertical dimensions of the face with no relative anterior movement of the chin. This repositioning of the mandible should have coincident corroborative effects on the dentition.

Dentition

From the previous descriptions in regard to the facial bones, it should be anticipated that the dentition could and should

demonstrate considerable activity in terms of adjustment and compensation with age. This is indeed the case.

That the teeth and surrounding alveolar structures have moved away from the cranial base could be expected in view of the description of the movement of the maxilla. It is clear that this process is related to sex (for absolute distances) and continues with age (5, 6, 7, 8, 9, 10,193, 14, 15, 16, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29). However, it is also evident that some structures may be differentially changing due to age and sex as the angulation of various points is also being altered in relation to the cranial base (75, 76, 77, 78, 79, 80, 83, 84, 85, 86, 88, 89, 90, 91, 92, 93, 94, 95, 95, 96, 97, 98, 99) with age. These two comments would then suggest that some of the basic assessments of the occlusion should also be altered. In regard to Down's occlusal plane, in relation to the Frankfort plane, there is a significant trend towards an increase toward a higher angle (steeper occlusal plane) continuing into the late twenties (240) although this trend is unclear when measuring to sella-nasion (233). This curious set of measures perhaps can be accounted for in terms of an age effect on the position of porion with age in males and the confluency of the male and female samples in regard to opposite growth effects seen in the other bones, and due to eruption of anterior teeth as will be noted subsequently which would influence the location of the anterior Down's point.

When assessing the functional occlusal plane, results are much more consistent with expected compensations. In regard to the palatal plane, the sella-nasion plane, and the PM vertical plane, the functional occlusal plane shows a decrease in angulation in the males and stability in the female (246, 232, 249). Thus, while the female occlusal plane is steeper in all regards to begin with, it remains fairly stable through time. Males, on the other hand, show a consistent change toward a flatter occlusal plane. One measure contradicts this, that is the functional occlusal plane (239) as measured to the Frankfort plane. This measure indicates males do not alter through time, however, if it is remembered that porion is descending with age as the posterior aspect of the functional occlusal plane is descending, no change in the occlusal plane is more apparent than real. Regardless of small conflicts in calculated values, it is clear that assessments of the occlusal plane indicate that it is becoming flatter significantly with age in males, except when the anterior teeth are included in the assessment where the tendency there is for a steeper occlusal plane in both sexes. Perhaps more individual tooth configurations will enlighten this relationship as is outlined in Figure 69.

The axis of the upper incisors when measured according to nasion-A point, sella-nasion plane, the palatal plane, and even the mandibular plane all indicate that the upper incisor is constantly uprighting with age (259, 256, 257, 258). It is further interesting to note that no sex differences exist for this inclination except in

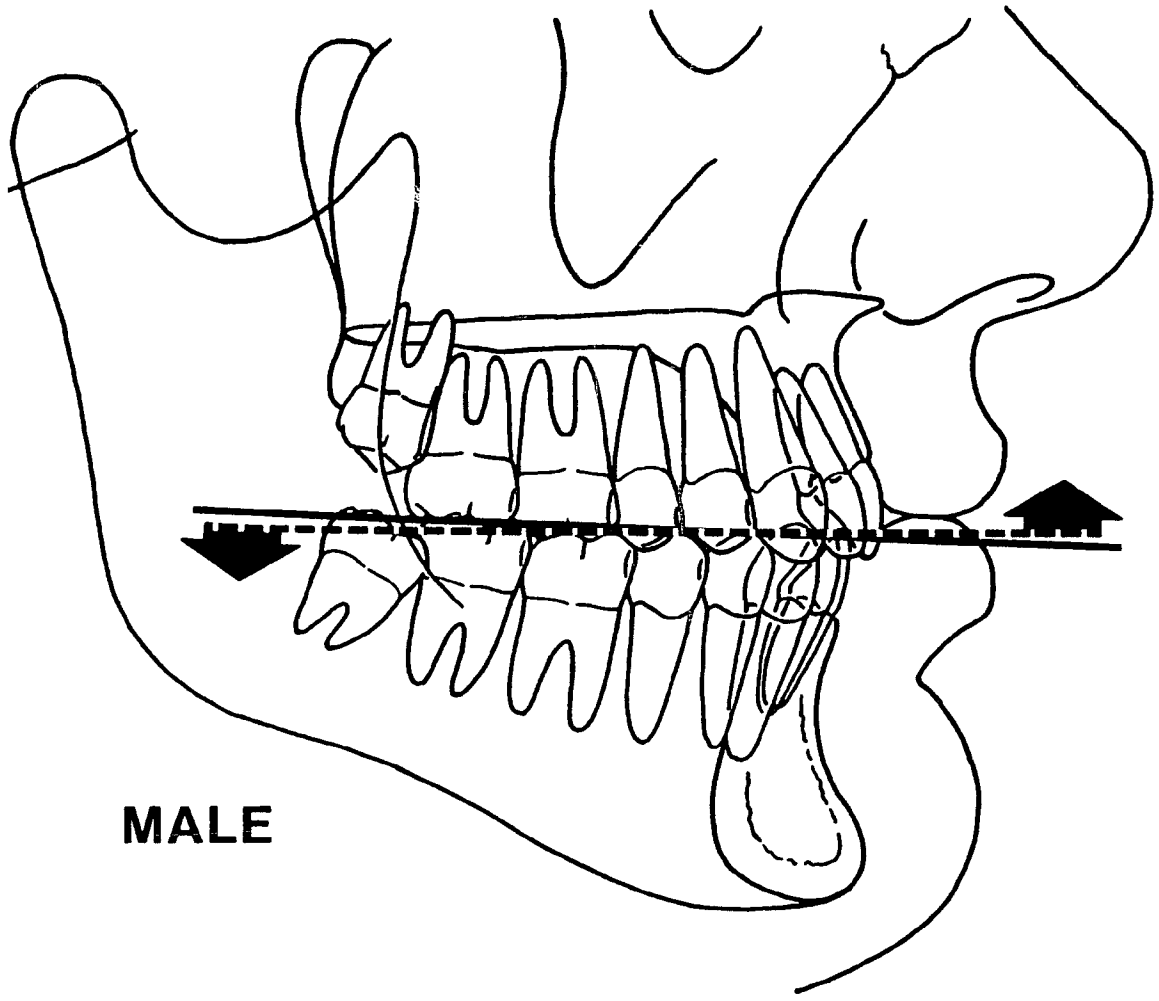


Figure 69. Male occlusal plane changes.

regard to the inclination of the upper incisor in regard to the mandibular plane. This is consistent with previous measures for sella-nasion-A and sella-nasion-palatal plane where no sex difference is noted in the initial and final values, but the converse is the case for sella-nasion-mandibular plane. This would suggest that while the orientation of the mandibular plane is different in both sexes, the inclination of the upper incisor is the same in both sexes and the incisor is constantly uprighting in both sexes into late adulthood.

The behavior of the upper molar is however a bit more complex. Its axis measured in relation to the palatal plane shows a significant uprighting in the male and a tendency for being more distally inclined in the female. There is a significant sex difference in this regard also.

In regard to the axis of the lower incisor measured to nasion-pogonion, A-point-pogonion, Frankfort plane, sella-nasion, palatal plane, Down's occlusal plane, and the mandibular plane the impression is given of consistency of inclination (268, 267, 262, 263, 264, 265, 266), except in the female where a strong tendency exists for a continued anterior inclination of lower incisor (262, 264). A sex difference also is demonstrated (262, 264) indicating a difference for initial and final values between the sexes so that the female incisors are more "flared" anteriorly than males in relation to upper facial structures, but in relation to the mandible they are more upright than males. This is consistent with a relatively re-

truded mandible seen in females where the lower anterior teeth would tilt forward so as to maintain contact as the mandibular plane rotates clockwise.

It appears then that the upper incisors upright in both sexes through age and the lower incisors tilt anteriorly only in the female. One would expect then that the inter-incisal angle would significantly alter in the male but remain stable in the female as the two movements would offset each other. This, indeed is what was seen (261).

The lower molar in relation to the mandibular plane moves complimentary to the upper molar with the molar becoming more upright in the male and a tendency for mesial tipping in the female. Initial and final values also differed on the basis of sex as the male molars were more upright in regard to the mandibular plane (269) These movements are summarized in Figures 70-73.

With the changes in inclination of the incisors one would expect to observe changes in their relative protrusion with less protrusion (or stability) of the upper incisor and more for the female lower incisor. Except for minor details involving complex movements of bones and teeth (176), a stability of relative protrusion of the incisors was observed (177, 178, 176, 158, 157), except for a tendency for more protrusion of the lower incisor (157) in the female.

While some of the movements perceived by the previous measures may be the result of the teeth being carried by the bones

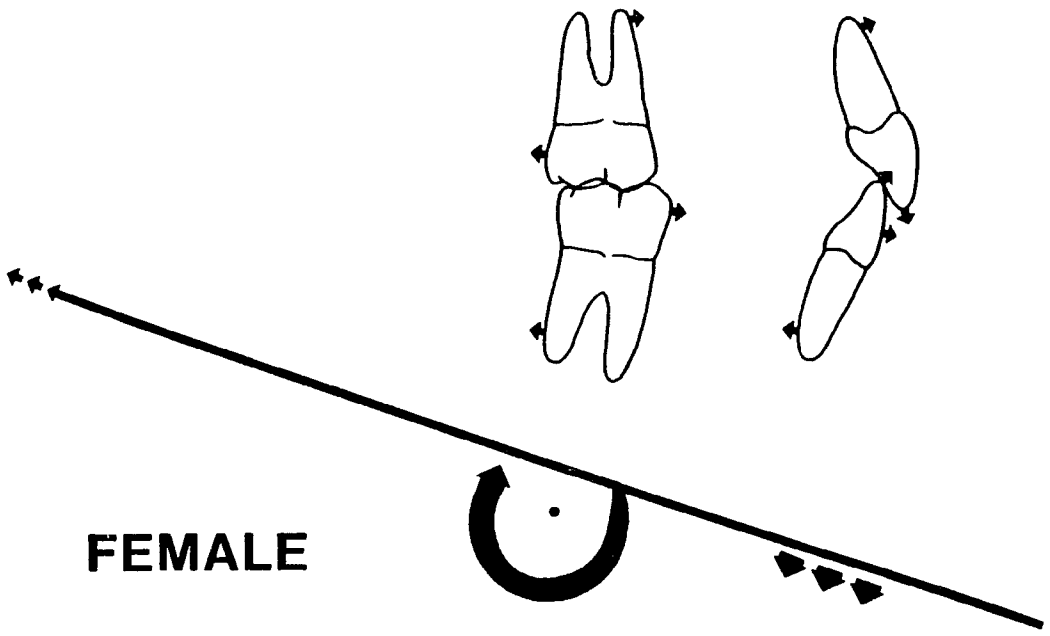


Figure 70. The directions of dental and mandibular plane movements in the female.

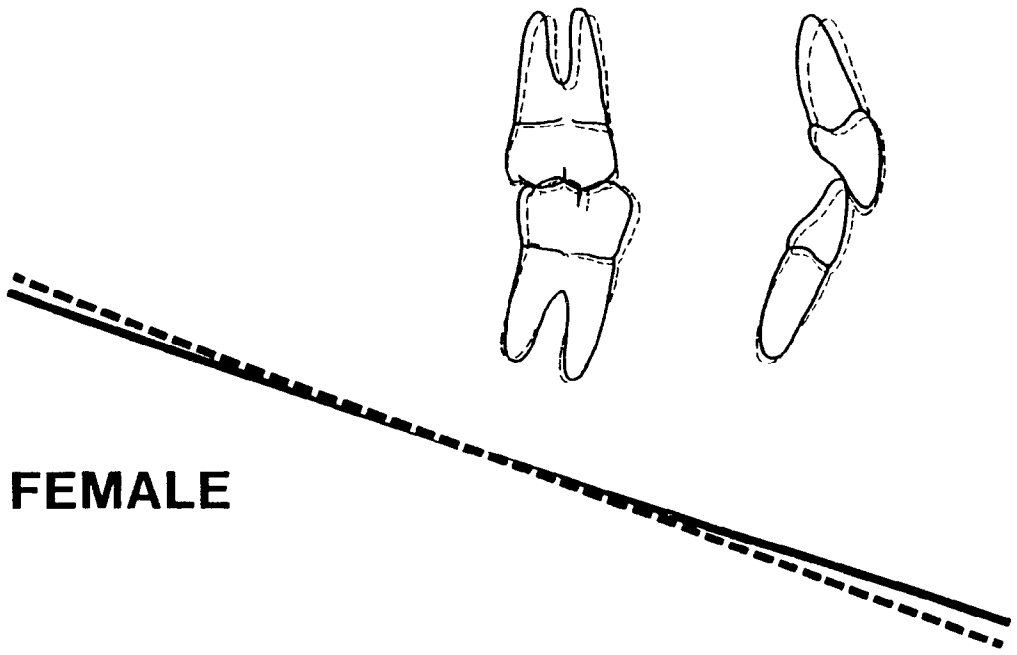


Figure 71. The resultant dental changes in the female.

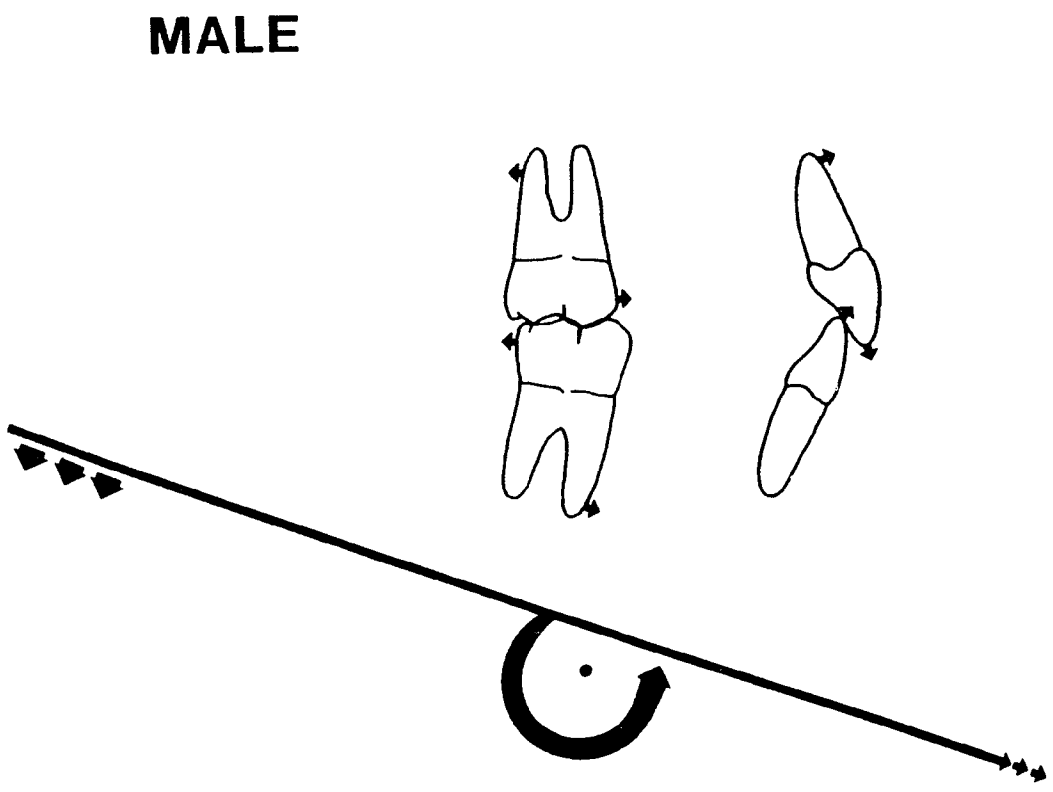


Figure 72. The directions of dental and mandibular plane movements in the male.

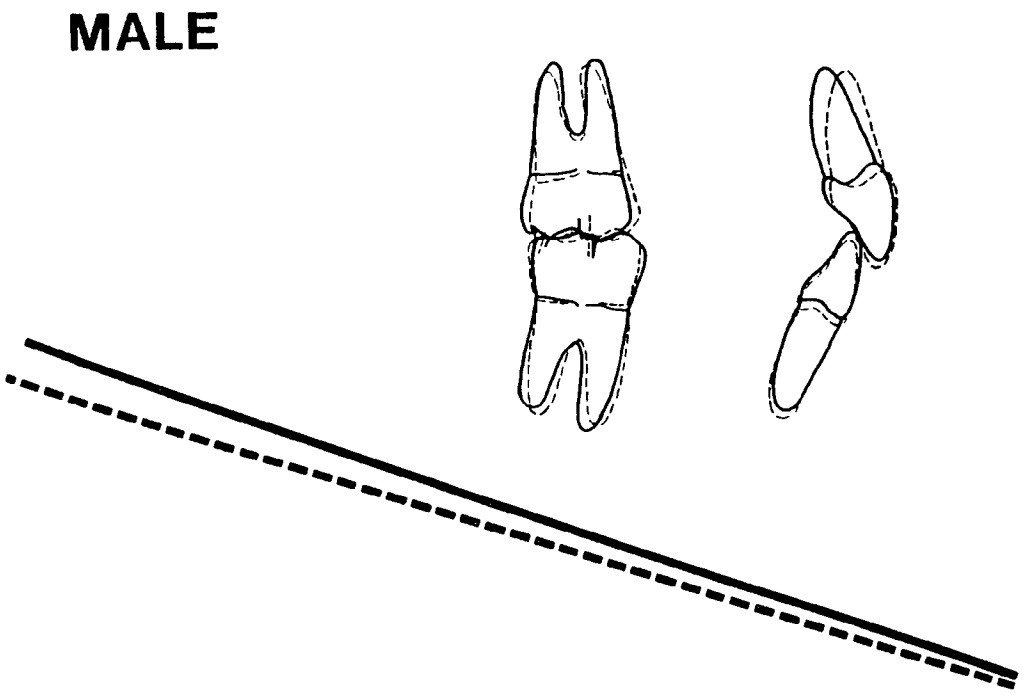


Figure 73. The resultant dental changes in the male.

as they adjust downward it is possible that the teeth themselves are adjusting beyond the axial changes already explored. That is to say the teeth may be continuing their eruption and the alveolus may be altering with time. Inspection of the maxillary arch measured from the palatal plane reveals positive increases in the height of the alveolus anteriorly and posteriorly and continued eruption of the anterior and posterior teeth (171, 172, 173, 174, 175). It is interesting to note that no sex difference exists as to the height of the alveolus anteriorly, but does, posteriorly. In addition a sex difference exists as to the distance from the palatal plane to the incisal edge and cusp tip of the molar. This relationship is perhaps due to the size of the anterior teeth and the height of the posterior alveolus both of which are greater in the male. It should also be noted that these changes in the maxillary teeth appear limited to the younger adult periods.

In the mandibular arch, considerable change also occurs but over the entire period of study. Measured from the mandibular plane there is a continued increase in the height of the alveolus and continued eruption of teeth. There is also a clear distinction as to sex differences for all measures (152, 153, 154, 155, 156) indicating that males have alveolar processes in the mandible which are clearly larger than the female. It should be noted in regard to these measures that it is impossible to ascertain whether the effect measured is the result of deposition of bone on the inferior aspect of the body of the mandible or eruption of teeth with additions of bone to the alveolus. A combination of these factors is most likely.

In spite of inclination changes and eruption of incisors, surprisingly no change in overbite was observed (22). Perhaps this was prevented by the attrition of anterior teeth which was a general observation.

It is clear that the dental area in general is far from dormant during aging, and mirrors or coincides with changes noted in contiguous osseous structures. It is likely that in this dentally healthy population that the dental changes reflect more or less healthy dental changes with age. Further is is unlikely that the dental changes serve to effect the osseous changes seen in this study. Had severe dental destruction been the rule, it is likely that quite different results would have noted as the facial bones would logically be expected to adjust accordingly.

Soft Tissue Profile

The soft tissue mask surrounding the osseous understructure undergoes notable and known alterations with age. The cephalometric analysis demonstrated these changes in detail which were documented to be of a larger order of change than the osseous structures were undergoing, but were coincident with their nature.

Soft tissue glabella moved forward well into the thirties (58). Beside a sex difference in terms of size (58), it was evident the location of glabella was higher in females (127). Glabella tended to move downward in location with time. Similar adjustments were shown for soft tissue nasion (59).

The most anterior point on the nose showed continued movement forward and down throughout all ages examined (60, 129). Males had larger noses (60), however there appeared to be no sex difference in regard to the angular relationship of the anterior nose point to the cranial base (129). The most anterior and inferior point on the nose behaved similarly (61, 130). The movement of the nose is further clarified by two other measures (223, 271) which demonstrate the tip of the nose is moving downward for both sexes but is relatively less prominent in the female (271).

This relationship is also seen in regard to the lips (219). Sella to subnasale shows a significant (but less so than the nose) change (62) which further amplifies the above description of the nose. While a significant increase in this distance occurred in the male at the earlier ages, none was seen in the female. Both sexes showed subnasale moving in a downward direction at all ages. This then would result in the nose of both sexes becoming more "pointed" or acutely angled with time as was noted to be the case (272, 273) with the female nose less acute than in the male.

The relative inactivity of subnasale in relation to the nose also showed an effect in relation to the upper lip. The angle from the tip of the nose through subnasale to the upper lip becomes more acute with age (274). Soft tissue A point is apparently moving forward in an amount and direction similar to subnasale (63, 132) as is the anterior point on the upper lip except that the

downward aspect is apparently more accentuated (133) as the lip lengthens.

Stomion follows the same course as it continually, across all ages, moves farther away from sella (65) and downward from sella-nasion and the anterior nasal spine (222, 134). The lower lip also follows this behavior (66, 135) as does soft tissue B point (67, 136), and soft tissue pogonion (68, 137). The angle formed by the lower lip, mental sulcus and pogonion becomes deeper for the female perhaps as the result of a relatively more prominent lower lip and less forward movement of soft tissue B point. Soft tissue gnathion and soft tissue menton followed similar forward and downward movements for all ages (69, 138, 70, 139).

The continuous alteration of the soft tissue is common to both sexes through time but several measures relate the changes are subtlely different for both sexes, and subtlely proportional in nature. Males have a more prominent soft tissue pogonion (218), a less acute mental sulcus (275), larger more prominent lower lips (217), and a larger more angled nose. Both sexes show relatively less prominence to the upper lip as it elongates (216) through time.

It is interesting to note however, with all the soft tissue alterations the tip of the nose relates continually to the location of stomion (221) showing no effect of age so as to suggest the midface is moving proportionately downward and forward through age. Soft tissue pogonion in relation to stomion increases slightly with time (220) as if to suggest the mandible is following a slightly different developmental course.

In relation to distant osseous structures (Z angle: 276, 277) a straightening of the profile is noted which is to be expected with a flattening of the upper lip prominence as it elongates and as the prominence of the lower lip relatively increases, along with an increase at soft tissue pogonion. Figures 74-76 provide a summary of the soft tissue changes.

The following description speaks little of diminuition, gravitational "sag" of tissues and the like descriptions in terms of degenerations associated with age. It is perhaps more likely that these changes represent the result of subtle differential positive increases in tissue vaguely reminiscent of those associated with embryological and postnatal facial changes.

Mechanisms

In terms of the mechanisms available to account for change, we are pressed by the available literature to conclude that few mechanisms are remaining after adolescence.

The Cranium

In adolescence (and before) it is felt that the calva demonstrates expansion on the basis of surface deposition on its ectocranial surface and resorption on the inner surface along with deposition at its sutural margins. However, the prime cause of an observed expansion is the increase in the size of the brain which is thought to literally effect an outward movement of the bones of the

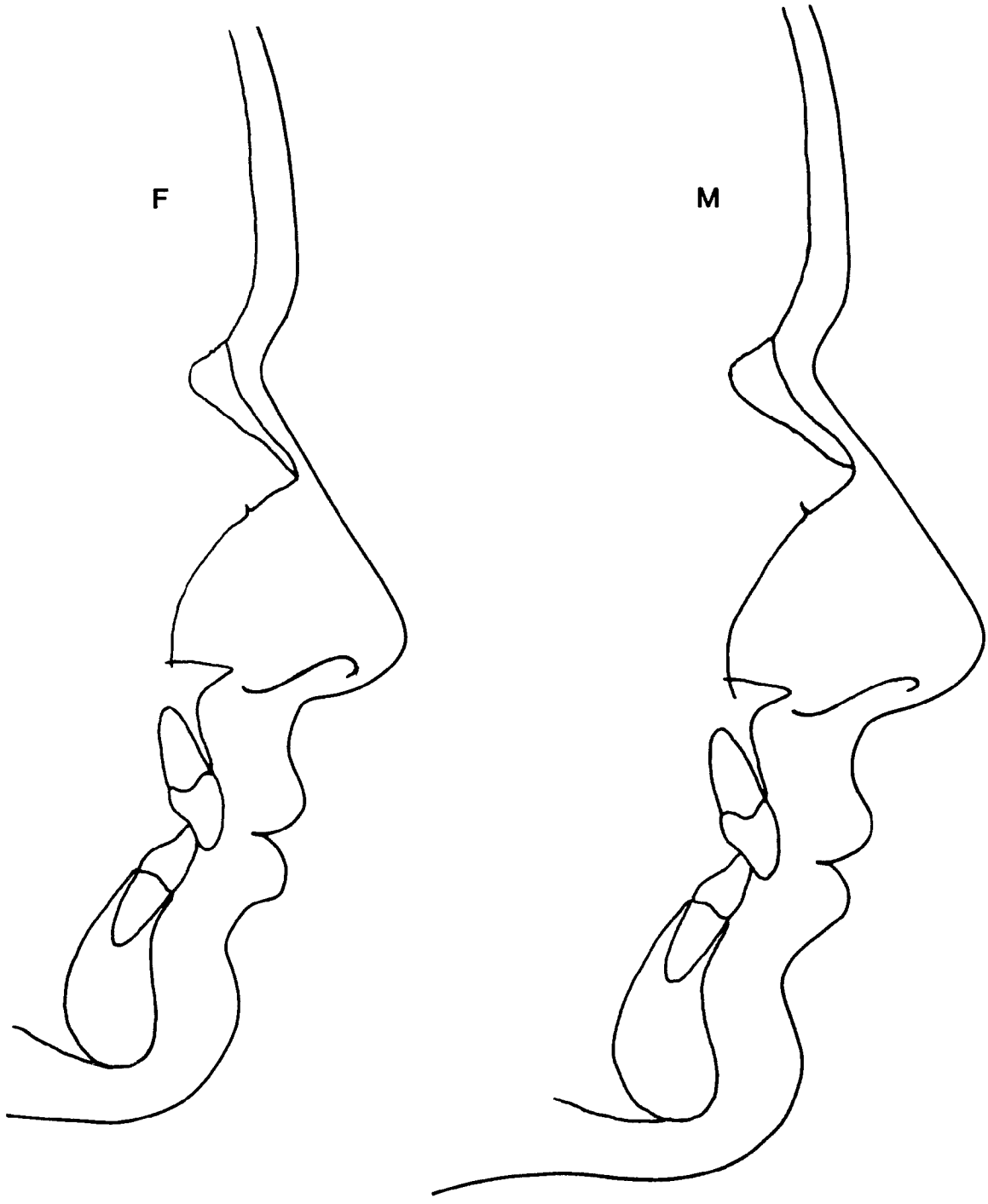


Figure 74. Soft tissue outlines for males and females at the initial ages. A composite picture.

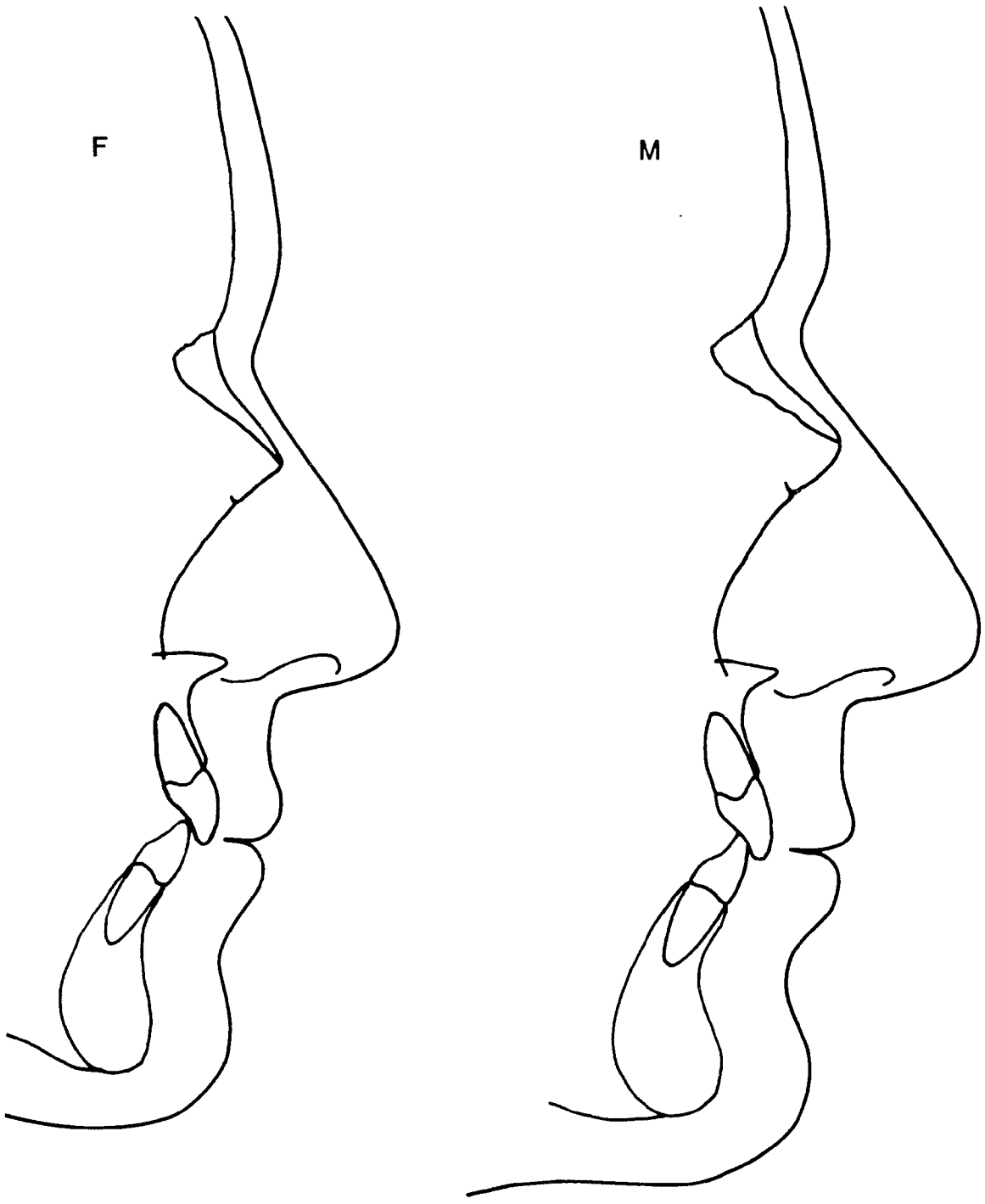


Figure 75. Soft tissue outlines for males and females at the final ages. A composite picture.

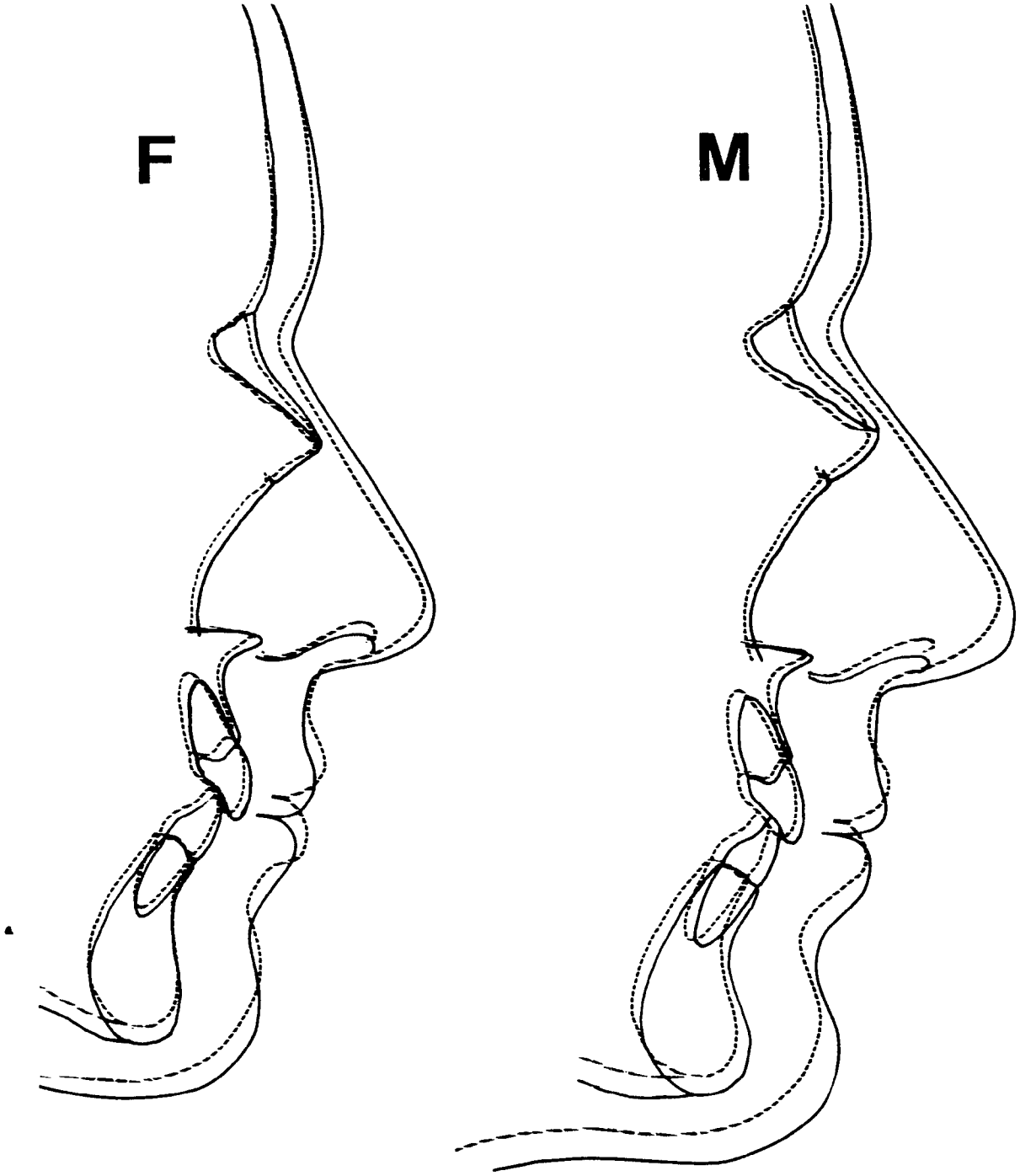


Figure 76. Soft tissue outlines for composite males and females. Superimposition was provided by registering on sella and orienting along sella-nasion. Registering at nasion would provide for a slightly different configurational change.

calva and the sutures react by filling in the voids created at their margins.

In the adult the suture systems appear to be of little significance after age 25 to 30 years (Todd and Lyons, 1925) although sutures are still apparent on older skulls (Scott, 1967). Also there are suggestions that the brain itself actually becomes smaller during adulthood. In the calva then few of the adolescent mechanisms appear available to effect a change in the adult, save remodeling.

In the skull base it is felt that the cartilaginous remnants of embryonic development may play a role in effecting a displacement (or flexure) of both the bones of the calva and the bones of the face during adolescence, although considerable controversy in regard to these actions exist. Proliferation of these cartilages may force the bones of the skull apart with appropriate sutural deposition to replace the void. In regard to the bones of the face two synchondrosal areas may be especially important. The sphenoethmoidal synchondrosis may be important in understanding the anterior displacement of the midface at least until about age 7 when this area is ossified (Ford, 1958). In regard to the sphenooccipital synchondrosis the maxilla and mandible are contiguous with either side of the synchondrosis and proliferation of the cartilage may have special importance in effecting a correlated occlusion of the dentition.

However, the existence of these cartilaginous synchondroses diminishes from birth to adult leading to a suggestion that if

they do play a role in growth and development their importance is greatest in utero and diminishes thereafter. The last remnant of cartilage in this regard is located between the sphenoid and the occipital bones, however, possible adjustment from the spheno-occipital synchondrosis seems unlikely after 25 years of age (Thilander and Ingerval, 1972; Powell and Brodie, 1963; Melsen, 1969; Ford, 1958; Scott, 1958; Bjork, 1966).

The Midface

In the development of the maxilla it is first formed about a template of cartilage which later resorbs for the most part except for the nasal septum. The ossified maxilla then increases in size by subperiosteal deposition. The deposition (and resorption), however is not uniform in the downward and forward growth seen during childhood. Vertical change occurs mainly by surface deposition on the palate, alveolus and the tooth sockets with corresponding resorption on the floor of the nasal cavity and maxillary sinus. There is also growth in the series of sutures which join the maxilla to the cranial base, zygoma and frontal bone. Horizontally, deposition and resorption continually reshape the anterior maxilla, but add little to its anterior extent. Posteriorly, however considerable deposition takes place notably at the tuberosity, the pterygomaxillary fissure and at the sutures which border the palatine and the pterygoid plates of the sphenoid. Anterior and posterior thrust of the maxilla is purported to be accomplished by the cranial base

cartilages and the nasal septum (although other thoughts have been expressed, notably the "functional matrix theory"). The pull of the septo-premaxillary ligament and myofibribroblastic activity in the sutures are also felt to play a role especially in the anterior translation movement of the maxilla.

In the adult, sutural activity seems to be apparently quite dormant in the early twenties (Bjork, 1866; Persson, 1973; Melsen, 1975) although there are obvious exceptions (Kokick, 1976) which suggest sutural adjustment is quite possible into the latest stages of adulthood. In regard to the nasal septum, growth activity was assessed by Vetter et al. (1983) who concluded growth occurred even at 20-35 years especially for the anterior free end. This may have an effect on nose growth, lengthening of the upper lip and maxillary growth depending on the availability of sutural adjustment. These mechanisms may have some importance in the results noted here.

The Mandible

After formation the mandible grows primarily by periosteal deposition all the while maintaining its shape by an interplay of deposition and resorption. The condyle on the other hand is responsible for increases in overall length through growth of the condylar cartilage. While not great in volume of bone produced, the amount is critical in terms of overall coordination of maxillo-mandibular growth. In this regard sufficient condylar and ramal

growth coupled with vertical development of the alveolar processes is necessary to effect a counterclockwise rotation of the mandible, or the opposite may occur should the effect not be sufficient. An intimate relationship is likely also in terms of muscle morphology and osseous condition. The "answer" to whether the growth processes is coordinated will be found in compensation by the dentition or the lack thereof.

In the adult the condylar contribution to growth is felt to terminate later than for the face in general, but not later than approximately 22 years (Bjork, 1951, 1963, 1966). Little change in verall morphology occurs after that time even with dental loss (Keen, 1945). In acromegaly, however, the mandible may obtain a considerably larger size. Apparently condylar growth and considerable remodeling remains possible in adulthood.

The Teeth

The teeth are apparently biologically labile in terms of age and exhibited considerable alteration. Originally considered a response to attrition, uprighting of the incisors has been noted through time (Lysell and Fillipsson, 1958; Hasund, 1965). Eruption of teeth without attrition has also been thought to lead to an increase in facial height due to increases in alveolar height (Hellman, 1927; Herzberg and Holic, 1943; Murphy, 1959; Manson, 1963). Forsberg (1976, 1979) also felt there was eruption of the molars along with a slight rotation of the mandible which gave rise to a

more lingual position of the upper incisors. This occurrence might also give rise to an increase in facial height. Lysell and Myrberg (1971) however feel that the incisors tendency to successively upright themselves might partly be a consequence of the anterior growth of the facial skeleton. This in turn would cause a certain adaptation of the bite to the facial muscles and the tongue.

Remodeling

While it might be possible to envision partially active, periodic, compensatory or initiatory adjustments by the suture systems, condyles, the nasal septum and teeth, it would appear the major mechanism left for critical analysis is remodeling. Remodeling is growth (Enlow, 1978).

Examples of known remodeling activity during aging would include apposition on the lower border of the mandible (Israel, 1973) and apposition at the crest of the upper and lower anterior alveolar crests (Ainamo and Talari, 1976; Forsberg, 1979). Other examples are known for the tubular bones of the body where continued activity has been consistently demonstrated. Likewise there is evidence for this activity in the skull (Israel, 1973; Forsberg, 1976, 1979).

For the sinuses this mechanism is invoked to describe the process of enlargement seen in the maxillary and frontal sinuses. Evans (1938) studied young radium dial painters who had vitally stained their skull, and demonstrated apposition of the anterior surface of the posterior wall of the frontal sinus.

Craniofacial skeleton remodeling has been extensively studied in the adolescent (Enlow, 1968; Hoyte and Enlow, 1966) up to the twenties (Linder-Arronson et al., 1975). Perhaps remodeling activity during aging may in essence be analogous to that occurring during adolescence except for the rate of change, the amount of change, and the demand usually placed on this mechanism.

Perhaps the adult situation describing the overall mechanism involved in craniofacial growth is summarized best by Enlow (1978):

> In all tissues and organs, growth introduces a continuous series of localized imbalances among the parts, and there is a sequential but essentially simultaneous leap-frogging of small-level, catch-up growth changes. Growth is a continual process of part-by-part, region-by-region striving toward a state of ultimate equilibrium. When such craniofacial-wide (and body-wide) balance becomes attained, growth itself is essentially complete. Should some intrinsic or extrinsic change be introduced at any local tissue level, the growth process is reactivated, and tissue proliferation and differentiation provide for transient or short-term growth and remodeling sufficient to restore a state of equilibrium, be it biomechanical, bioelectric, physiological, hormonal, vascular, neurological, or otherwise. In this restricted sense, the endothermic mammalian body like that of the ectothermic reptile, continues to "grow" throughout life.

The present work is consistent with this notation.

Discussion Summary

What is evident from this discussion, is that, what is generally believed about adult growth does not alter the facts of biology which in this case amounts to the admission that growth is apparently operative at wider age spans than previously thought and there may be no cessation of growth at all. As Baer (1956)

believes the distinction between childhood and adulthood is arbitrary and this work amplifies this feeling. The changes noted overall are small, but consistently provide evidence for a continued remodeling of the craniofacial complex throughout life (Figures 77-78). It is also fairly clear that with respect to age and sex, round bones or flat bones behave alike. Growth has no age and true bone expansion is an effect of age.

Significance

The present study which demonstrates continued craniofacial change with age has several important ramifications. Later life changes, though subtle, likely have a significant effect on the physical properties of bone, the dentition, the periodontium and the T.M.J. At present much of what is known in regard to the growing child and the edentulous aged individual is extrapolated to the ages in between. In dental diagnosis, reconstruction, and surgery this is perhaps sufficient, but certainly not appropriate. Proper diagnosis and treatment of facial disorders depends on an understanding of the growth and development of the human craniofacial complex. Hence, the knowledge gained here is not only of academic interest, but also important clinically. In dentistry this material may form a baseline for the evaluation of craniofacial abnormality and pathology for use by the clinicians involved in the diagnosis and treatment of the aging individual.

Figure 77. Growth potential throughout life. Figure adapted from an illustration in the Bolton Study.

Figure 77

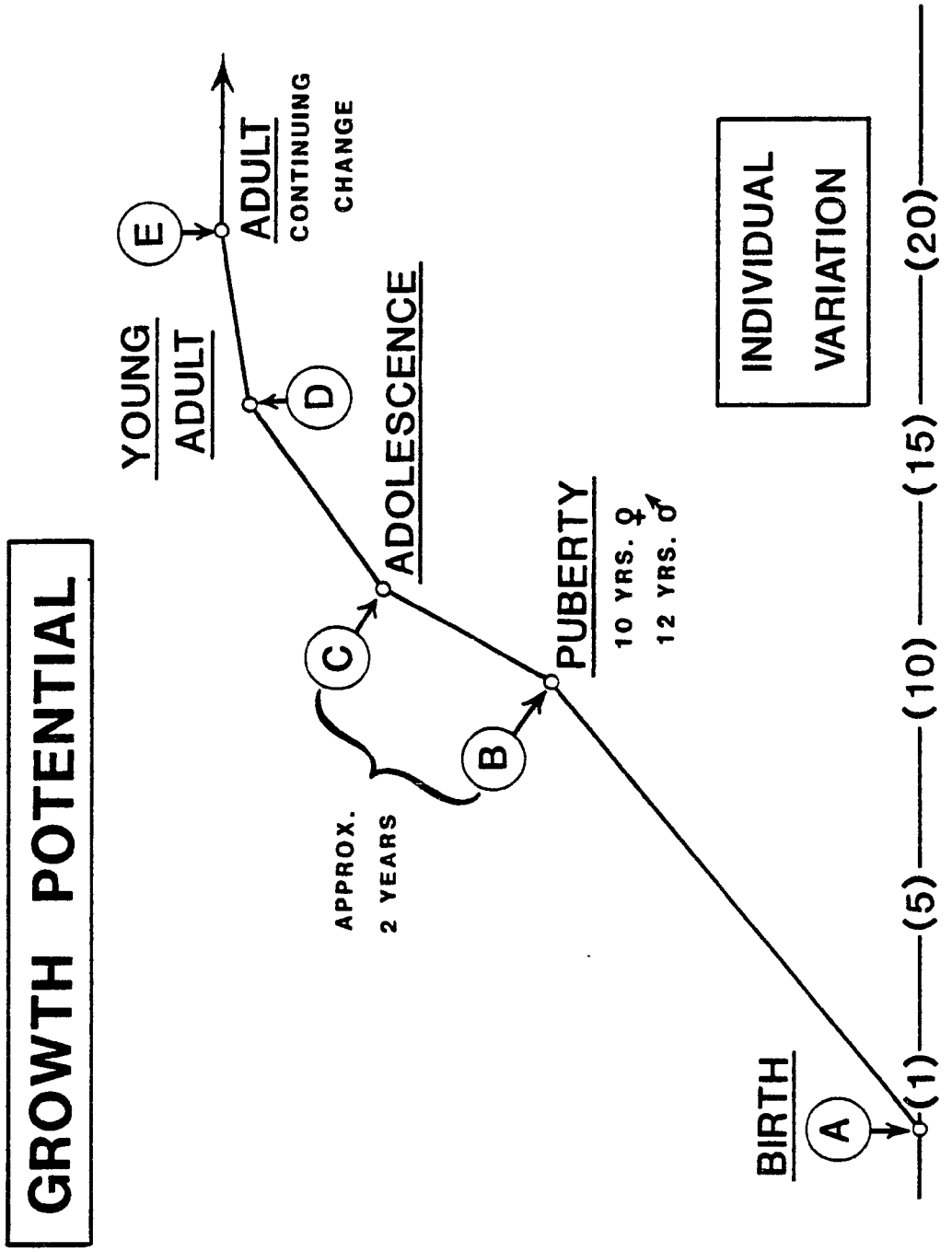
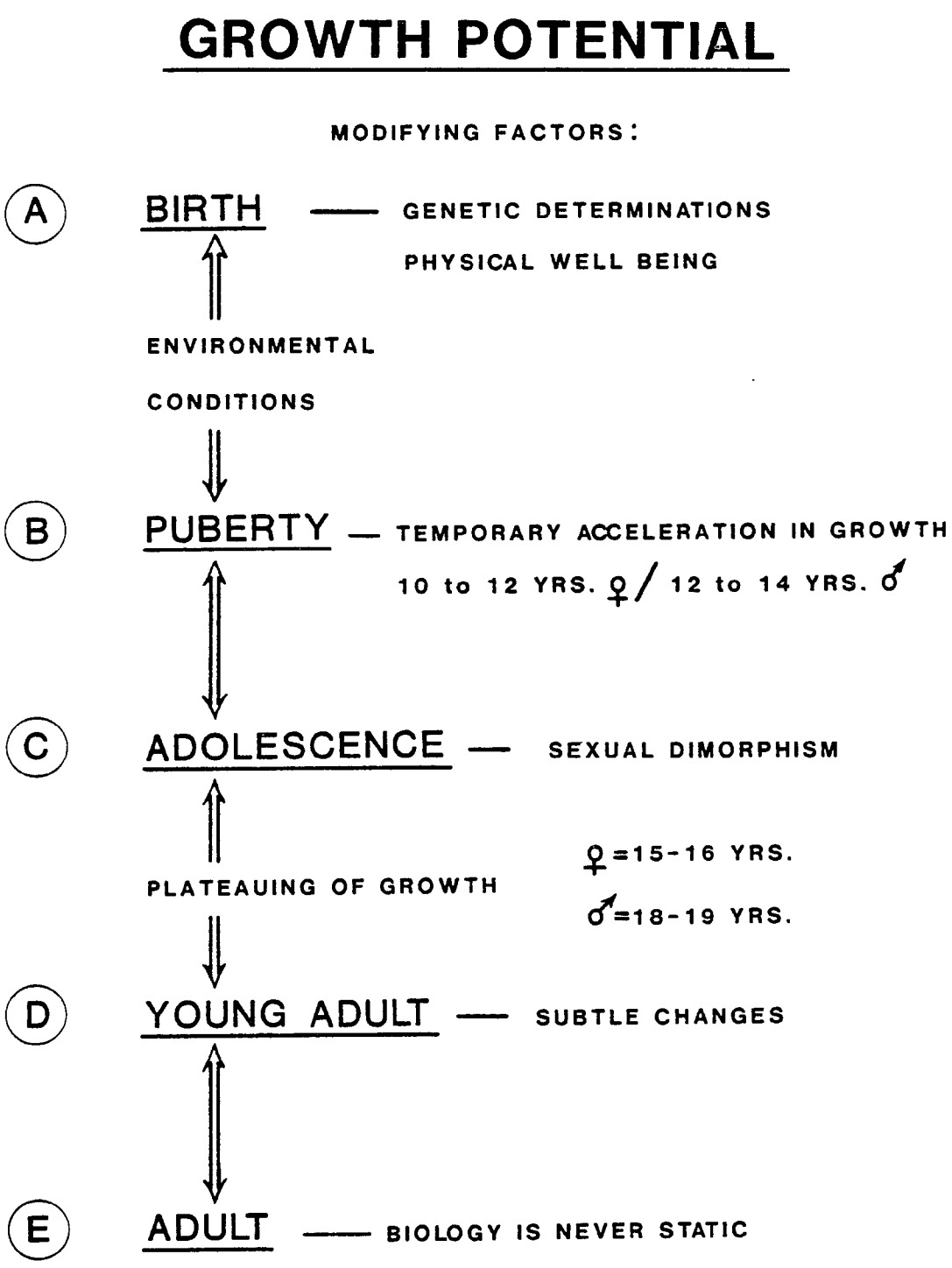

GROWTH POTENTIAL
BIRTH
A
(1)
(5)
(10)
(15)
(20)
INDIVIDUAL VARIATION
PUBERTY
10 YRS. ♀
12 YRS. ♂
B
C
APPROX. 2 YEARS
ADOLESCENCE
D
YOUNG ADULT
E
ADULT
CONTINUING CHANGE

Figure 78. The stages of growth and development. A summary adapted from a drawing in the Bolton Study.

Figure 78


GROWTH POTENTIAL
MODIFYING FACTORS:
A
BIRTH
GENETIC DETERMINATIONS
PHYSICAL WELL BEING
ENVIRONMENTAL
CONDITIONS
B
PUBERTY
TEMPORARY ACCELERATION IN GROWTH
10 to 12 YRS. ♀ / 12 to 14 YRS. ♂
C
ADOLESCENCE
SEXUAL DIMORPHISM
PLATEAUING OF GROWTH
♀=15-16 YRS.
♂=18-19 YRS.
D
YOUNG ADULT
SUBTLE CHANGES
E
ADULT
BIOLOGY IS NEVER STATIC

In reconstructive dentistry and orthodontics, maintenance of the status quo, "occlusal stability", is thought to be an important conceptual basis for diagnosis, treatment and research (Graf and Geering, 1977). In contrast change and altering spatial relationship may be the more important conceptual view and physiologically correct characteristic of the adult.

In terms of restorative dentistry, several general observations are of significance. Notably some severe third molar impactions were apparently not noted even under routine dental care. Also it was readily apparent that the greatest source of damage to the teeth was cervical abrasion from toothbrushing. Restorative materials were assessed to be in good condition for those made of gold (and silver points and gutta percha for endodontic procedures), while old amalgam restorations were generally judged in poor condition. Although all participants were reportedly under care at present, most dental restorations present were "old".

For the prosthodontist these results may explain why some dentures poorly occlude after a number of years. A loss of alveolar crest and resultant loss of vertical dimension may play a role in this observation, but so may growth. Also in regard to prosthetic tooth arrangement it may be necessary to rethink arrangements on the basis of soft and hard tissue age changes so as to prevent an "18 year dental look" in an aged individual. Tooth arrangement in relation to soft tissues and age should not be contradictory unless that is a goal. Further, realizing that growth

may be occurring, in the future it may be possible to make use of this possibility for formation on the arches instead of observing loss of alveolar bone.

In regard to periodontics, aging should be thought of as positive or increasing rather than in the negative degenerative terms commonly used in reference to age related loss of investing bone, teeth and alterations of mandibular morphology. Age itself does not mean tooth loss or bone loss. Much to the contrary.

Ainamo (1978) in summing the results of previous (X-sectional) studies in regard to the relationships between soft tissue (mucogingival junction, attached gingiva) and hard tissue structures (nasal floor, lower border of the mandible, cementoenamel junction) deduced that growth of the alveolar process occurred with age (20's to 50's). This view is also shared by Weinman (1941), Anneroth and Ericson (1967), Loe and Listgarten (1973), and Batenhorst et al. (1974). Ainamo felt this was the cause of an increase in facial height with age as noted in the literature. In males, Ainamo (1978) felt there was some age related increase in the maxillary basal bone in agreement with Hersberg and Holic (1943), and Baer (1956). The increases noted by Ainamo were noted here, but in view of the ever changing osseous structures he used as stabile landmarks, the stability of the soft tissue arrangement can be questioned. Mazeland (1980), Batenhorst et al. (1974), Boyd (1978) and Dorfman (1978) however, have indicated increasing gingival width with age. Whatever the result, it is clear that an increase in alveolar height is possible in the absence of pathology.

In regard to the occlusion it is very clear that teeth can and do change in position with age. The changes, both in bone and tooth position are subtle, but change does occur and this will have significance as the teeth relate to occlusal status. It is clear that microns of movement occur per year, but it is also clear inter-occlusal discrimination is 10-20 microns (Moller, 1978). As such an occlusal adjustment should not be considered definitive, but rather palliative as time will alter relationships so carefully ground in.

The results of the T.M.J. examination are discussed elsewhere, but suffice it to say this study provides little basis by which future T.M.J. symptoms could be predicted. In spite of "poor" occlusions, little T.M.J. distress was seen.

In regard to orthodontics, age has historically played an important part in designing treatments for the adolescent. This study contends no less importance should be given to treating the adult. As adults do change through time, it is at the very least necessary to use "age loaded" standards (at present--adolescent) to assess the adult. If this was not done during the formulation of a dento-skeletal diagnosis, it is not unreasonable to imagine that an orthodontic patient sent to an oral surgeon might also have a genial reduction on the basis that the patient is 50 years of age (or rather because they are not 18) rather than because their lower face height was too long for their age. Also, in diagnosis and treatment assessments, it is clear that the basic tenents of superimposition (based on a point of growth cessation) remains a problem.

Perhaps the methods of Bookstein will successfully circumvent this problem.

In developing predictive aids regarding facial growth and third molars, it is obvious that the present information is not included in such schemes, which make them more incomplete than they presently are. This material will be useful in assessing the need for extraction of third molars. Perhaps an awareness of change beyond the teen years, will elicit the development of new "clinical laws" regarding third molars and growth. Certainly present "third molar prediction" schemes are flawed in their disregard of the possibility for change after 18 years of age.

In terms of treatment of adults, the amount of growth present over a two year treatment will have no substantive influence (beneficial or negative) on treatment. This is especially important to note in regard to "functional appliances", and this study should not be used as justification for their use in adults. That is because, when applied to a standard Class II malocclusion, if normal adult maxillary growth is slowed and normal adult mandibular growth is simply permitted or slightly enhanced, it is estimated that in the absence of other factors the functional appliance would have to be worn more than a decade or more to effect the correction.

In regard to relapse, this study has a direct bearing. Orthodontists have a concept that after braces (especially with retainers) that we as orthodontists are totally responsible, through our care and treatment for lasting perfection and stability. How-

ever, the orthodontist has little control over the biological aspects of change and even less control over the feeling of guilt and dishonor should the perfect result find its way into the closet. Certainly there are relapses when certain physiological relationships are overwhelmed by improper diagnoses, appliances and improper technique (overexpansion, incomplete correction, poor uprighting, etc.), but orthodontists must admit the possibility of post-orthodontic change over time due to the continued growth of the craniofacial complex, and certainly we should diminish the guilt when it does occur. On the other hand, the present results should be used to enlighten and form the basis for further study and not form the basis for excuses.

On the basis of results contained in the present study it would be fairly easy to envision clinical laws which might suggest some criteria for expecting relapse. On the basis of the present study, a suggestion can be made that a treated case's future growth may lead to relapse or may even enhance the correction. The results also suggest Angle Class II females malocclusion may be more prone to relapse after treatment and during adulthood than Class II males. Similarly, Class III males would be more prone to relapse than Class III treated females. The awareness of the events of adult change serve to form an appreciation for the possibilities in this regard.

In regard to surgery of the face, it may be forensically inappropriate to apply late adolescent standards to adult patients as is common practice at present. Also, the question of when to surg-

erize, based on the premise of waiting until growth ceases, should be scrutinized, especially in view of some of the dramatic changes present in the twenties. Pubertal growth markers may indicate the end of puberty but not the end of craniofacial growth. More likely a slowing. Perhaps, in balance, a series of cephalograms should be taken (if remaining growth is important) to determine the extent of change.

This material may also be used to provide some information regarding orthognathic surgery relapses. Some long term relapse may be the result of the poor growth, evident prior to surgery, re-expressing itself after surgery, and not the result of poor technique. What would be more desirable is to actually affect a change in the osseous structures and their future growth so even though they grew, the growth was now in balance.

In clinical sciences, if one is dealing with dental or facial reconstruction where stability of the adult craniofacial architecture is assumed, expected and desired and supposedly necessary to stabilize the sometimes subtle nuances of dental reconstruction and surgery, the clinician is assuming a somewhat niave position. It is untenable really to consider the craniofacial skeleton and its growth is switched off like a light switch (or a dimmer) and thereafter is not capable of change. To think that the craniofacial complex has entered a period where the ever-so-responsive face of prepuberty and puberty is no longer inflicted with changes in environmental pressure or ability to alter is not logical. Change is the only sure-

ty during adulthood as a subtle response and continued conformation of the organism in regard to its state. Regardless of the sophistication of the corrective technology, if the biology of the system being corrected is not known or appreciated, correction is likely to ultimately fail and deemed a technological failure or an unfortunate accident of biology. However, biology itself makes few mistakes.

In related disciplines, the results here may have some meaning. In terms of speech alterations with age a change in the internal and external skull architecture is compatible with known alterations in speech quality, notably reduced vowel formant frequencies (Kent, 1979).

For radiology it is important to recognize the altered density of the structures to be radiographed. Soft tissue shields used in cephalometrics may have to be altered for the adult. This would also effect measurement of the mineral content of bone.

In forensic and anthropometric reconstruction, identification and judgement of age it is necessary to realize the adult changes. When realized, this may be used to advantage; without it, induced confusion may result. In anthropometric cross-sectional studies among populations, samples are usually grouped on the basis of dental condition. Beyond the eruption of third molars, proper aging of material may be difficult in the absence of discrete traits. One would wonder if measures of "robusticity" were valid unless age and patterns of adult bone gain and loss were carefully taken into account.

For the researcher this information should be of worth in improving insight into facial growth processes, provide data for comparison with other past and future studies, form a baseline for evaluation of craniofacial abnormalities and pathology, help in craniofacial prediction schemes and assist those involved in pattern recognition and craniofacial taxonomy. In regard to teaching, this material is expected to provide a new, previously non-existent block of information in regard to communicating and understanding the attainment and aging of physical morphology. Perhaps this material, however, will be of greatest value relevant to the development of new concepts of growth, development, and aging and the evaluation of these new data in the light of old principles.

As a concept in the study of aging, it may be important to recognize the idea of continued growth in regard to life span. Animals which continue to grow indefinitely have poorly defined life spans or it is not possible to say what the life spans are (Kohn, 1978). With increasing time we may be growing more slowly and aging more rapidly as an inverse developmental process (McCay, 1952; Simms, 1956) which may be inhibitory or contradictory in nature. Lengthening of life may be the result of continuing growth (Kohn, 1978). In a more general sense before the aspects of aging can be predicted and controlled, they must be described. This is an attempt in this regard.

Thus, perhaps the significance of this work is perhaps foremost in terms of reopening one's thoughts to the possibility of change in the adult.

CHAPTER V

CONCLUSIONS

It is clear the ability of cells, tissues and organs to produce change in the craniofacial complex ceases perhaps at death and not at some developmental event along the way. Growth as defined continues. The importance of the study is not in the amount (although this may be important clinically) but rather that change could and did occur--which in essence reaffirms a physiological principal which in thought could well be used someday by the clinician to influence and direct bone formation.

This growth cannot be explained solely on the basis of remodeling and thus is contrary to contemporary thought regarding the mechanisms of craniofacial growth.

1. Considerable craniofacial alteration occurs beyond 17 years of age in the human.

2. Growth of the craniofacial skeleton continued into the oldest age spans studied in an apparently decelerating manner.

3. Both size and shape attributes of the craniofacial complex altered with time. Differential change was evident.

4. In young adulthood the directions of growth were apparently specific to the individual and sex. In later adulthood vertical dimensional change appeared common.

5. Growth of males differed from that of females. Females were smaller at all ages, grew less, and grew in a more vertical direction than females.

6. Mandibular plane rotations in a forward direction were seen in males with posterior rotations in the females. Compensatory changes were noted for the dentition.

7. An apparent deceleration of growth in the females in the teen years was followed by a resumption of increased activity in the twenties.

8. Besides size, males and females showed dimorphism especially in the region of the orbit with the female demonstrating a more upright and superior orientation.

9. Enlargement of the 3rd cervical vertebra in terms of external dimensions was demonstrated.

10. Orthodontically treated cases and those individuals with multiple tooth loss also demonstrated continuous change, but the nature and amount was different from untreated dentally healthy individuals. Significant differences were noted in the size and position of the mandible and development of the midface.

11. Soft tissue changes were dramatic as expected, of a greater nature than skeletal alteration, and primarily involved an elongation of the nose, flattening of the lips and augmentation of the chin.

Death is but an end to dying

Montaigne

Death is but an end to growing

Sinclair

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A TREATISE ON THE CONTINUUM OF GROWTH IN THE AGING CRANIOFACIAL SKELETON

VOLUME II

by

Rolf Gordon Behrents

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Human Growth and Development)
in The University of Michigan
1984

Doctoral Committee:

Professor Robert E. Moyers, Chairman
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APPENDICES

APPENDIX A

CALCULATIONS

KEY TO CALCULATION ILLUSTRATIONS

Measure: 4 different types of measures are demonstrated.

SIMP = Simple linear distance between two points

PDIS = Linear perpendicular distance between a point and a line

3PTA = An angular measure involving 3 points

4PTA = An angular measure involving 4 points

T-Test: 2 different contrasts are shown.

A paired T-test is indicated by "T" for initial to final ages
P
and "T" for paired with altered initial ages.
age

A two-sample T-test is specified as "T" for a male-female contrast.
SEX

"T" for an untreated-treated contrast; and
UNTX

"T" for an untreated-major dental problem contrast.
Dental

Significance Levels:

* = probability 0.05

** = probability 0.01

*** = probability 0.001

SAMPLE SIZE

CALCULATION OON
MEASURE N
NAME SAMPLE SIZE

INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
113	113	113	113	113	113	113	52

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	113	113	79	79	34	34	226	56	27	10	4	28	282	12	250
INITIAL	113	Prs.	79	Prs	34	Prs.		Prs.	Prs.	Prs.	Prs.	Prs		Prs.	

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83	
MALE	MEAN SD N	84	31	63	36	39	(253)
FEMALE	MEAN SD N	39	24	29	27	15	(134)
		(123)	(55)	(92)	(63)	(54)	((387))

AGE

CALCULATION 00A
MEASURE AGE
NAME AGE OF SAMPLES

INITIAL TO FINAL

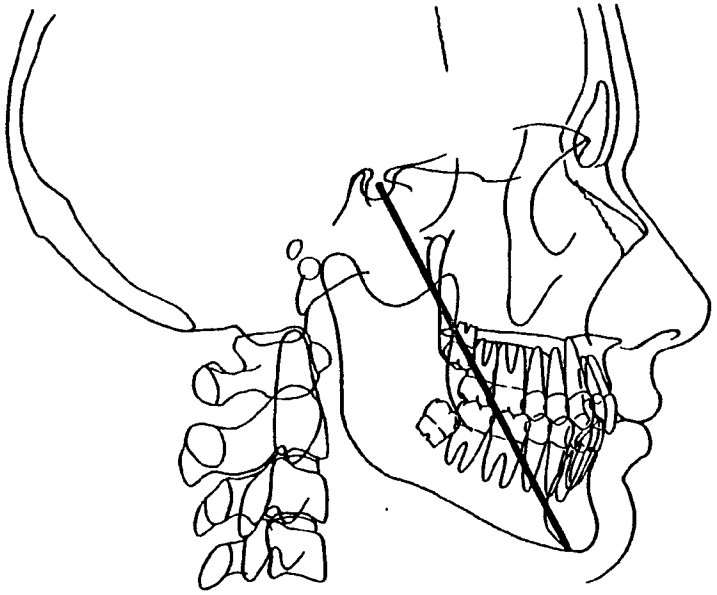
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
113	0	26.7	13.4	50	6	-	1.00

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	46.4	***	46.6	***	46.1	***	-	51.2	53.8	67.2	70.5	39.2	-	64.1	-
INITIAL	19.7		19.8		19.6			30.9 ***	35.6 ***	41.5 ***	50.3 ***	18.7 ***		25.3 ***	

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN SD N	17-18	19-20	21-30	31-50	51-83
FEMALE	MEAN SD N	17-18	19-20	21-30	31-50	51-83



CALCULATION 001

MEASURE SIMP 46-1

NAME SELLA TO MENTON

INITIAL TO FINAL

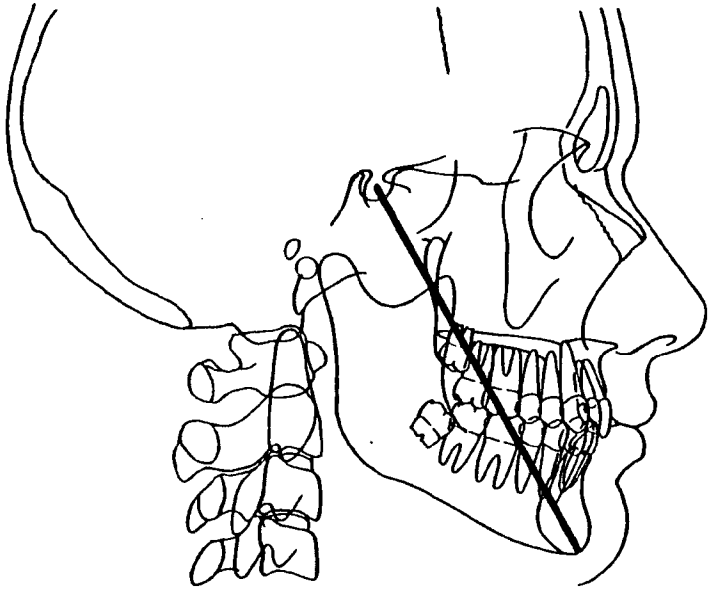
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
107	6	2.9	2.6	16.1	-3.1	2.2	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	131.7	***	135.1	***	124.0	***	***	***	***	***	**	**	*	**	***
INITIAL	128.9		131.9		121.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	131.7	133.1	134.0	135.4	134.1
	SD	5.7	6.6	6.8	8.4	6.8
	N	84	31	63	36	39
FEMALE	MEAN	121.6	121.5	120.1	123.0	126.5
	SD	5.2	5.0	5.8	7.0	6.5
	N	39	24	29	27	15



CALCULATION 002

MEASURE SIMP 46-2

NAME SELLA TO GNATHION

INITIAL TO FINAL

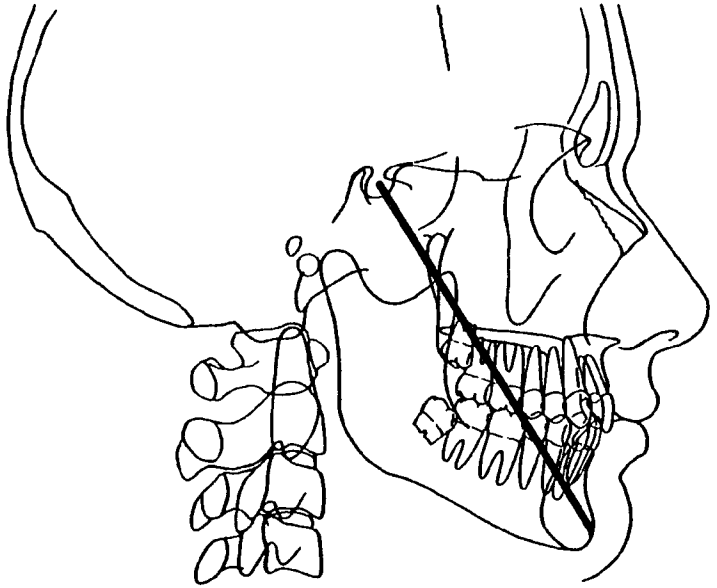
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
106	7	2.8	2.4	15.4	-.7	2.1	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	134.1	***	137.3	***	126.4	***	***	***	***	**	_	***	*	**	***
INITIAL	131.3		134.2		124.5										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	133.9	135.4	136.2	137.9	136.2
	SD	5.5	6.6	6.9	8.5	6.8
	N	84	31	63	36	39
FEMALE	MEAN	124.2	124.2	123.0	125.5	128.9
	SD	5.0	4.7	5.4	7.2	6.6
	N	39	24	29	27	15



CALCULATION 003

MEASURE SIMP 46-3

NAME SELLA TO POGONION

INITIAL TO FINAL

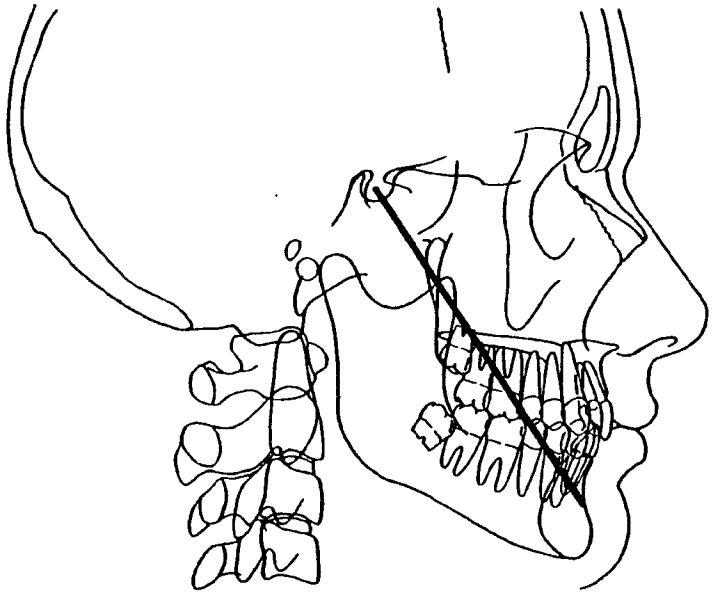
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
110	3	3.0	2.5	16.0	-.4	2.3	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	129.5	***	132.5	***	122.5	***	***	***	***	*	—	***	—	***	***
INITIAL	126.5		129.3		120.2										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	129.0	130.6	131.3	132.9	131.4
	SD	5.5	7.0	6.9	8.5	6.5
	N	84	31	63	36	39
FEMALE	MEAN	119.8	119.8	118.7	121.2	124.7
	SD	5.0	4.8	5.5	7.0	6.0
	N	39	24	29	27	15



CALCULATION 004

MEASURE SIMP 46-4

NAME SELLA TO B POINT

INITIAL TO FINAL

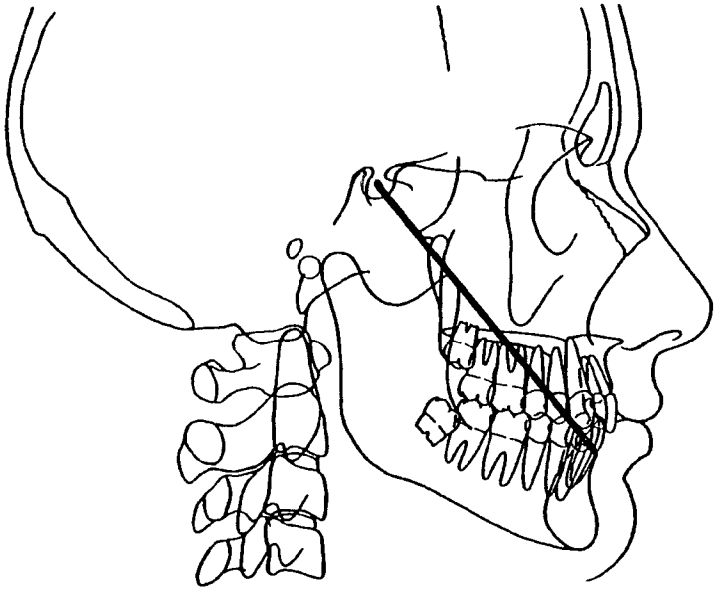
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
95	18	2.0	2.2	11.0	-2.0	1.8	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	115.1	***	117.5	***	109.5	***	***	***	*	—	—	**	—	—	—
INITIAL	113.1		115.2		108.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	115.1	115.8	116.9	118.0	116.2
	SD	5.3	6.4	6.2	7.0	6.4
	N	84	31	63	36	39
FEMALE	MEAN	108.2	107.8	106.7	108.8	111.2
	SD	3.6	4.0	4.1	5.4	5.3
	N	39	24	29	27	15



CALCULATION 005

MEASURE SIMP 46-5

NAME SELLA TO INFRADENTALE

INITIAL TO FINAL

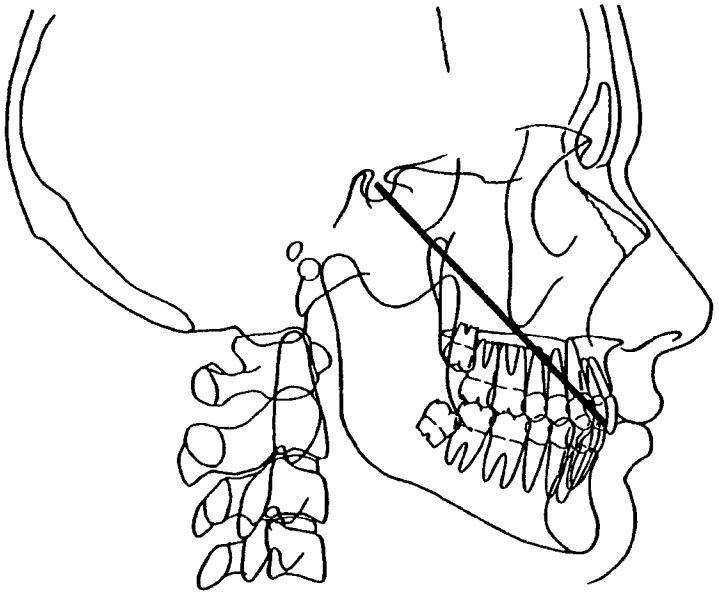
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
103	10	2.0	1.9	10.9	-1.2	1.8	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	110.3	***	112.4	***	105.3	***	***	***	**	*	*	***	—	NA	NA
INITIAL	108.3		110.2		103.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	110.1	110.8	111.5	113.3	111.2
	SD	4.9	5.7	5.6	6.4	5.8
	N	84	31	63	36	39
FEMALE	MEAN	103.9	103.9	102.9	104.6	107.1
	SD	3.5	3.6	3.4	4.6	4.9
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 006

MEASURE SIMP 46-6

NAME SELLA TO LOWER INCISOR INCISAL EDGE

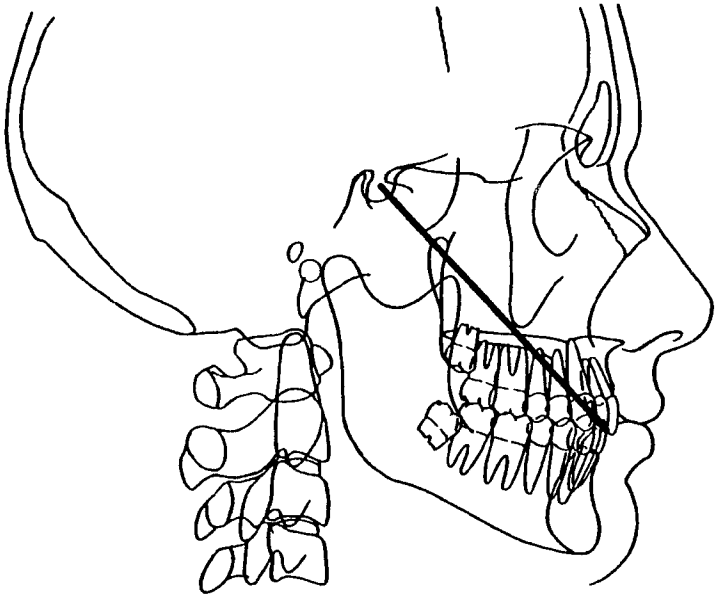
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
98	15	2.0	1.9	9.9	-1.4	1.9	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	104.2	***	106.1	***	99.6	***	***	***	**	**	—	***	—	NA	NA
INITIAL	102.2		104.0		98.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	103.8	104.5	105.1	107.5	104.9
	SD	5.1	5.5	5.4	5.8	5.9
	N	84	31	63	36	39
FEMALE	MEAN	98.3	98.3	97.7	98.6	101.7
	SD	3.4	3.5	3.3	4.5	4.4
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 007

MEASURE SIMP 46-7

NAME SELLA TO ANTERIOR DOWNS POINT

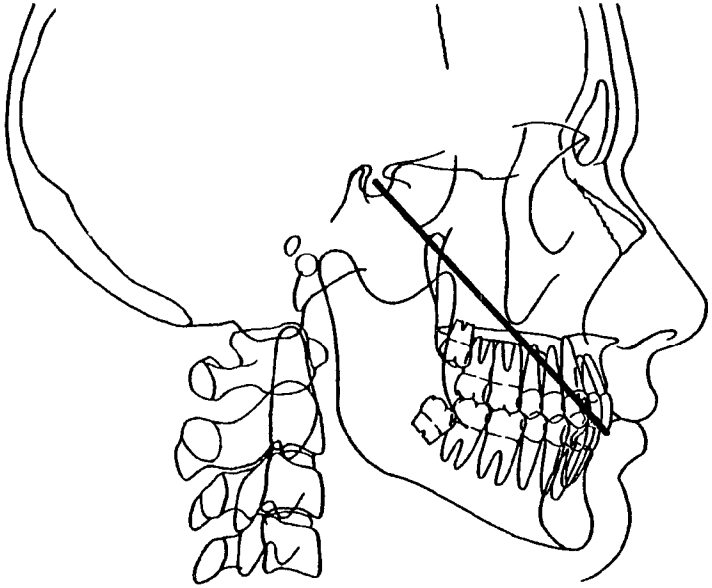
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
102	11	1.9	1.7	9.4	-1.1	1.9	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	106.6	***	108.7	***	102.0	**	***	***	**	**	—	***	—	NA	NA
INITIAL	104.7		106.6		100.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	106.4	107.1	107.5	109.9	107.8
	SD	4.8	5.1	5.0	5.6	5.4
	N	84	31	63	36	39
FEMALE	MEAN	100.6	100.5	100.0	101.2	104.1
	SD	3.4	3.7	3.4	4.5	4.2
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 008

MEASURE SIMP 46-8

NAME SELLA TO UPPER INCISOR INCISAL EDGE

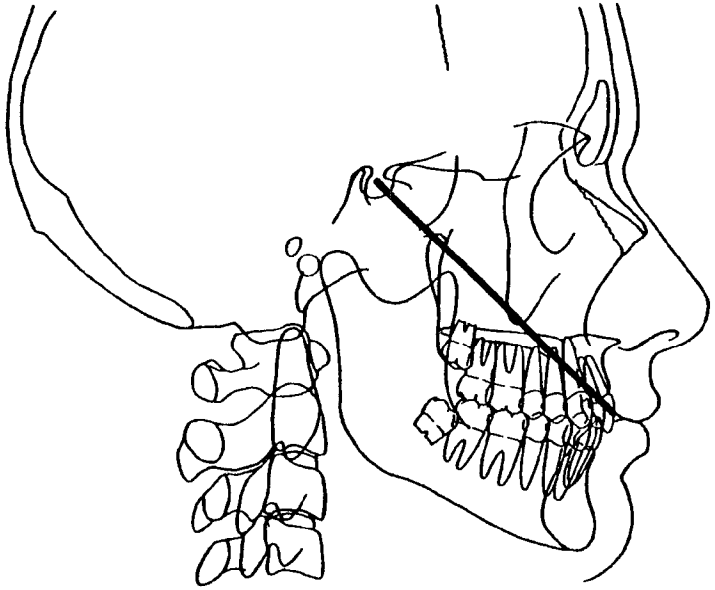
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
105	8	1.9	1.5	7.8	-.8	1.8	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	109.3	***	111.4	***	104.5	***	***	***	***	*	—	***	—	NA	NA
INITIAL	107.5		109.4		102.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	109.3	109.9	110.2	112.6	110.9
	SD	4.7	4.9	4.7	5.6	5.1
	N	84	31	63	36	39
FEMALE	MEAN	103.3	102.9	102.6	104.1	106.7
	SD	3.5	4.0	3.8	4.8	4.0
	N	39	24	29	27	15



CALCULATION 009

MEASURE SIMP 46-9

NAME SELLA TO LABIAL OF THE UPPER INCISOR

INITIAL TO FINAL

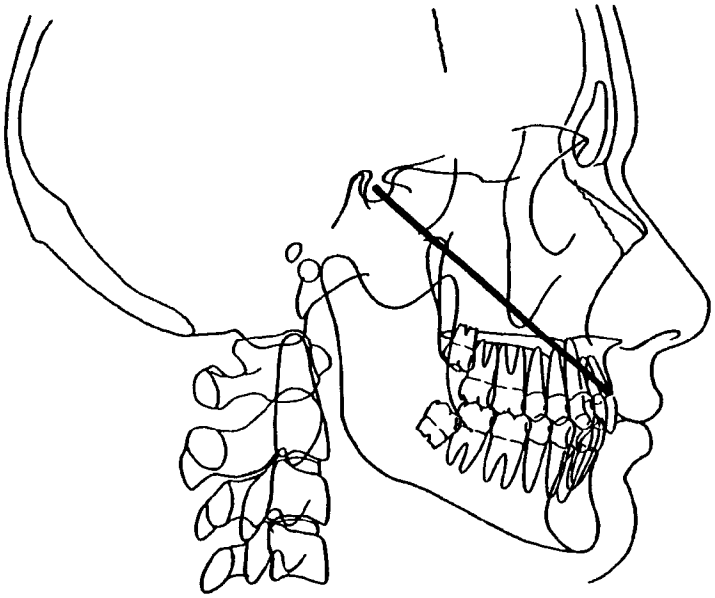
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
104	9	2.5	1.9	8.6	-2.5	2.4	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	106.5	***	108.5	***	102.0	***	***	***	***	*	—	***	—	NA	NA
INITIAL	104.0		105.9		99.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	105.7	106.3	106.8	109.5	108.1
	SD	4.6	4.8	4.5	5.7	5.1
	N	84	31	63	36	39
FEMALE	MEAN	100.2	100.1	99.9	101.3	104.0
	SD	3.4	3.9	3.5	4.8	3.5
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 010

MEASURE SIMP 46-10

NAME SELLA TO SUPRADENTALE

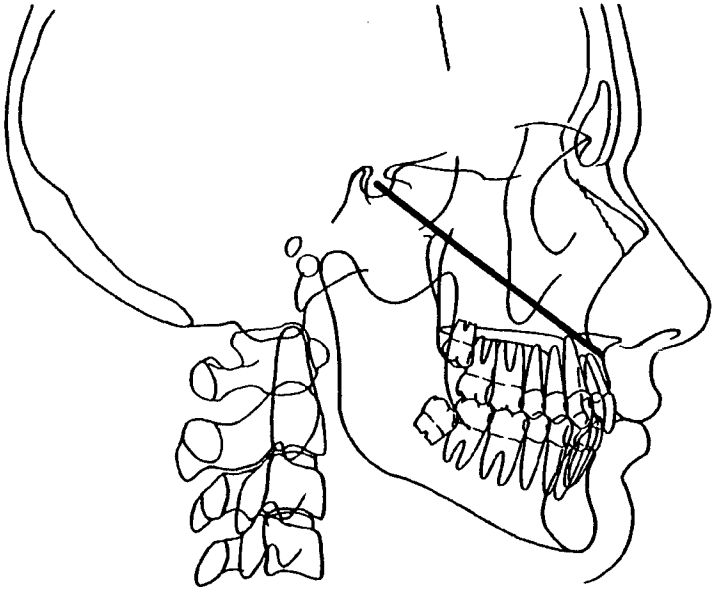
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
106	7	1.7	1.3	6.7	-1.3	1.7	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	99.6	***	101.4	***	95.3	***	***	***	***	***	*	***	**	NA	NA
INITIAL	97.9		99.7		93.6										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	99.3	99.9	100.2	103.0	101.0
	SD	4.4	4.6	4.5	5.1	4.8
	N	84	31	63	36	39
FEMALE	MEAN	94.2	93.3	93.9	95.2	97.7
	SD	3.3	4.3	3.7	4.7	4.2
	N	39	24	29	27	15



CALCULATION 011

MEASURE SIMP 46-11

NAME SELLA TO A POINT

INITIAL TO FINAL

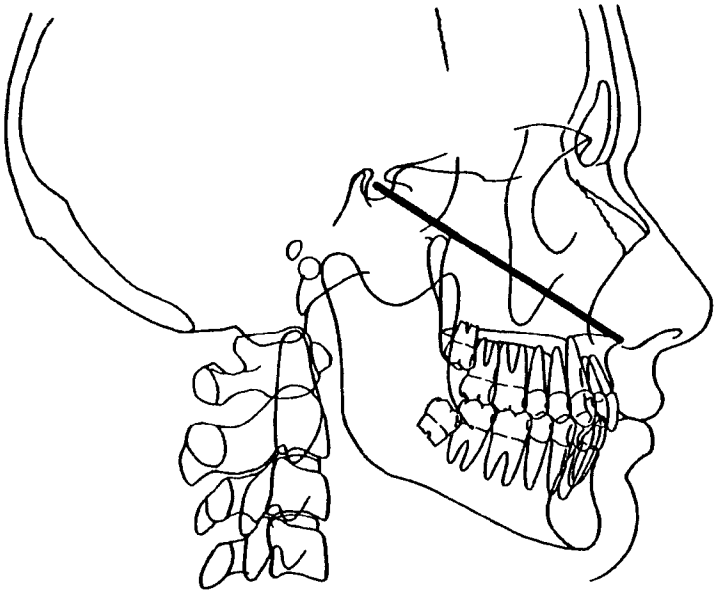
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
91	22	1.3	1.4	5.4	-2.3	1.4	.94

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	91.4	***	93.3	***	87.0	***	***	***	**	*	—	***	—	***	—
INITIAL	90.2		91.9		86.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	91.7	92.0	92.7	95.5	92.4
	SD	4.2	4.4	4.0	4.6	4.6
	N	84	31	63	36	39
FEMALE	MEAN	86.6	86.0	86.1	87.7	89.0
	SD	3.6	4.4	4.0	4.5	3.9
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 012

MEASURE SIMP 46-12

NAME SELLA TO ANS

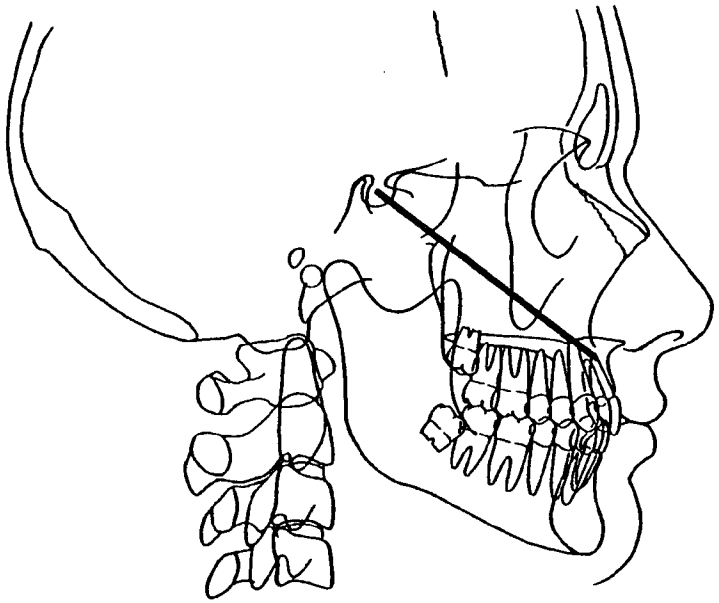
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
100	13	1.5	1.8	9.1	-1.7	1.6	.97

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	92.5	***	94.3	***	88.1	***	***	***	*	—	—	***	—	**	***
INITIAL	91.0		92.7		87.0										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	92.4	92.8	93.3	95.6	93.8
	SD	3.9	4.1	3.9	4.1	4.6
	N	84	31	63	36	39
FEMALE	MEAN	87.6	87.0	87.4	88.2	89.9
	SD	3.9	4.6	4.2	4.3	4.3
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 013

MEASURE SIMP 46-13

NAME SELLA TO UPPER INCISOR ROOT APEX

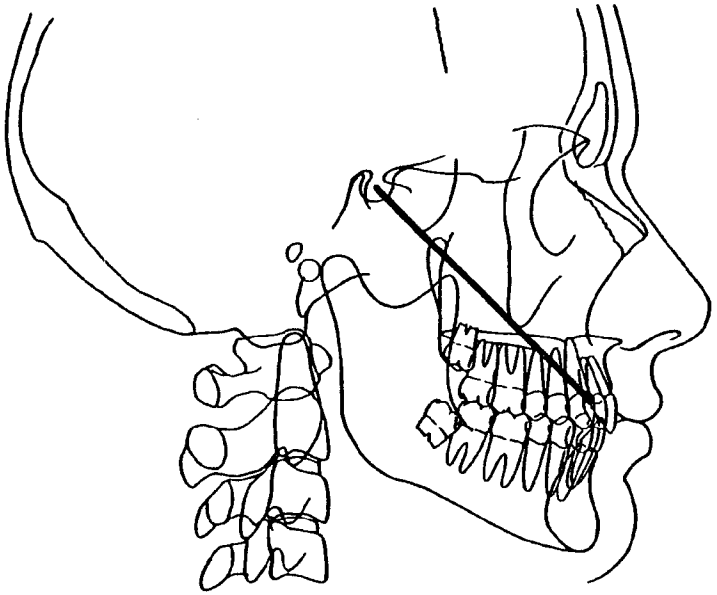
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
105	8	2.5	1.8	8.6	-1.3	2.9	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	88.1	***	89.8	***	84.1	***	***	***	***	**	—	***	*	NA	NA
INITIAL	85.6		87.1		82.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	86.6	87.4	88.2	91.3	89.8
	SD	4.3	4.1	4.1	4.7	5.0
	N	84	31	63	36	39
FEMALE	MEAN	82.6	82.1	82.5	84.0	86.6
	SD	3.4	4.3	3.6	5.0	4.3
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 014

MEASURE SIMP 46-14

NAME SELLA TO UPPER INCISOR LINGUAL BONY CONTACT POINT

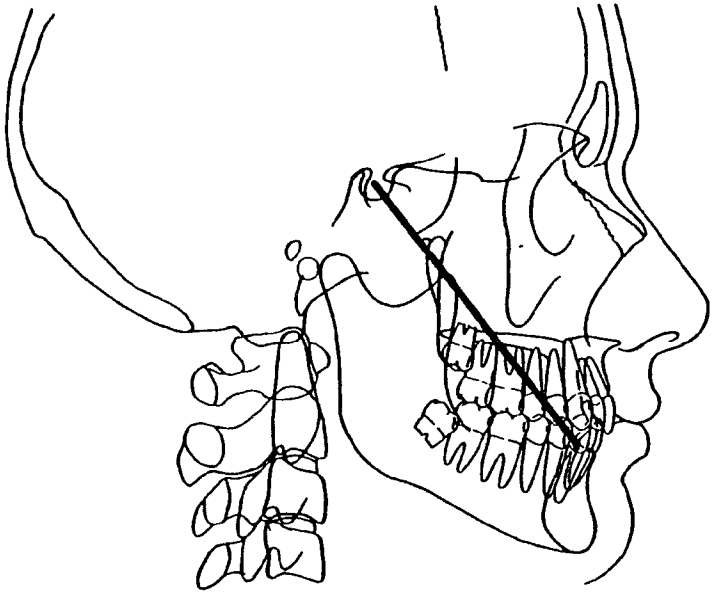
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
103	10	2.0	1.4	7.6	-1.1	2.1	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	96.7	***	98.5	***	92.3	***	***	***	***	**	**	***	*	NA	NA
INITIAL	94.7		96.4		90.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	96.2	96.9	97.5	99.9	98.2
	SD	4.4	4.5	4.3	5.4	4.9
	N	84	31	63	36	39
FEMALE	MEAN	91.1	90.6	90.8	92.0	94.4
	SD	3.1	3.8	3.7	4.7	4.0
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 015

MEASURE SIMP 46-15

NAME SELLA TO LOWER INCISOR
LINGUAL BONY CONTACT POINT

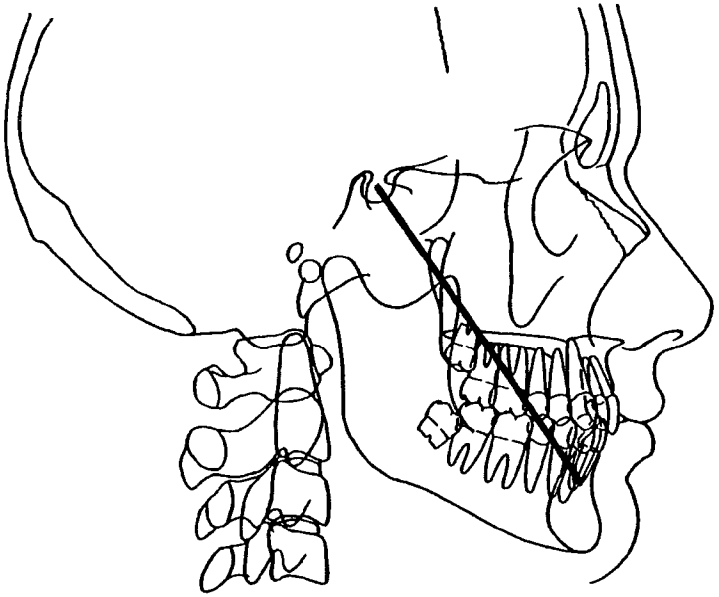
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
102	11	2.0	1.8	10.3	-2.6	1.9	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	104.5	***	106.6	***	99.6	***	***	***	**	*	*	***	—	NA	NA
INITIAL	102.5		104.3		98.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	104.2	104.9	105.9	107.6	105.4
	SD	4.8	5.7	5.5	6.1	5.6
	N	84	31	63	36	39
FEMALE	MEAN	98.2	98.1	97.4	99.1	101.4
	SD	3.4	3.5	3.5	4.6	4.6
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 016

MEASURE SIMP 46-16

NAME SELLA TO LOWER INCISOR ROOT APEX

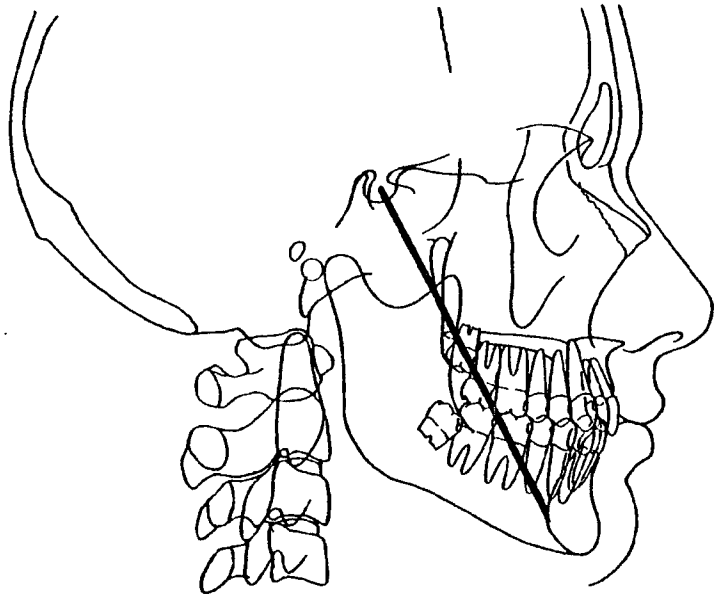
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
98	15	1.9	2.1	11.8	-1.9	1.7	.98

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	112.8	***	115.3	***	107.2	***	***	***	***	**	—	***	—	NA	NA
INITIAL	110.9		112.9		106.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	113.0	113.7	114.6	115.5	114.1
	SD	4.7	6.0	5.9	6.6	5.9
	N	84	31	63	36	39
FEMALE	MEAN	106.1	106.0	104.9	106.8	109.0
	SD	3.9	4.1	4.3	4.9	5.0
	N	39	24	29	27	15



CALCULATION 017

MEASURE SIMP 46-17

NAME SELLA TO LINGUAL SYMPHYSEAL POINT

INITIAL TO FINAL

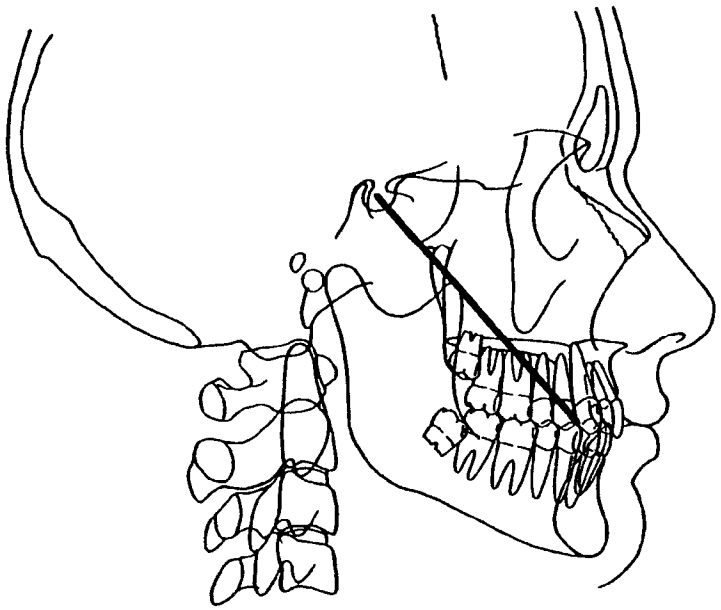
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
101	12	2.5	2.4	14.5	-2.8	2.2	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	116.1	***	118.6	***	110.2	***	***	***	***	**	*	***	—	—	—
INITIAL	113.6		115.8		108.5										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	115.7	116.6	117.9	118.7	117.7
	SD	5.6	7.0	7.1	8.3	7.0
	N	84	31	63	36	39
FEMALE	MEAN	108.1	108.7	106.3	108.4	112.3
	SD	5.7	5.2	6.8	6.4	5.6
	N	39	24	29	27	15



CALCULATION 018

MEASURE SIMP 46-18

NAME SELLA TO PREMOLAR MESIAL CONTACT POINT

INITIAL TO FINAL

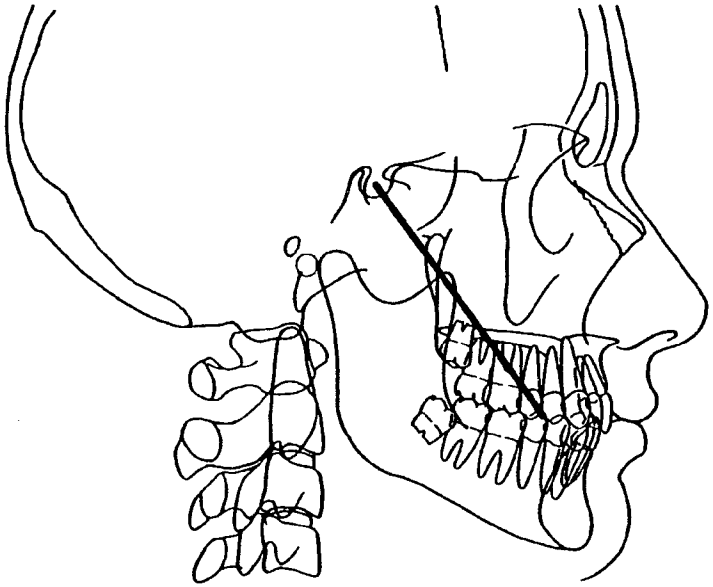
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
108	5	2.5	1.9	8.7	-1.5	2.6	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	96.4	***	98.3	***	91.9	***	***	***	***	**	*	***	**	NA	NA
INITIAL	93.9		95.7		89.8										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	95.4	96.2	97.2	99.4	97.7
	SD	4.5	4.7	4.7	5.4	5.2
	N	84	31	63	36	39
FEMALE	MEAN	89.8	89.8	89.4	91.0	94.3
	SD	3.3	3.8	3.7	5.2	5.0
	N	39	24	29	27	15



CALCULATION 019

MEASURE SIMP 46-19

NAME SELLA TO PREMOLAR DISTAL CONTACT POINT

INITIAL TO FINAL

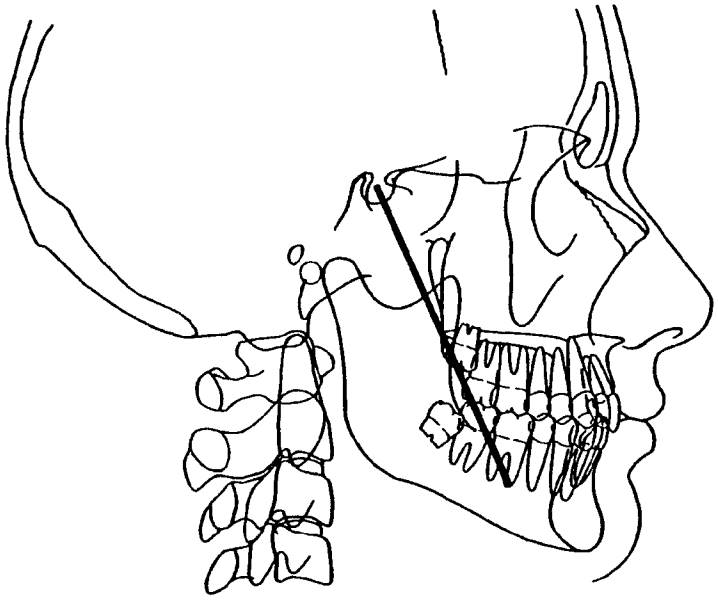
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
102	11	2.4	2.1	8.8	-2.3	2.6	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	91.9	***	93.9	***	87.3	***	***	***	***	*	—	***	*	NA	NA
INITIAL	89.5		91.3		85.5										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	90.9	91.6	92.9	94.9	93.3
	SD	4.5	4.8	4.7	5.3	5.3
	N	84	31	63	36	39
FEMALE	MEAN	85.3	85.1	84.5	86.4	89.6
	SD	3.3	3.8	3.8	5.5	5.1
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 020

MEASURE SIMP 46-20

NAME SELLA TO LOWER MOLAR ROOT APEX

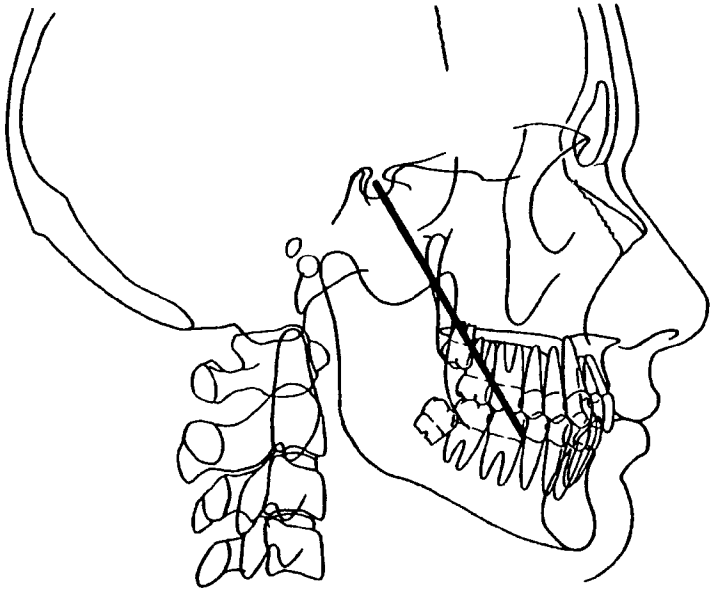
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
100	13	2.3	2.3	11.7	-2.7	2.3	.98

	UNTREATED												TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+		T P	T UNTX	T P	T UNTX
FINAL	102.7	***	105.3	***	96.6	***	***	***	***	—	—		***	—	NA	NA
INITIAL	100.4		102.9		94.7											

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	102.9	103.7	104.9	106.2	104.8
	SD	4.8	5.5	5.5	6.9	6.0
	N	84	31	63	36	39
FEMALE	MEAN	94.7	94.8	93.2	95.9	98.8
	SD	4.3	4.4	4.4	5.5	5.3
	N	39	24	29	27	15



CALCULATION 021

MEASURE SIMP 46-21

NAME SELLA TO LOWER MOLAR MESIAL CEJ

INITIAL TO FINAL

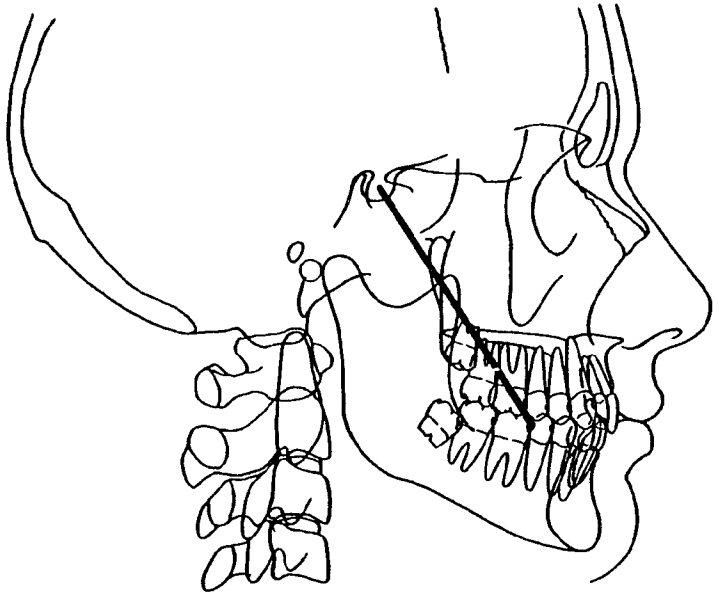
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
107	6	2.7	2.2	11.0	-1.0	2.9	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	94.1	***	96.4	***	88.5	***	***	***	***	**	*	***	—	NA	NA
INITIAL	91.4		93.4		86.5										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	93.2	93.9	95.4	97.0	95.9
	SD	4.4	5.0	5.1	6.4	5.5
	N	84	31	63	36	39
FEMALE	MEAN	86.5	86.3	85.4	87.7	90.9
	SD	3.5	3.9	4.0	5.1	5.1
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 022

MEASURE SIMP 46-22

NAME SELLA TO LOWER MOLAR MESIAL CONTACT POINT

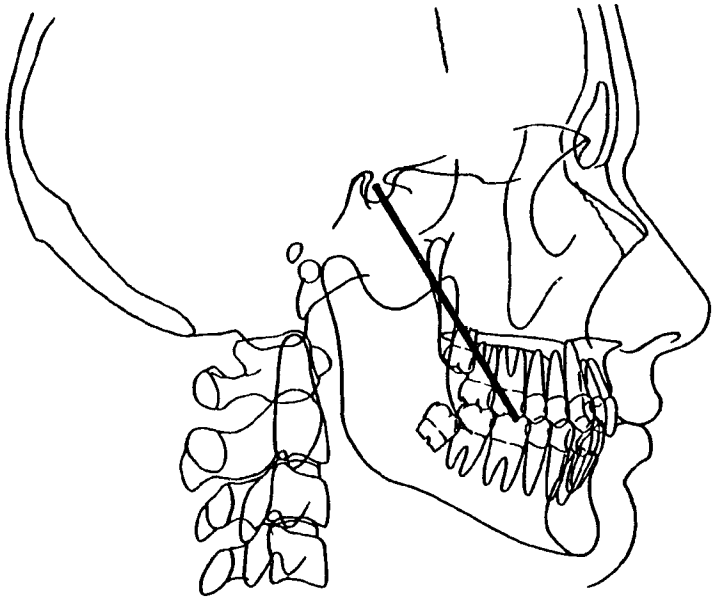
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
103	10	2.4	2.0	10.2	-.8	2.8	.98

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	91.1	***	93.4	***	85.9	***	***	***	***	***	**	***	—	NA	NA
INITIAL	88.7		90.6		84.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	90.4	91.0	92.5	94.1	92.6
	SD	4.4	4.9	4.9	6.1	5.3
	N	84	31	63	36	39
FEMALE	MEAN	84.0	83.8	82.9	85.1	88.3
	SD	3.3	3.7	3.9	4.9	4.8
	N	39	24	29	27	15



CALCULATION 023

MEASURE SIMP 46-23

NAME SELLA TO UPPER MOLAR MESIAL CUSP TIP

INITIAL TO FINAL

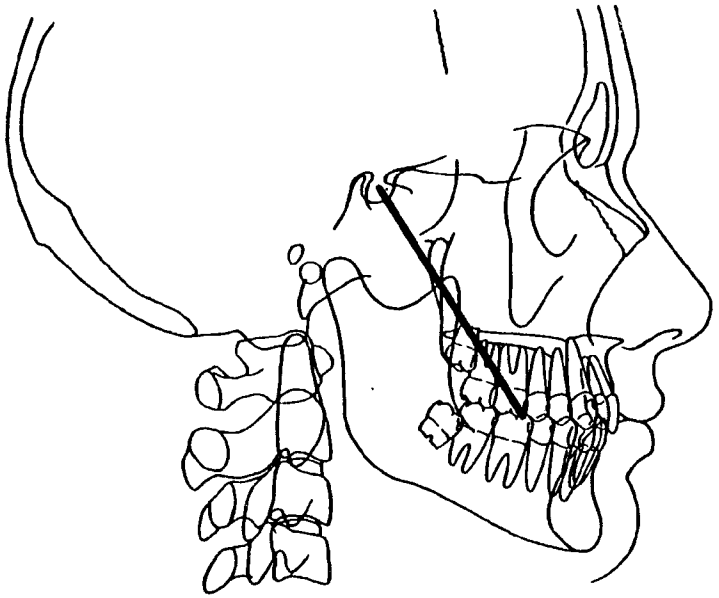
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
102	11	2.3	2.0	8.4	-1.5	2.7	.97

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	86.0	***	88.1	***	81.1	***	***	***	***	**	—	***	*	NA	NA
INITIAL	83.7		85.6		79.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	85.2	86.2	87.3	88.9	87.7
	SD	4.5	4.7	4.7	5.6	5.2
	N	84	31	63	36	39
FEMALE	MEAN	79.3	79.1	78.3	80.2	83.4
	SD	3.5	4.0	3.6	5.1	4.8
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 024

MEASURE SIMP 46-24

NAME SELLA TO POSTERIOR DOWNS POINT

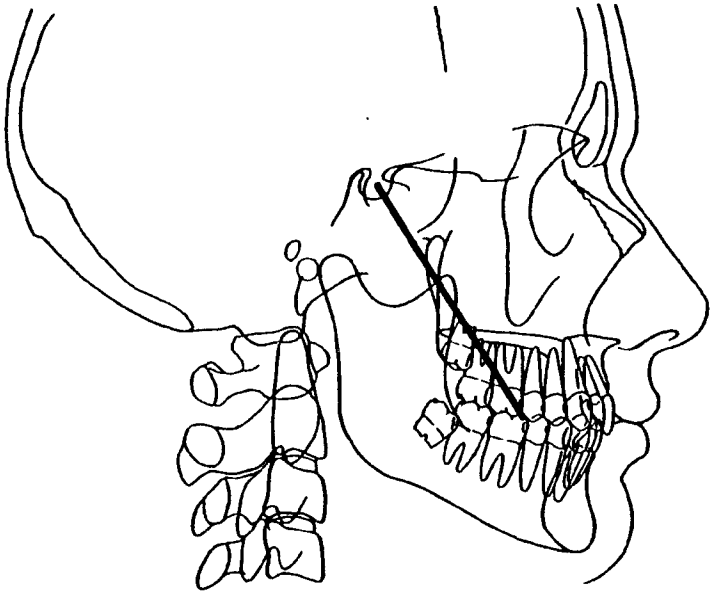
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
104	9	2.4	2.0	9.0	-.7	2.8	.98

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	86.5	***	88.6	***	81.6	***	***	***	***	***	*	***	—	NA	NA
INITIAL	84.1		86.0		79.8										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	85.6	86.5	87.7	89.5	88.2
	SD	4.3	4.6	4.7	5.7	5.0
	N	84	31	63	36	39
FEMALE	MEAN	79.8	79.5	78.9	80.7	84.0
	SD	3.4	3.6	3.5	4.9	4.8
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 025

MEASURE SIMP 46-25

NAME SELLA TO LOWER MOLAR MESIAL CUSP TIP

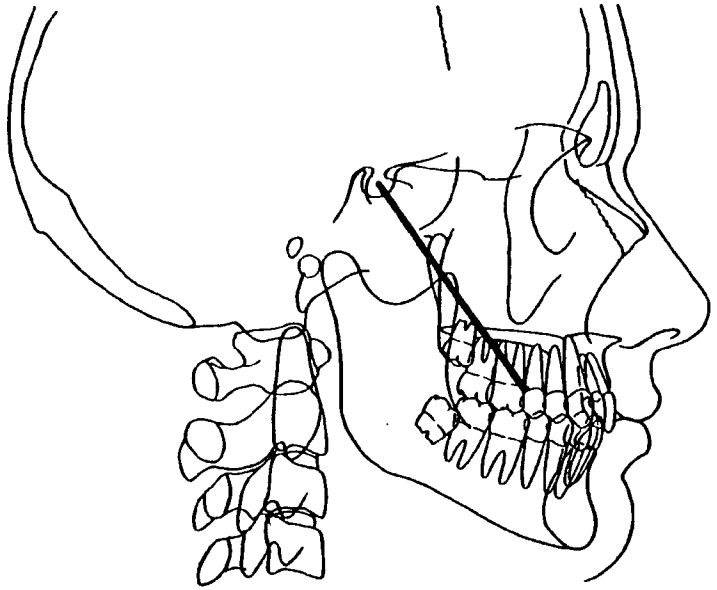
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
102	11	2.4	2.1	9.7	-.8	2.8	.97

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	87.3	***	89.3	***	82.5	***	***	***	***	***	—	***	—	NA	NA
INITIAL	84.9		86.6		80.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	86.3	87.0	88.4	90.4	88.6
	SD	4.3	4.8	4.9	5.8	5.0
	N	84	31	63	36	39
FEMALE	MEAN	80.5	80.2	79.8	81.6	84.9
	SD	3.2	3.5	3.6	5.0	4.9
	N	39	24	29	27	15



CALCULATION 026

MEASURE SIMP 46-26

NAME SELLA TO UPPER MOLAR MESIAL CEJ

INITIAL TO FINAL

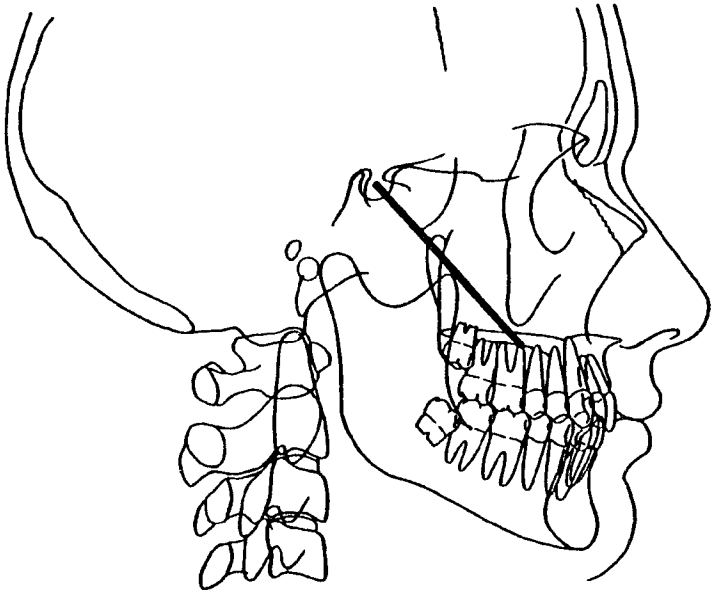
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
106	7	2.1	1.9	9.6	-2.4	2.7	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	81.1	***	83.0	***	76.5	***	***	***	***	**	*	***	*	NA	NA
INITIAL	78.9		80.7		74.8										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	80.5	81.1	82.1	84.0	82.7
	SD	4.2	4.4	4.5	5.2	4.8
	N	84	31	63	36	39
FEMALE	MEAN	74.9	74.3	73.5	75.6	79.0
	SD	3.4	3.7	3.6	4.9	4.5
	N	39	24	29	27	15



CALCULATION 027

MEASURE SIMP 46-27

NAME SELLA TO UPPER MOLAR ROOT APEX

INITIAL TO FINAL

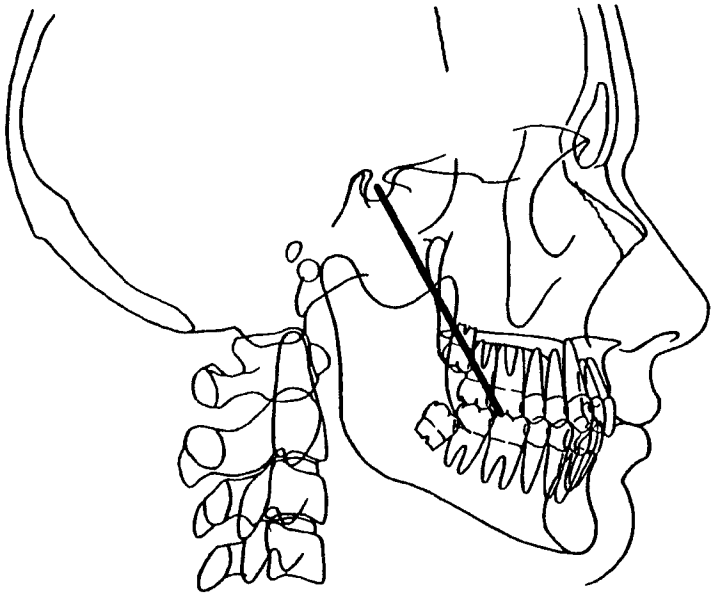
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
96	17	2.2	2.1	9.7	-1.5	3.3	.94

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	70.7	***	72.4	***	66.8	***	***	***	***	***	—	***	*	NA	NA
INITIAL	68.5		70.1		64.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	69.5	70.0	71.4	73.6	72.1
	SD	4.0	4.5	4.3	4.9	4.7
	N	84	31	63	36	39
FEMALE	MEAN	64.9	64.7	64.0	65.5	69.3
	SD	2.9	3.2	3.2	4.2	4.5
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 028

MEASURE SIMP 46-28

NAME SELLA TO UPPER MOLAR DISTAL CONTACT POINT

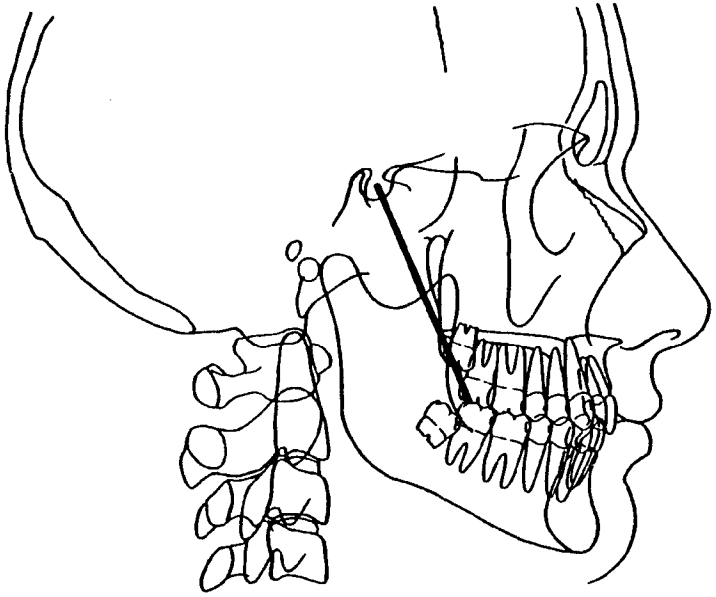
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
108	5	2.6	1.9	10.2	-.6	3.3	.96

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	81.2	***	83.4	***	76.2	***	***	***	***	—	—	***	—	NA	NA
INITIAL	78.6		80.6		73.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	80.2	81.3	82.5	84.2	82.9
	SD	4.4	4.8	5.0	5.6	5.1
	N	84	31	63	36	39
FEMALE	MEAN	74.1	73.6	72.8	74.9	78.8
	SD	3.5	4.2	4.1	5.5	4.9
	N	39	24	29	27	15



CALCULATION 029

MEASURE SIMP 46-29

NAME SELLA TO FUNCTIONAL OCCLUSAL PLANE POINT

INITIAL TO FINAL

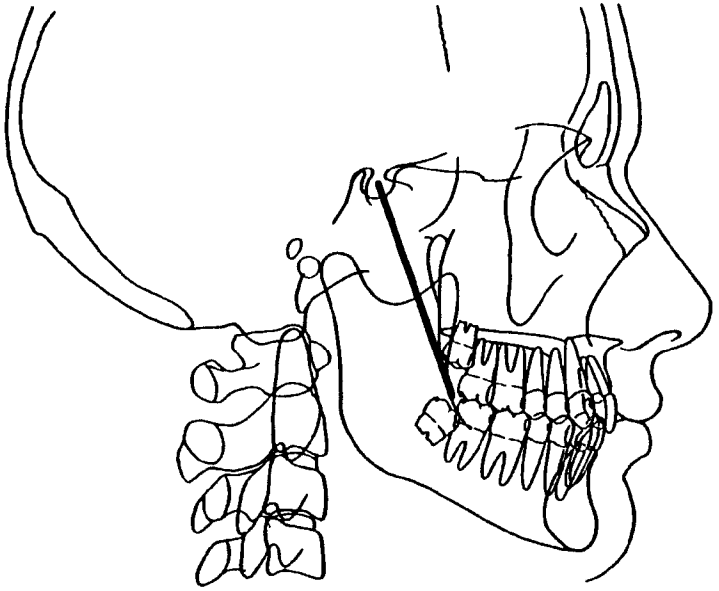
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
106	7	2.7	2.2	10.7	-.7	3.7	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	74.5	***	76.7	***	69.4	***	***	***	*	—	—	***	—	NA	NA
INITIAL	71.8		73.8		67.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	73.5	74.4	76.0	77.3	76.2
	SD	4.5	4.8	5.1	5.9	5.4
	N	84	31	63	36	39
FEMALE	MEAN	67.0	66.8	66.3	68.6	71.7
	SD	3.5	3.7	3.9	5.0	4.7
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 030

MEASURE SIMP 46-30

NAME SELLA TO ANTERIOR BORDER OF THE RAMUS

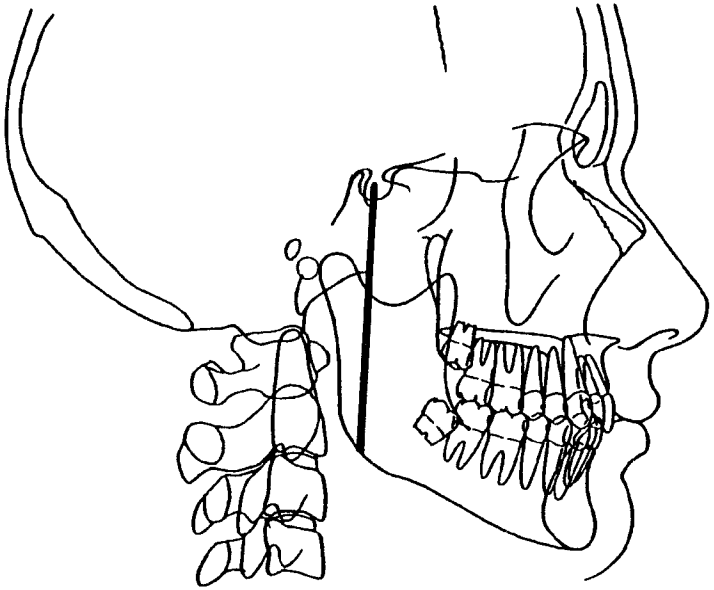
INITIAL TO FINAL

UNTREATED							
GAIN	NO* GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
85 ·	28	1.8	2.3	10.1	-2.5	2.7	.96

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	71.2	***	73.3	***	66.4	**	***	**	—	—	—	***	—	—	—
INITIAL	69.4		71.1		65.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	70.8	71.9	73.2	73.9	72.7
	SD	4.5	4.8	5.0	6.3	5.4
	N	84	31	63	36	39
FEMALE	MEAN	65.0	64.9	64.5	66.1	67.7
	SD	3.3	3.3	3.4	4.2	4.1
	N	39	24	29	27	15



CALCULATION 031

MEASURE SIMP 46-31

NAME SELLA TO GONION

INITIAL TO FINAL

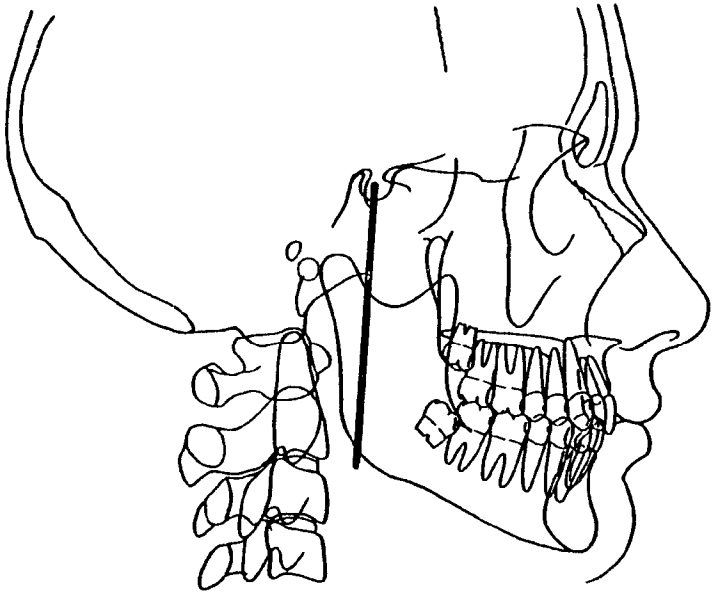
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
102	11	3.0	2.6	14.8	-1.2	3.6	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	85.5	***	89.0	***	77.4	***	***	***	***	—	—	***	**	**	***
INITIAL	82.5		85.4		75.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	84.4	87.0	88.6	89.0	89.3
	SD	5.3	5.8	6.3	6.9	5.7
	N	84	31	63	36	39
FEMALE	MEAN	75.3	74.7	73.3	76.3	80.6
	SD	4.9	5.1	5.2	5.5	5.9
	N	39	24	29	27	15



CALCULATION 032

MEASURE SIMP 46-32

NAME SELLA TO GONIAL INTERSECTION

INITIAL TO FINAL

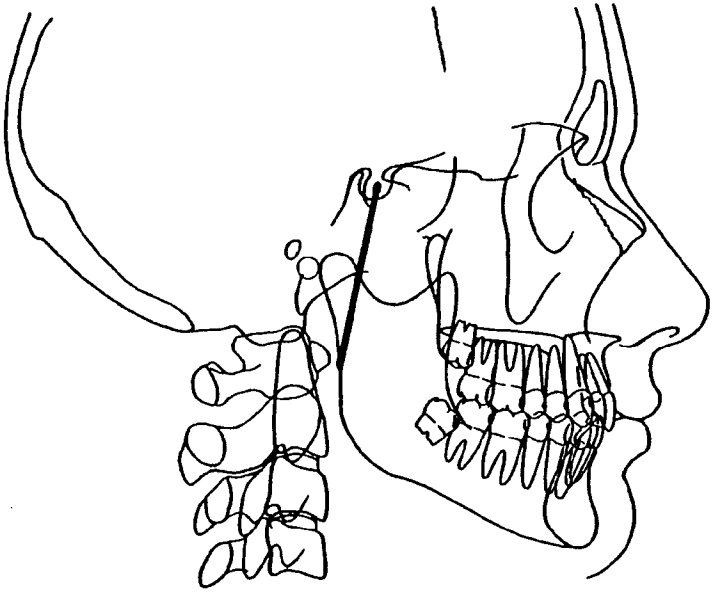
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
103	10	3.1	2.7	14.2	-1.0	3.6	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	88.2	***	91.9	***	79.7	***	***	***	*	—	—	***	**	**	***
INITIAL	85.1		88.1		78.2										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	87.2	90.1	91.6	92.4	92.3
	SD	5.5	6.5	6.8	7.5	6.0
	N	84	31	63	36	39
FEMALE	MEAN	77.6	77.1	75.8	78.8	83.0
	SD	5.1	5.5	5.1	5.6	6.2
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 033

MEASURE SIMP 46-33

NAME SELLA TO POSTERIOR BORDER OF THE RAMUS

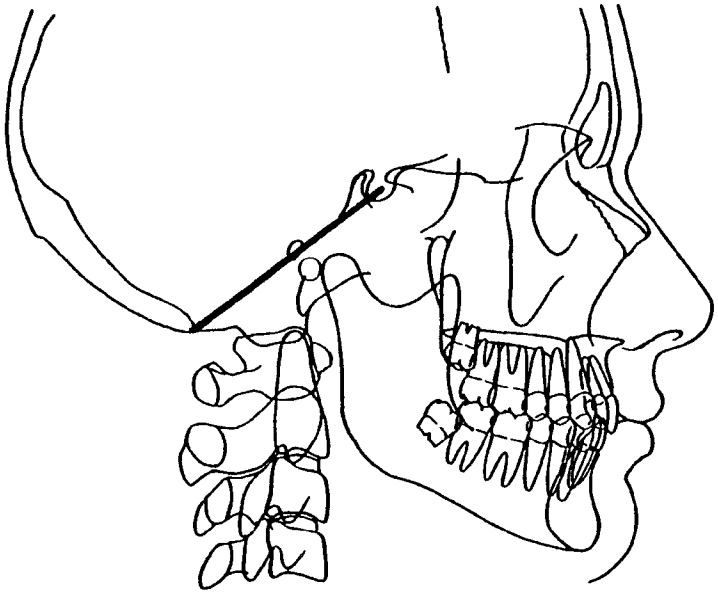
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
88	25	2.5	2.9	11.5	-2.3	4.1	.95

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	64.0	***	66.6	***	58.1	***	***	—	—	—	—	***	—	—	—
INITIAL	61.5		63.8		56.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	63.4	65.1	66.5	66.9	66.6
	SD	5.2	5.7	6.0	7.4	6.0
	N	84	31	63	36	39
FEMALE	MEAN	55.9	56 4	55.7	58.0	59.2
	SD	4.3	4.2	4.1	4.8	5.0
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 034

MEASURE SIMP 46-38

NAME SELLA TO OPISTHION

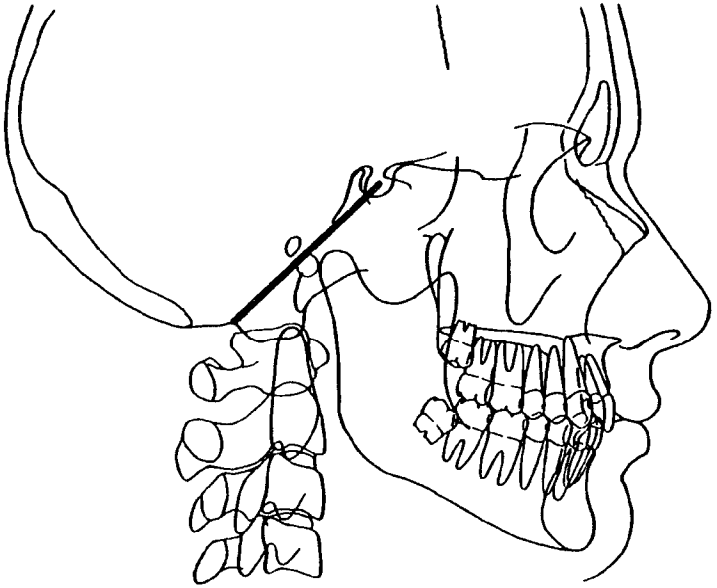
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
62	51	.4	1.6	5.5	-2.7	.5	.98

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	78.5	*	80.1	—	74.8	—	***	—	—	—	—	—	—	—	**
INITIAL	78.1		79.9		74.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	79.6	80.2	80.1	80.5	80.2
	SD	3.8	4.5	4.2	3.9	3.5
	N	84	31	63	36	39
FEMALE	MEAN	74.7	75.1	73.6	73.9	75.9
	SD	3.7	2.9	3.6	3.7	4.7
	N	39	24	29	27	15



CALCULATION 035

MEASURE SIMP 46-39

NAME SELLA TO BOLTON POINT

INITIAL TO FINAL

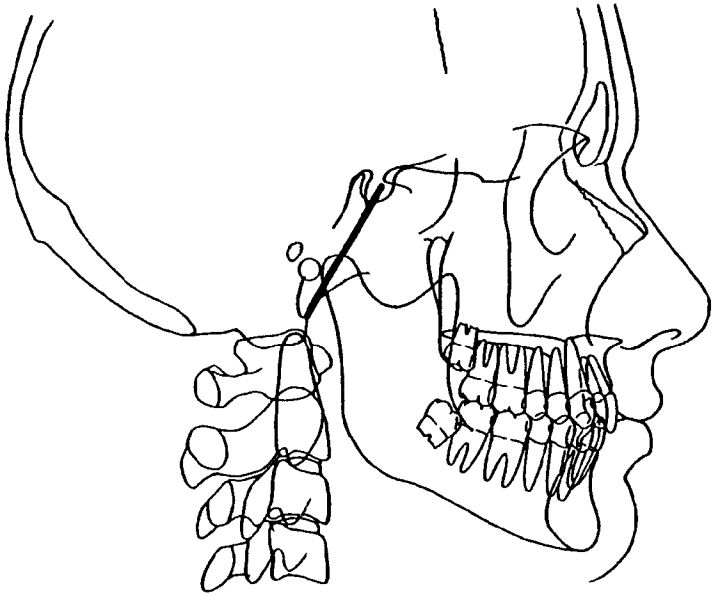
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
74	39	.5	1.5	6.4	-2.9	.8	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	64.3	***	65.8	**	60.8	*	***	*	—	—	*	—	—	—	***
INITIAL	63.8		65.3		60.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	65.3	65.5	65.4	66.0	66.1
	SD	3.1	3.4	3.3	2.4	2.9
	N	84	31	63	36	39
FEMALE	MEAN	61.0	60.8	59.7	59.5	61.8
	SD	2.9	2.6	2.7	3.7	3.2
	N	39	24	29	27	15



CALCULATION 036

MEASURE SIMP 46-40

NAME SELLA TO BASION

INITIAL TO FINAL

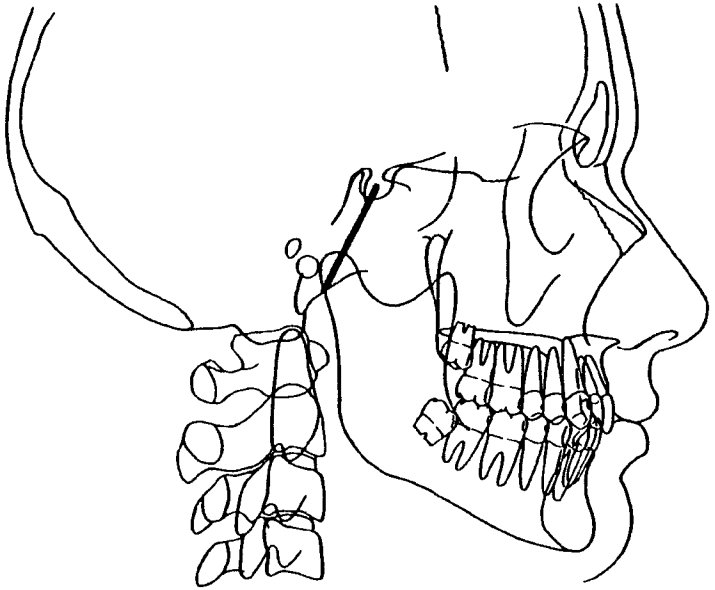
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
80	33	.6	1.2	4.4	-2.3	1.3	.94

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	49.2	***	50.5	***	46.3	—	***	—	—	—	—	*	—	**	***
INITIAL	48.6		49.8		45.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	49.8	50.3	50.9	50.3	50.5
	SD	3.3	3.3	3.1	3.4	3.2
	N	84	31	63	36	39
FEMALE	MEAN	46.1	46.3	46.4	45.0	47.3
	SD	2.5	2.5	3.2	3.0	2.5
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 037

MEASURE SIMP 46-41

NAME SELLA TO ARTICULARE, POSTERIOR

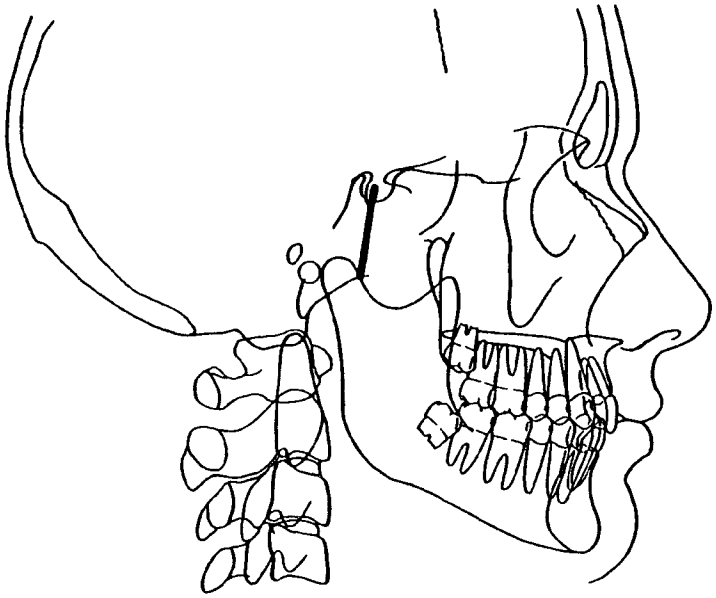
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
69	44	.6	1.2	4.8	-2.0	1.4	.97

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	38.1	***	39.6	***	34.7	—	***	—	—	—	—	**	—	—	**
INITIAL	37.6		38.9		34.5										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	38.8	38.8	39.6	39.6	40.2
	SD	3.3	3.3	3.9	4.2	3.4
	N	84	31	63	36	39
FEMALE	MEAN	34.9	34.3	33.4	34.3	36.0
	SD	3.3	3.1	3.4	4.1	2.8
	N	39	24	29	27	15



CALCULATION 038

MEASURE SIMP 46-42

NAME SELLA TO ANTERIOR ARTICULARE

INITIAL TO FINAL

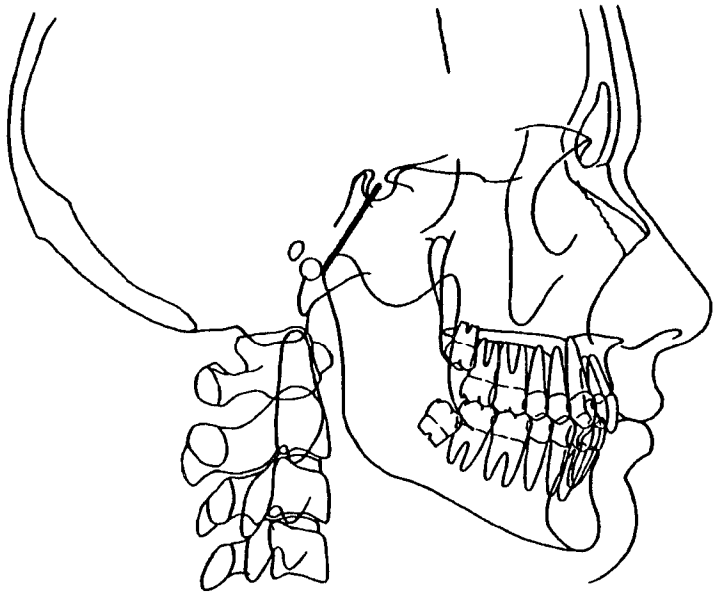
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
70	43	.3	1.1	3.6	-2.5	1.0	.95

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	28.1	*	29.1	—	26.0	*	***	*	*	*	—	—	—	—	***
INITIAL	27.9		28.9		25.6										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	28.7	28.7	29.2	29.1	29.4
	SD	2.9	2.9	3.2	3.0	3.2
	N	84	31	63	36	39
FEMALE	MEAN	26.1	26.1	25.4	24.9	26.8
	SD	2.7	2.7	2.7	3.2	2.9
	N	39	24	29	27	15



CALCULATION 039

MEASURE SIMP 46-43

NAME SELLA TO CONDYLION

INITIAL TO FINAL

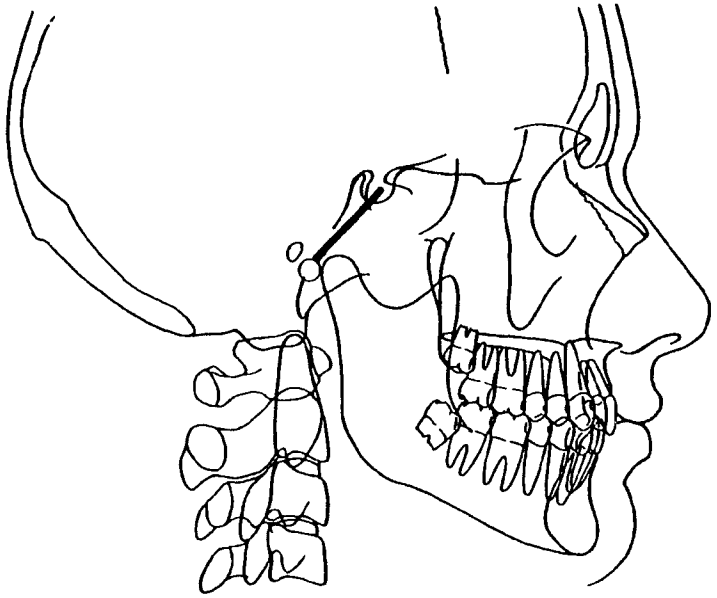
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
56	57	.1	1.7	7.0	-3.7	.7	.93

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	28.8	—	30.0	—	25.9	—	***	—	—	—	—	—	—	—	**
INITIAL	28.7		30.0		25.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	29.6	29.8	30.3	30.0	30.7
	SD	3.7	3.9	4.0	3.3	3.3
	N	84	31	63	36	39
FEMALE	MEAN	26.0	25.6	24.4	25.8	27.2
	SD	3.3	3.1	3.7	3.5	1.9
	N	39	24	29	27	15



CALCULATION 040

MEASURE SIMP 46-44

NAME SELLA TO PORION

INITIAL TO FINAL

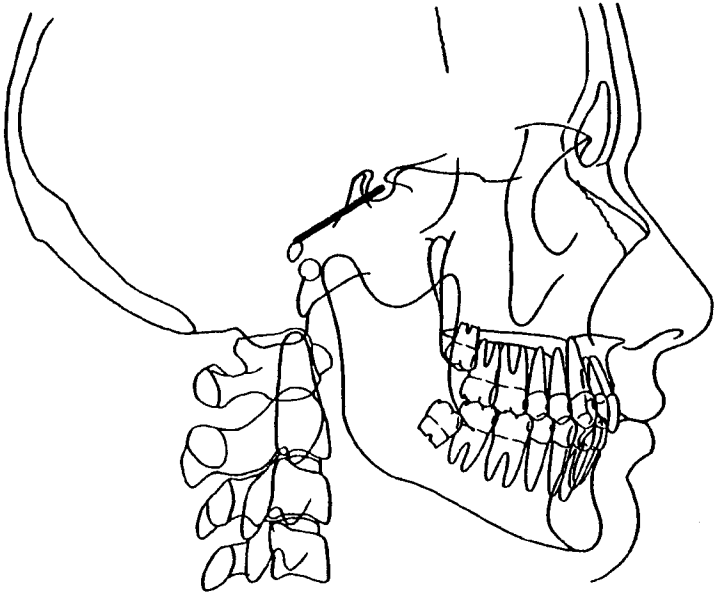
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
70	43	1.3	3.5	9.8	-6.7	4.8	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	33.2	***	34.1	***	31.0	—	***	**	—	—	—	**	—	—	*
INITIAL	31.9		32.7		30.0										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	33.2	32.5	33.2	33.4	34.8
	SD	4.2	5.8	4.9	4.6	4.9
	N	84	31	63	36	39
FEMALE	MEAN	29.6	28.7	29.1	29.7	31.8
	SD	4.0	3.2	3.9	3.8	4.2
	N	39	24	29	27	15



CALCULATION 041

MEASURE SIMP 46-45

NAME SELLA TO ANATOMIC PORION

INITIAL TO FINAL

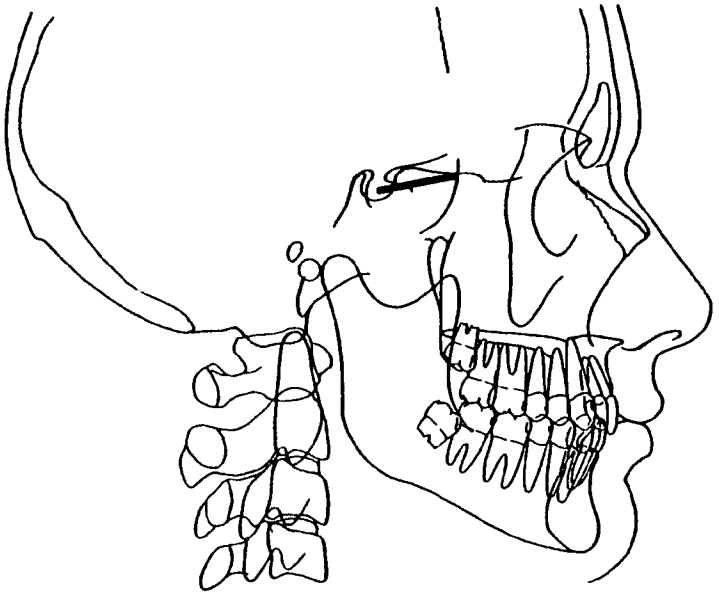
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
52	61	-.3	2.5	8.1	-10.4	-.6	.95

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	31.2	—	31.9	—	29.8	***	***	*	—	—	—	—	*	*	—
INITIAL	31.6		32.3		30.0										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	32.0	32.1	32.3	31.5	33.0
	SD	3.7	5.5	4.3	2.9	3.5
	N	84	31	63	36	39
FEMALE	MEAN	30.0	29.5	28.6	28.8	30.8
	SD	3.4	2.8	3.2	3.1	2.7
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 042

MEASURE SIMP 46-47

NAME SELLA TO ETHMOID REGISTRATION POINT

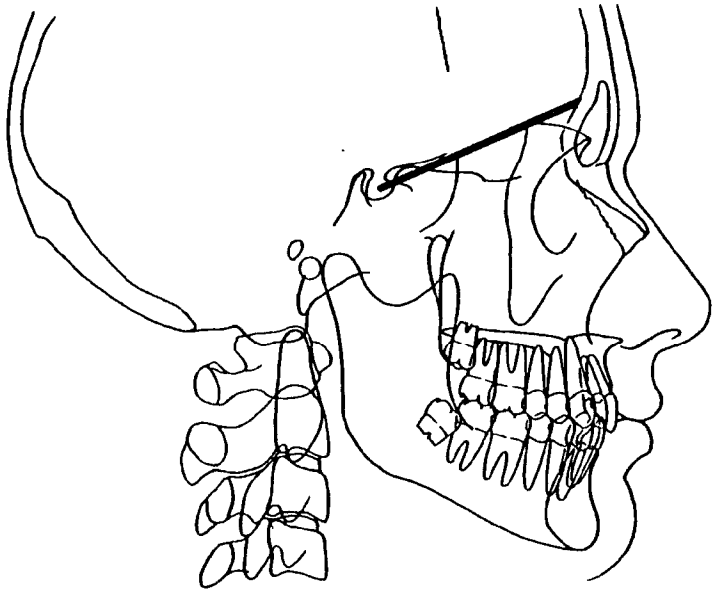
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
65	48	.1	.7	2.7	-1.5	.4	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	26.7	—	27.3	*	25.2	—	***	—	—	—	—	—	**	*	**
INITIAL	26.5		27.1		25.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	27.3	27.8	27.4	27.0	27.1
	SD	2.5	2.4	2.5	2.4	2.3
	N	84	31	63	36	39
FEMALE	MEAN	25.3	25.0	24.9	25.1	25.3
	SD	2.0	1.7	1.8	1.7	2.2
	N	39	24	29	27	15



CALCULATION 043

MEASURE SIMP 46-48

NAME SELLA TO INTERNAL OF FRONTAL BONE AT GLABELLA

INITIAL TO FINAL

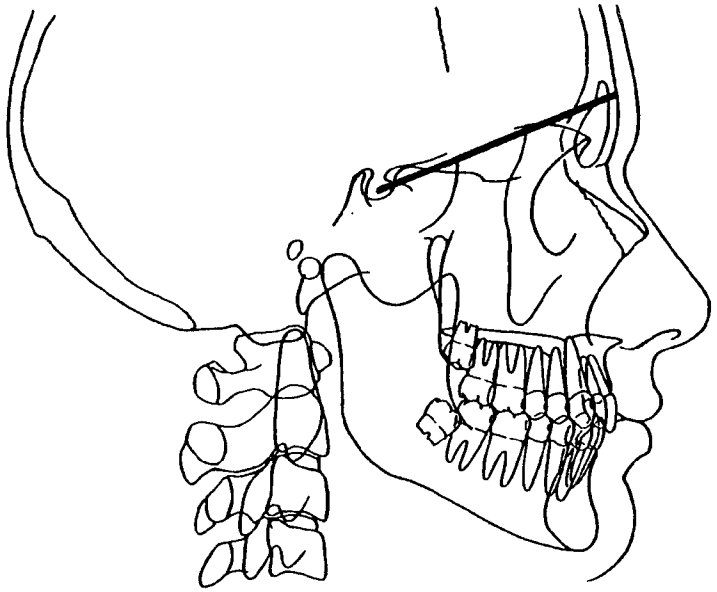
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
57	56	.2	1.6	4.6	-6.1	.3	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	65.3	—	65.7	—	64.3	—	*	—	—	—	—	—	—	—	***
INITIAL	65.1		65.5		64.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	66.1	66.4	65.3	66.5	65.1
	SD	3.8	4.6	4.2	5.8	3.6
	N	84	31	63	36	39
FEMALE	MEAN	64.5	64.5	63.8	65.7	64.6
	SD	3.9	3.8	3.5	3.9	3.5
	N	39	24	29	27	15



CALCULATION 044

MEASURE SIMP 46-49

NAME SELLA TO GLABELLA

INITIAL TO FINAL

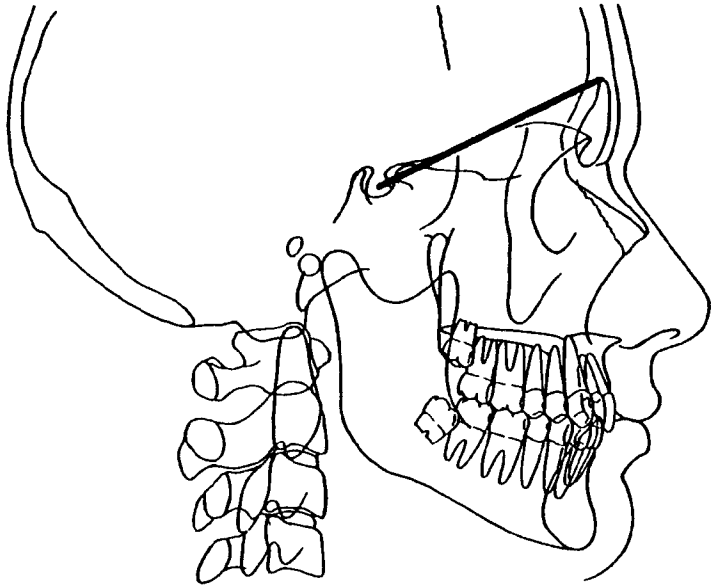
UNTREATED						
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
100	13	1.5	1.4	4.8	-2.5	1.9	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	82.4	***	84.1	***	78.4	***	***	***	—	—	—	***	*	***	***
INITIAL	80.9		82.3		77.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	82.1	83.1	83.2	84.8	83.9
	SD	3.5	3.7	3.4	4.2	3.3
	N	84	31	63	36	39
FEMALE	MEAN	77.9	77.6	76.6	79.1	79.9
	SD	3.6	3.7	3.5	3.3	2.7
	N	39	24	29	27	15



CALCULATION 045

MEASURE SIMP 46-50

NAME SELLA TO FRONTAL SINUS SUPERIOR

INITIAL TO FINAL

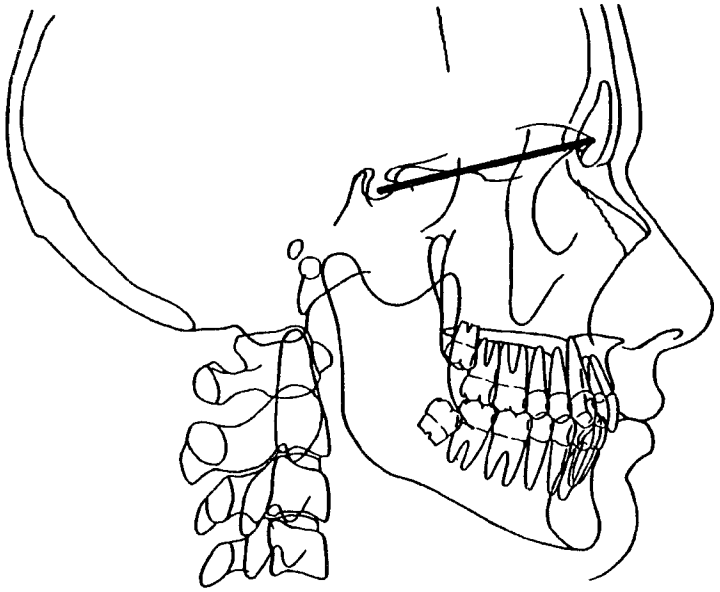
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
96	17	1.3	1.6	7.5	-2.4	1.7	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	80.0	***	81.1	***	77.5	***	***	***	**	*	—	***	—	*	—
INITIAL	78.7		79.6		76.6										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	79.9	80.7	80.6	80.3	81.4
	SD	4.4	3.7	4.6	5.5	5.1
	N	84	31	63	36	39
FEMALE	MEAN	76.5	75.7	76.3	78.8	78.0
	SD	4.7	5.3	4.7	3.9	5.0
	N	39	24	29	27	15



CALCULATION 046

MEASURE SIMP 46-51

NAME SELLA TO SUPRAORBITALE

INITIAL TO FINAL

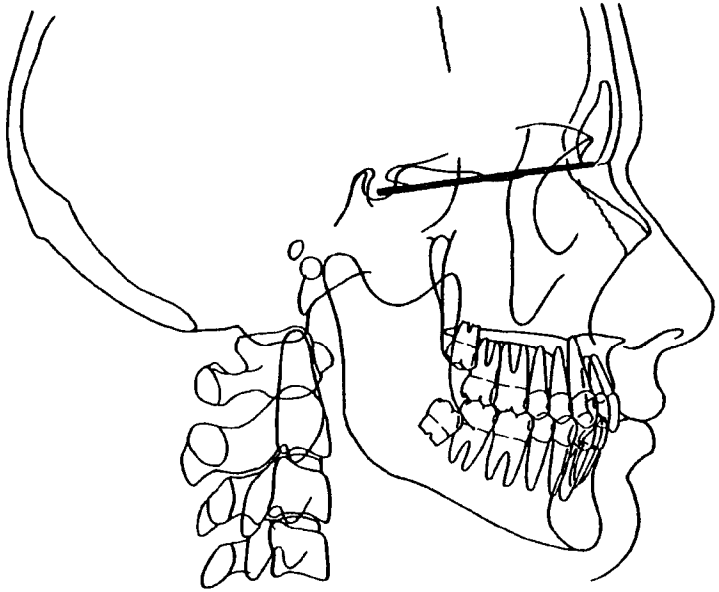
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
90	23	1.2	1.5	4.7	-2.0	1.7	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	72.5	***	73.8	***	69.4	***	***	**	—	—	—	***	*	**	***
INITIAL	71.3		72.4		68.6										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	72.5	72.6	72.8	74.1	73.7
	SD	3.3	2.7	2.9	3.4	2.5
	N	84	31	63	36	39
FEMALE	MEAN	68.5	68.3	67.7	69.7	70.2
	SD	3.2	3.0	2.1	2.5	2.5
	N	39	24	29	27	15



CALCULATION 047

MEASURE SIMP 46-52

NAME SELLA TO FRONTAL SINUS INFERIOR

INITIAL TO FINAL

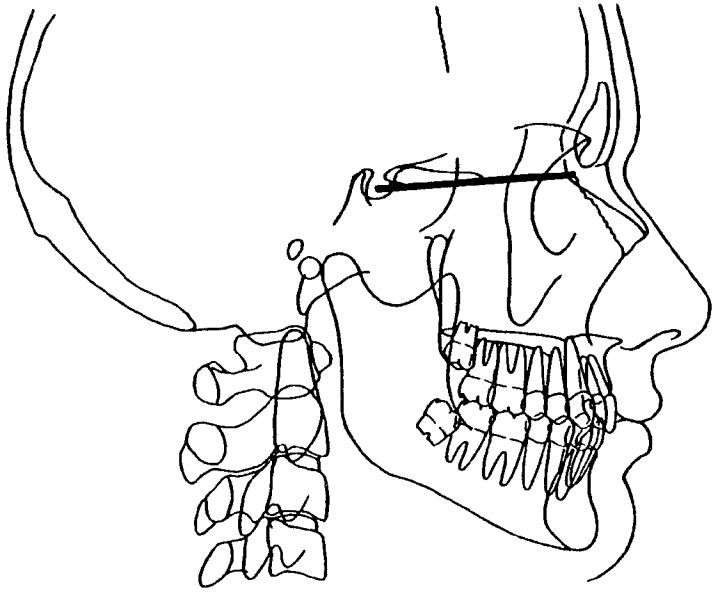
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
72	41	.5	3.4	10.6	-13.9	1.0	.97

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	66.2	—	67.4	—	63.4	—	***	—	—	—	*	—	—	—	***
INITIAL	65.6		66.8		62.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	66.6	66.5	66.6	67.3	67.0
	SD	4.7	4.3	4.3	4.0	4.4
	N	84	31	63	36	39
FEMALE	MEAN	62.7	62.0	61.9	63.6	64.2
	SD	3.5	3.3	3.2	3.0	3.9
	N	39	24	29	27	15



CALCULATION 048

MEASURE SIMP 46-53

NAME SELLA TO FRONTOMAXILLARY NASAL SUTURE

INITIAL TO FINAL

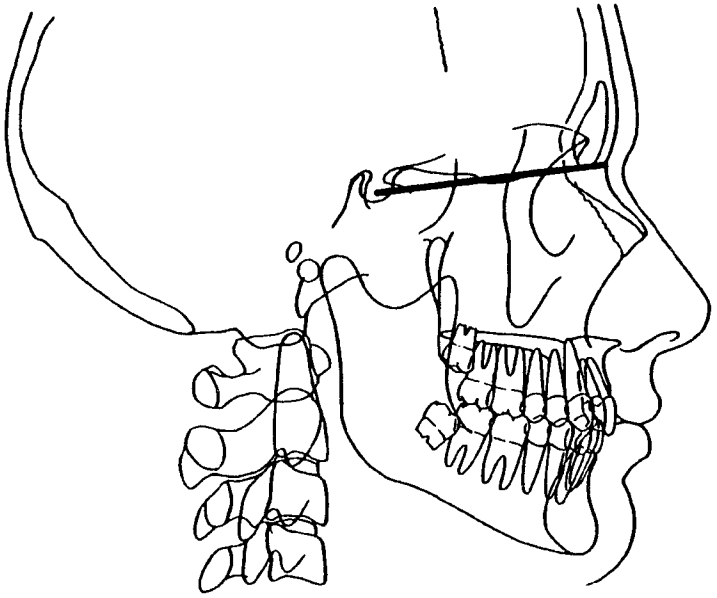
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
89	24	1.5	1.8	5.4	-3.2	2.1	.97

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	70.0	***	71.1	***	67.6	***	***	***	**	—	—	***	—	—	***
INITIAL	68.6		69.6		66.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	69.3	69.9	69.9	71.7	70.2
	SD	3.5	3.7	3.9	3.5	3.4
	N	84	31	63	36	39
FEMALE	MEAN	66.2	66.2	65.8	67.9	68.5
	SD	3.2	3.1	2.4	2.6	3.2
	N	39	24	29	27	15



CALCULATION 049

MEASURE SIMP 46-54

NAME SELLA TO NASION

INITIAL TO FINAL

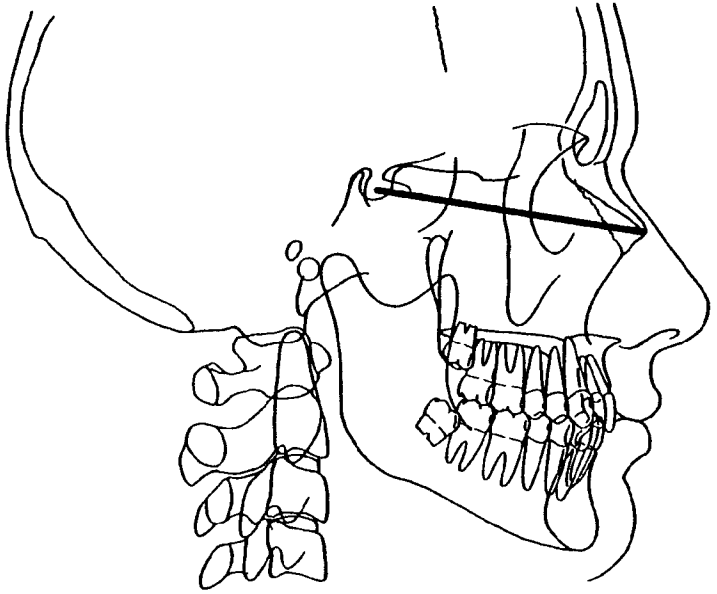
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
104	9	1.1	.8	3.1	-.9	1.5	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	75.7	***	76.9	***	72.9	***	***	***	***	**	—	***	*	***	***
INITIAL	74.6		75.8		71.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	75.6	75.8	75.7	77.5	76.5
	SD	3.3	3.5	3.3	3.4	2.9
	N	84	31	63	36	39
FEMALE	MEAN	71.8	71.4	70.7	73.4	73.6
	SD	3.2	3.0	1.9	2.6	2.8
	N	39	24	29	27	15



CALCULATION 050

MEASURE SIMP 46-55

NAME SELLA TO TIP OF NASAL BONE

INITIAL TO FINAL

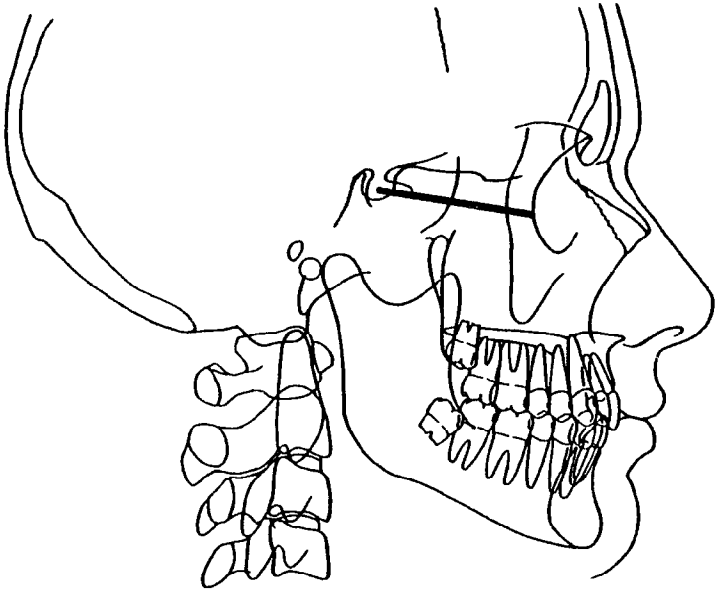
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
105	8	1.3	1.2	4.9	-3.7	1.5	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	89.3	***	91.0	***	85.2	***	***	***	***	**	—	***	*	*	***
INITIAL	88.0		89.7		84.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	89.4	90.0	89.6	92.0	90.6
	SD	5.0	5.4	4.2	4.4	3.7
	N	84	31	63	36	39
FEMALE	MEAN	84.2	83.9	83.7	85.5	86.0
	SD	4.2	4.2	3.0	3.8	3.9
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 051

MEASURE SIMP 46-56

NAME SELLA TO LATERAL ORBIT

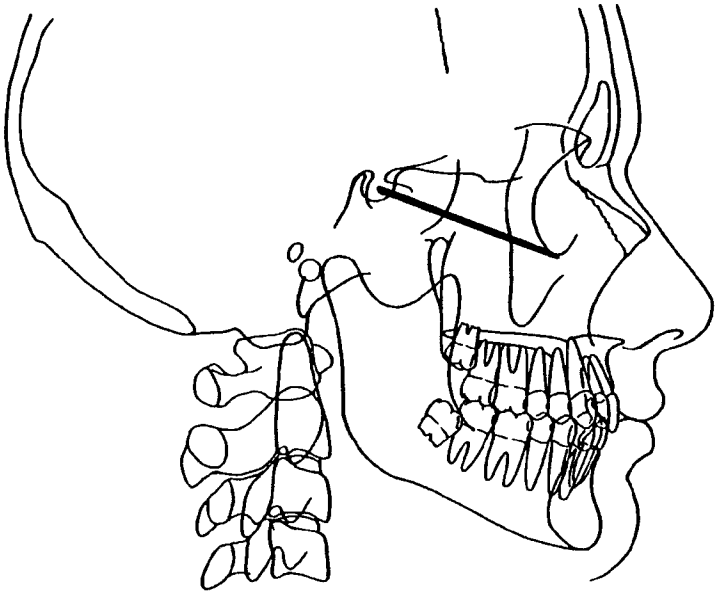
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
87	26	.7	.9	3.2	-1.8	1.3	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	51.7	***	52.5	***	49.7	***	***	***	—	—	—	*	***	***	**
INITIAL	51.0		51.8		49.2										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	51.8	51.5	51.9	53.7	52.4
	SD	3.0	3.0	2.8	3.1	3.4
	N	84	31	63	36	39
FEMALE	MEAN	49.1	48.5	48.4	50.7	50.8
	SD	2.5	2.8	2.9	2.3	2.0
	N	39	24	29	27	15



CALCULATION 052

MEASURE SIMP 46-57

NAME SELLA TO ORBITALE

INITIAL TO FINAL

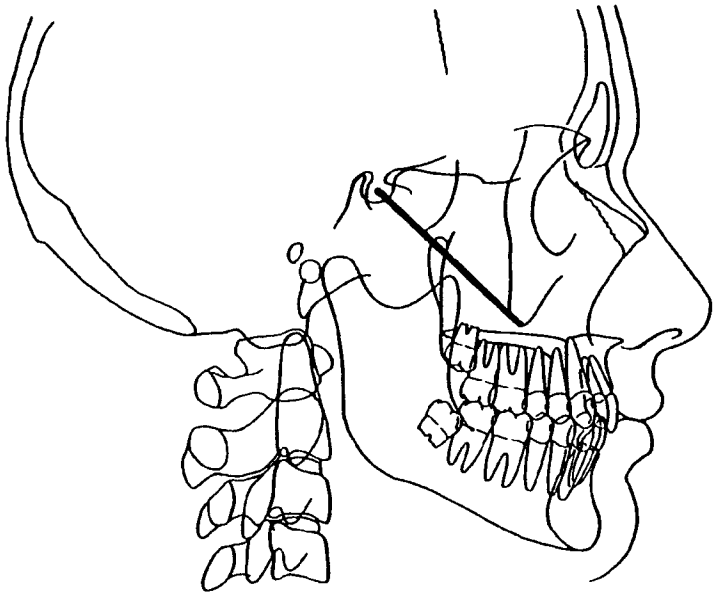
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
99	14	1.1	1.2	4.6	-3.5	1.8	.96

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	62.4	***	63.3	***	60.3	***	***	***	***	**	—	***	***	—	***
INITIAL	61.3		62.2		59.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	62.2	62.2	62.7	64.3	63.2
	SD	2.9	3.1	3.2	3.3	3.7
	N	84	31	63	36	39
FEMALE	MEAN	59.0	59.0	58.9	60.6	61.5
	SD	2.6	2.3	2.2	2.6	2.6
	N	39	24	29	27	15



CALCULATION 053

MEASURE SIMP 46-58

NAME SELLA TO INFERIOR ZYGOMA

INITIAL TO FINAL

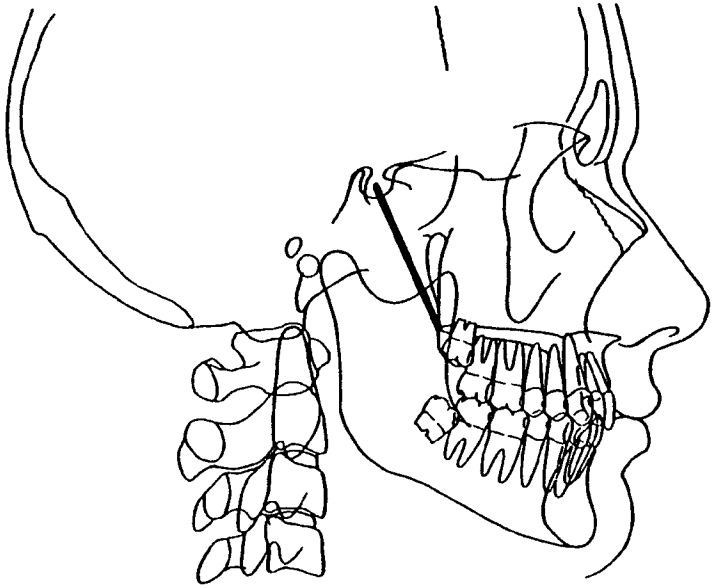
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
98	15	1.1	1.4	6.6	-3.5	1.9	.97

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	63.5	***	64.7	***	60.8	***	***	***	**	**	*	***	***	*	***
INITIAL	62.3		63.5		59.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	63.3	63.5	64.3	66.0	64.5
	SD	3.6	4.6	4.2	4.6	4.4
	N	84	31	63	36	39
FEMALE	MEAN	59.7	59.4	59.3	61.3	62.0
	SD	3.3	3.2	3.4	3.6	3.4
	N	39	24	29	27	15



CALCULATION 054

MEASURE SIMP 46-59

NAME SELLA TO PNS

INITIAL TO FINAL

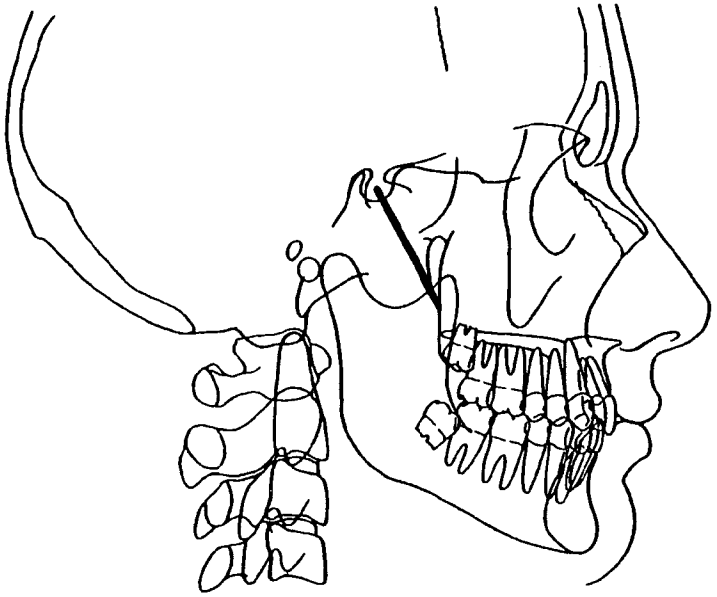
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
90	23	.9	1.2	3.9	-2.3	1.8	.96

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	50.7	***	51.9	***	48.1	***	***	***	**	—	—	***	—	—	***
INITIAL	49.8		50.9		47.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	50.7	50.8	51.5	52.7	51.4
	SD	3.4	3.8	3.3	3.8	3.6
	N	84	31	63	36	39
FEMALE	MEAN	47.9	47.6	47.4	47.2	49.5
	SD	2.6	3.0	3.1	3.6	2.7
	N	39	24	29	27	15



CALCULATION 055

MEASURE SIMP 46-60

NAME SELLA TO PTM INFERIOR

INITIAL TO FINAL

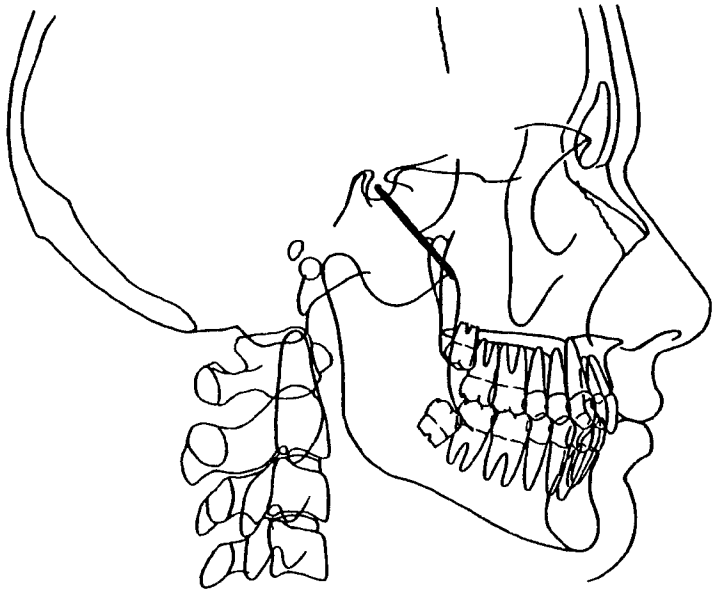
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
65	48	.3	1.6	5.4	-5.3	.9	.94

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	38.5	*	39.6	*	36.0	—	***	***	***	***	*	—	*	*	*
INITIAL	38.2		39.1		36.0										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	39.1	38.8	39.3	40.0	39.8
	SD	3.5	3.5	3.2	3.9	3.6
	N	84	31	63	36	39
FEMALE	MEAN	36.3	35.7	35.5	36.0	36.6
	SD	2.6	2.4	2.2	2.6	2.9
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 056

MEASURE SIMP 46-61

NAME SELLA TO CORONOID PROCESS

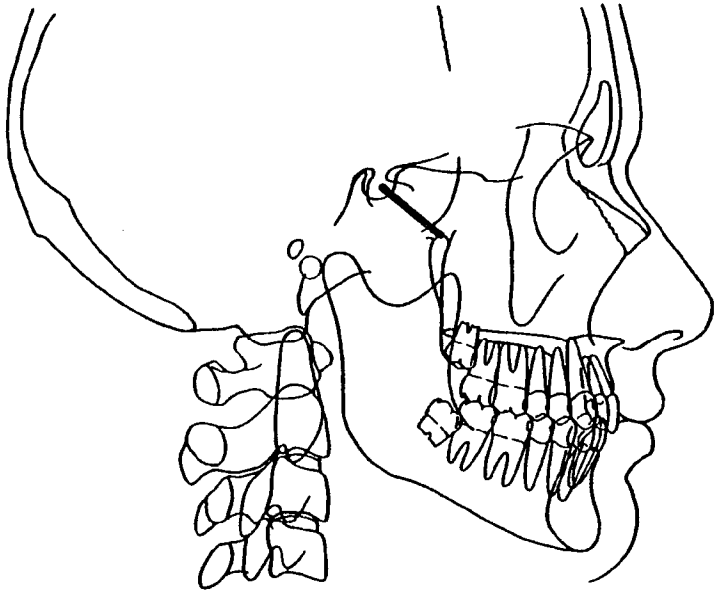
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
80	33	1.1	2.4	6.6	-5.2	3.0	.98

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	38.7	***	39.5	***	36.9	**	***	*	**	**	—	—	—	*	*
INITIAL	37.6		38.5		35.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	38.6	38.6	39.5	39.1	39.6
	SD	3.8	4.7	5.0	4.2	4.7
	N	84	31	63	36	39
FEMALE	MEAN	35.7	35.4	34.2	35.0	39.7
	SD	3.9	3.6	3.7	3.8	3.1
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 057

MEASURE SIMP 46-62

NAME SELLA TO PTM SUPERIOR

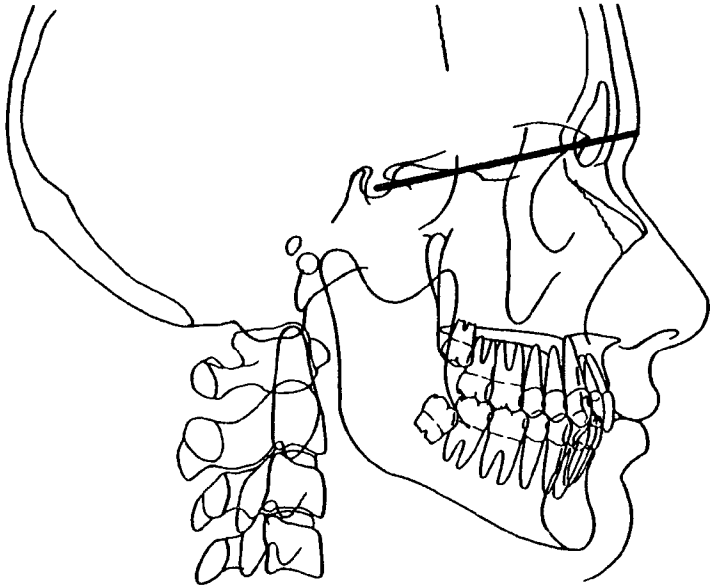
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
60	53	-.1	.9	2.7	-2.2	-.1	.94

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	25.6	—	26.1	—	24.4	—	***	—	—	—	—	—	**	—	**
INITIAL	25.7		26.2		24.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	26.2	26.2	25.9	26.7	25.8
	SD	2.5	2.5	2.4	2.8	2.3
	N	84	31	63	36	39
FEMALE	MEAN	24.5	24.5	23.8	24.2	25.4
	SD	2.1	2.0	1.6	1.9	2.2
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 058

MEASURE SIMP 46-75

NAME SELLA TO SOFT TISSUE GLABELLA

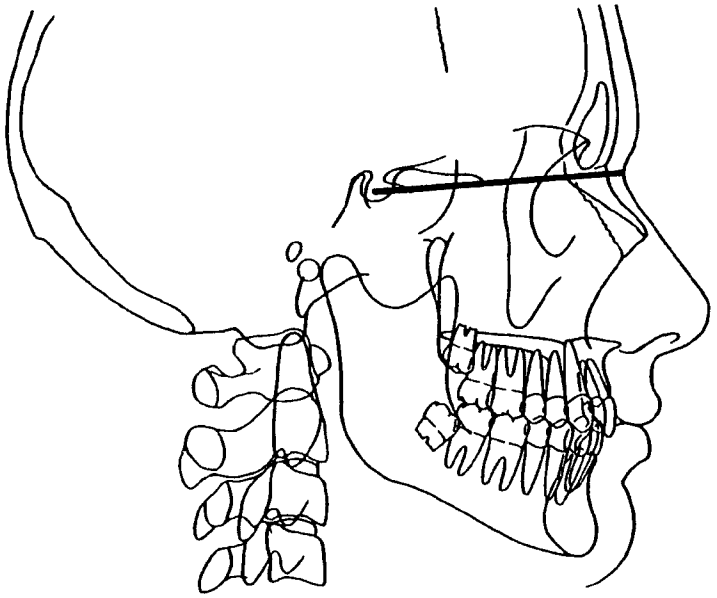
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
93	20	1.6	1.8	6.7	-2.7	1.8	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	89.1	***	90.9	***	84.9	**	***	***	*	—	—	***	**	***	***
INITIAL	87.5		89.0		84.2										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	89.0	89.5	89.3	91.3	91.2
	SD	3.6	3.5	3.5	4.2	3.5
	N	84	31	63	36	39
FEMALE	MEAN	84.4	83.9	82.7	84.8	86.9
	SD	3.4	3.6	3.1	3.4	2.3
	N	39	24	29	27	15



CALCULATION 059

MEASURE SIMP 46-76

NAME SELLA TO SOFT TISSUE NASION

INITIAL TO FINAL

UNTREATED

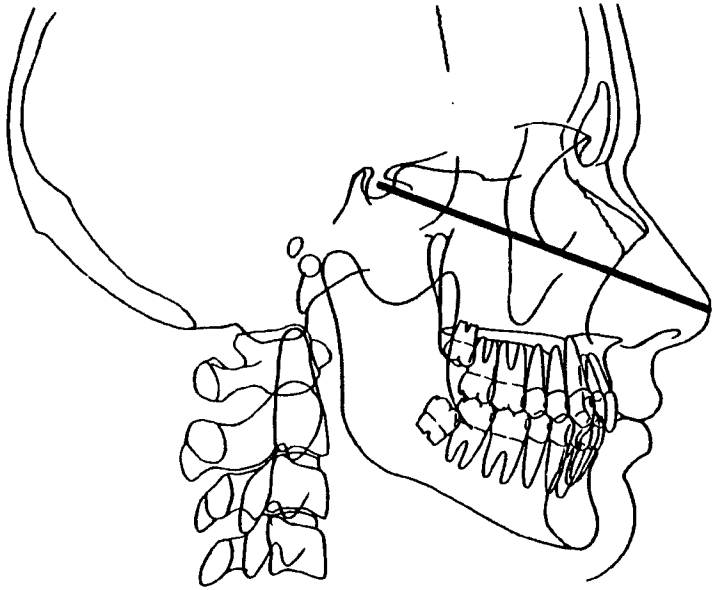
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
101	12	1.8	1.6	6.6	-1.6	2.2	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	82.1	***	83.8	***	78.3	***	***	***	**	*	—	***	**	***	***
INITIAL	80.4		82.0		76.6										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	82.0	82.6	81.8	84.0	84.0
	SD	3.4	3.2	3.4	3.5	3.3
	N	84	31	63	36	39
FEMALE	MEAN	76.7	76.5	75.3	77.7	79.9
	SD	3.0	2.9	1.6	2.9	3.5
	N	39	24	29	27	15



CALCULATION 060

MEASURE SIMP 46-77

NAME SELLA TO ANTERIOR NOSE POINT

INITIAL TO FINAL

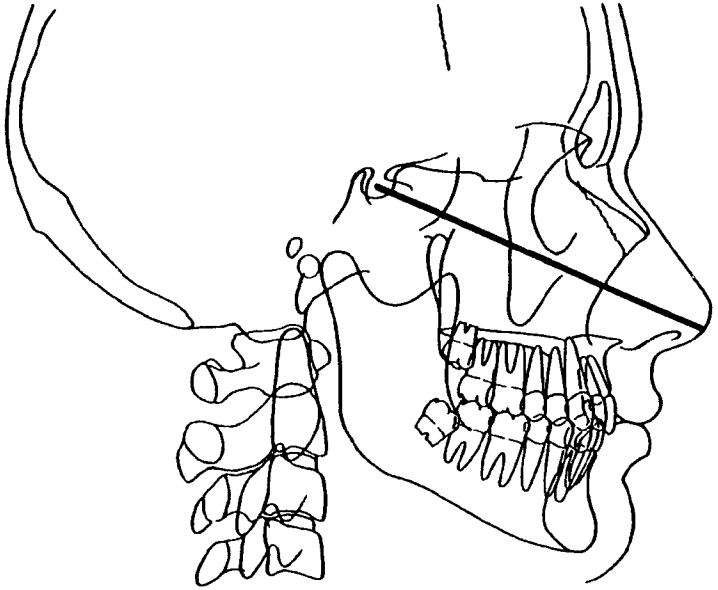
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
110	3	2.9	2.2	10.9	-.7	2.6	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	116.4	***	119.3	***	109.6	***	***	***	***	*	—	***	**	***	***
INITIAL	113.5		116.1		107.5										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	115.5	116.9	117.3	121.0	119.0
	SD	5.0	4.9	4.1	4.3	3.8
	N	84	31	63	36	39
FEMALE	MEAN	107.7	107.8	107.8	108.8	111.7
	SD	4.3	4.2	3.1	4.0	3.8
	N	39	24	29	27	15



CALCULATION 061

MEASURE SIMP 46-78

NAME SELLA TO NOSE POINT-B

INITIAL TO FINAL

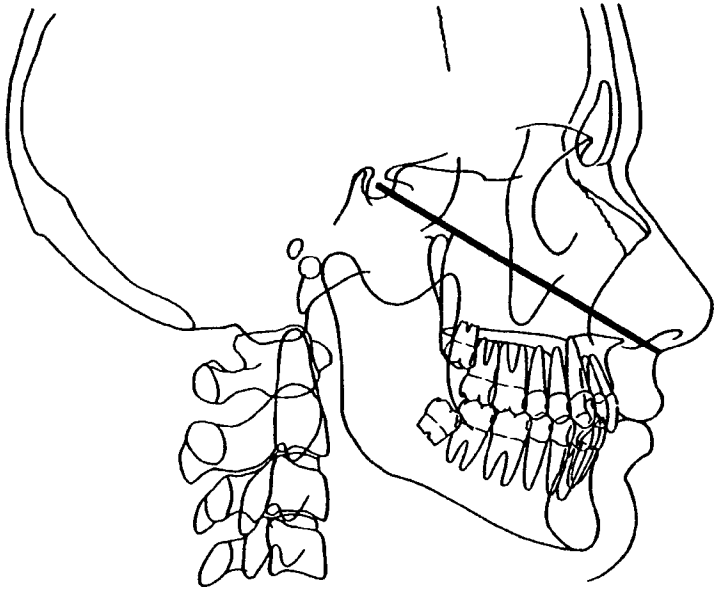
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
103	10	2.7	2.2	11.2	-1.1	2.4	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	116.3	***	119.2	***	109.5	***	***	***	***	*	—	***	**	***	***
INITIAL	113.6		116.1		107.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	115.6	116.8	117.3	120.9	119.1
	SD	5.0	5.0	4.1	4.5	4.1
	N	84	31	63	36	39
FEMALE	MEAN	107.9	107.9	107.7	108.7	111.7
	SD	4.3	4.4	3.3	4.0	4.2
	N	39	24	29	27	15



CALCULATION 062

MEASURE SIMP 46-79

NAME SELLA TO SUBNASALE

INITIAL TO FINAL

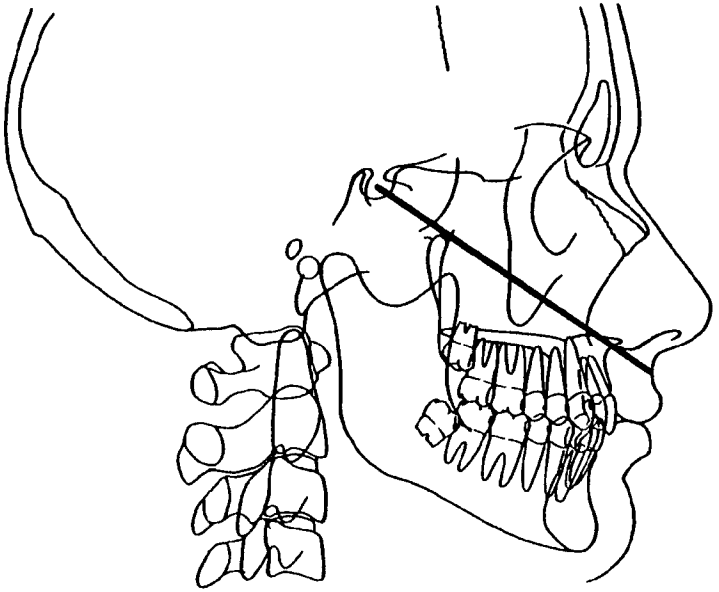
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
69	44	.5	1.8	6.1	-4.7	.5	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	104.6	**	107.3	***	98.6	—	***	—	—	—	—	**	**	—	***
INITIAL	104.1		106.4		98.8										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	106.2	106.7	107.1	109.3	106.2
	SD	4.2	4.1	3.7	4.6	4.5
	N	84	31	63	36	39
FEMALE	MEAN	99.3	98.9	98.5	98.7	100.3
	SD	3.8	4.3	3.4	4.4	3.6
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 063

MEASURE SIMP 46-80

NAME SELLA TO SOFT TISSUE A POINT

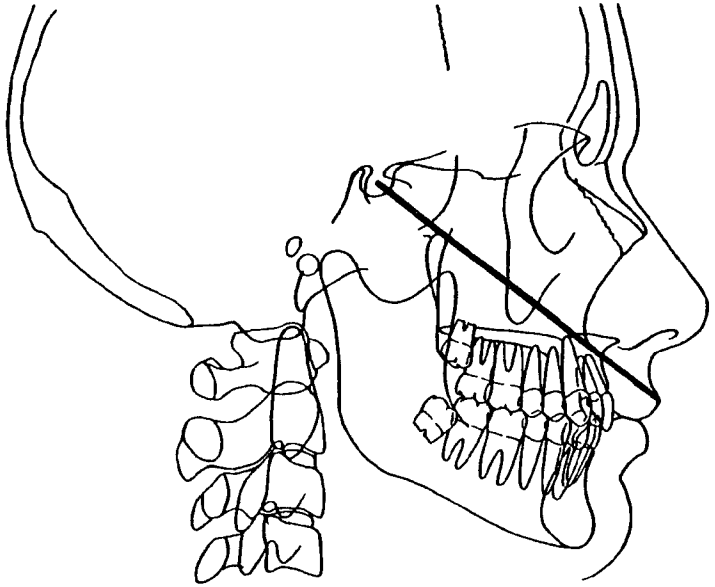
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
94	19	2.3	2.2	7.5	-2.4	2.1	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	108.9	***	111.9	***	101.9	**	***	***	**	***	**	***	**	**	***
INITIAL	106.6		109.1		101.0										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	108.6	109.3	110.1	113.4	111.3
	SD	4.5	4.4	4.6	4.4	4.7
	N	84	31	63	36	39
FEMALE	MEAN	101.3	101.0	101.0	101.3	104.1
	SD	3.3	3.6	2.8	4.9	4.5
	N	39	24	29	27	15



CALCULATION 064

MEASURE SIMP 46-81

NAME SELLA TO UPPER LIP ANTERIOR

INITIAL TO FINAL

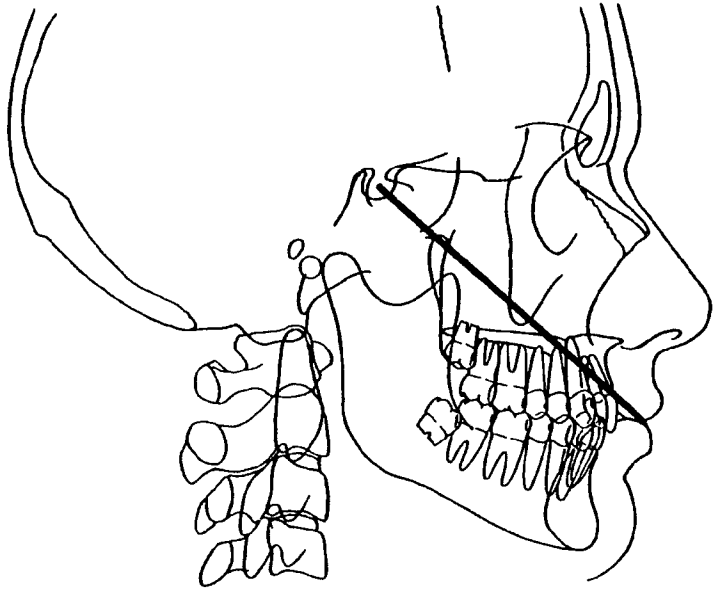
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
88	25	1.9	2.3	9.1	-3.9	1.7	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	115.2	***	118.2	***	108.1	**	***	***	*	**	*	**	**	**	***
INITIAL	113.3		115.9		107.2										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	115.6	116.8	116.8	119.4	117.9
	SD	4.9	4.6	4.8	5.1	5.4
	N	84	31	63	36	39
FEMALE	MEAN	107.5	107.2	106.7	107.5	111.0
	SD	3.2	3.6	3.1	4.7	3.6
	N	39	24	29	27	15



CALCULATION 065

MEASURE SIMP 46-82

NAME SELLA TO STOMION

INITIAL TO FINAL

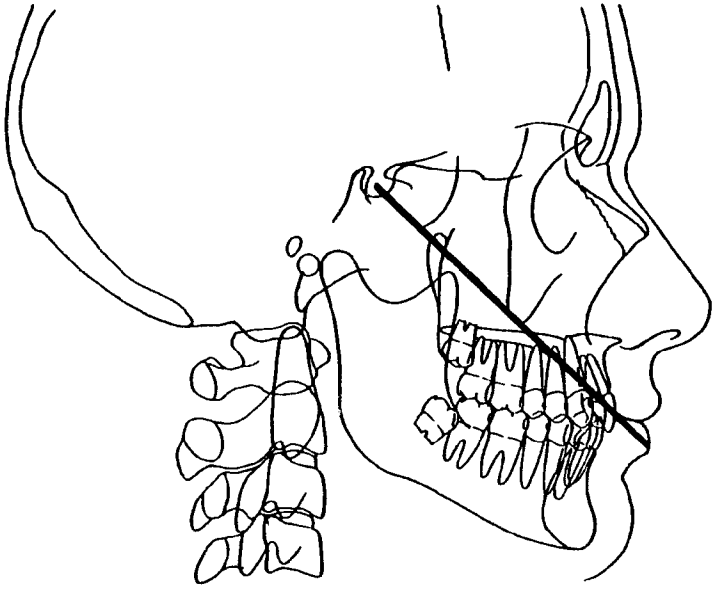
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
101	12	2.6	2.3	11.4	-2.1	2.3	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	114.3	***	117.1	***	107.6	***	***	***	**	***	*	***	**	**	***
INITIAL	111.6		114.0		106.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	113.8	115.0	115.3	117.9	117.0
	SD	4.8	4.8	4.9	5.2	5.5
	N	84	31	63	36	39
FEMALE	MEAN	106.4	106.1	105.6	106.4	110.9
	SD	3.3	3.6	3.6	4.5	3.9
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 066

MEASURE SIMP 46-83

NAME SELLA TO LOWER LIP ANTERIOR

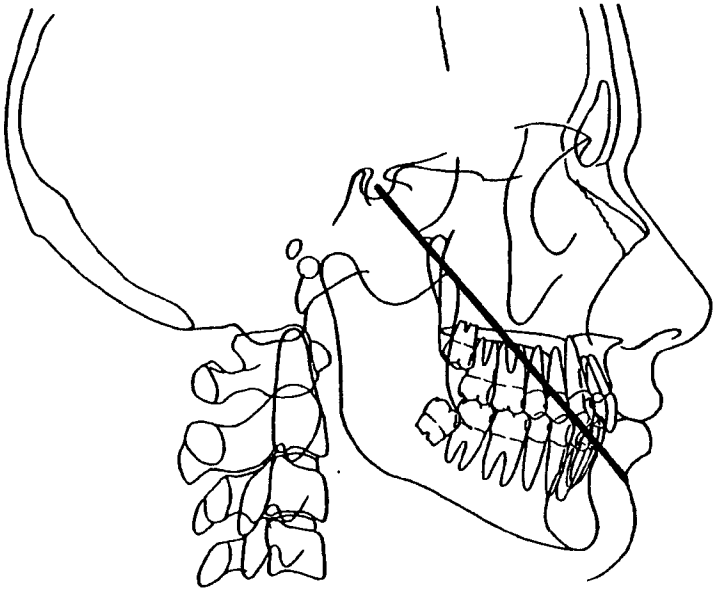
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
90	23	2.1	2.6	11.7	-3.1	1.7	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	121.4	***	124.2	***	114.9	**	***	***	*	**	*	***	*	***	***
INITIAL	119.4		121.7		114.0										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	121.7	122.7	122.6	124.7	124.1
	SD	5.0	4.9	5.2	5.5	5.8
	N	84	31	63	36	39
FEMALE	MEAN	114.5	114.3	112.7	114.1	118.1
	SD	3.5	4.4	3.5	4.8	4.7
	N	39	24	29	27	15



CALCULATION 067

MEASURE SIMP 46-84

NAME SELLA TO MENTAL SULCUS

INITIAL TO FINAL

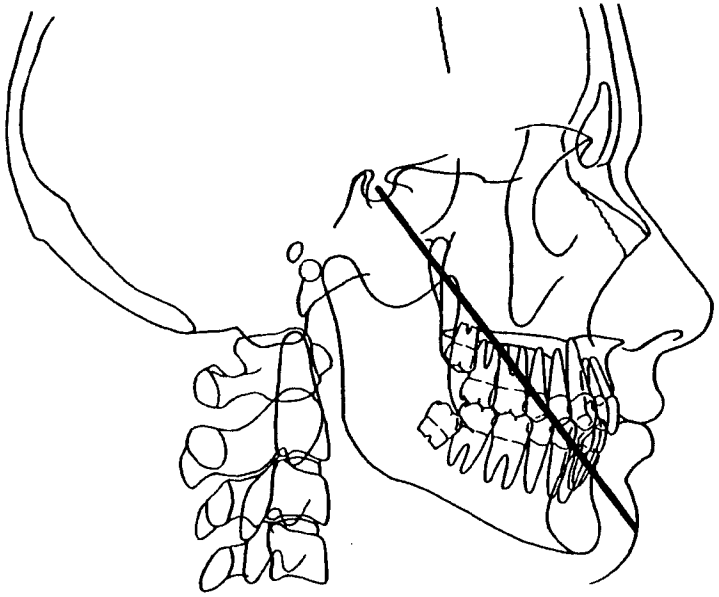
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
108	5	3.9	2.7	13.9	-1.5	3.2	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	124.6	***	127.5	***	118.0	***	***	***	***	**	*	***	*	**	**
INITIAL	120.7		123.0		115.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	122.8	123.5	124.7	127.6	127.5
	SD	5.4	5.7	6.1	6.7	6.6
	N	84	31	63	36	39
FEMALE	MEAN	115.4	115.6	114.6	116.6	121.0
	SD	3.5	4.0	3.7	4.9	5.5
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 068

MEASURE SIMP 46-85

NAME SELLA TO SOFT TISSUE POGONION

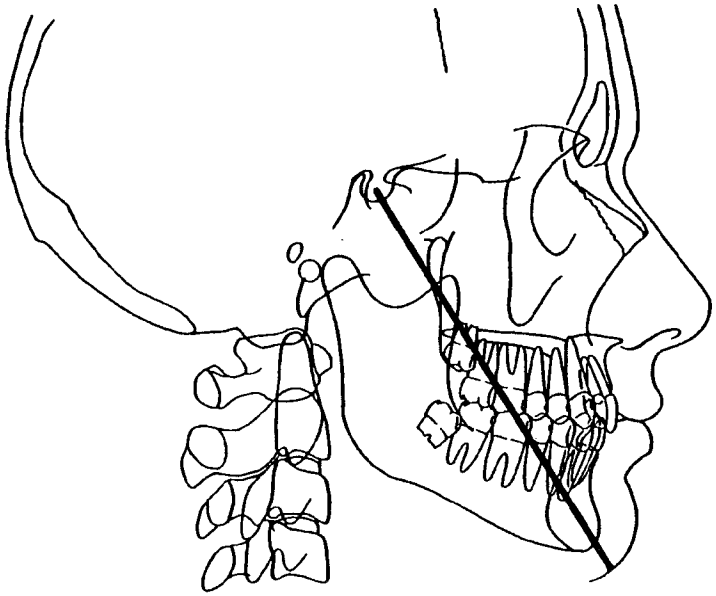
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
103	10	4.9	4.0	17.5	-3.3	3.7	.98

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	137.7	***	141.2	***	129.6	***	***	***	**	**	—	***	**	***	***
INITIAL	132.7		135.4		126.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	134.8	136.0	137.7	140.6	142.2
	SD	5.8	5.8	6.3	7.3	6.9
	N	84	31	63	36	39
FEMALE	MEAN	126.1	126.4	124.7	127.8	133.8
	SD	4.5	4.6	4.4	6.1	5.9
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 069

MEASURE SIMP 46-86

NAME SELLA TO SOFT TISSUE GNATHION

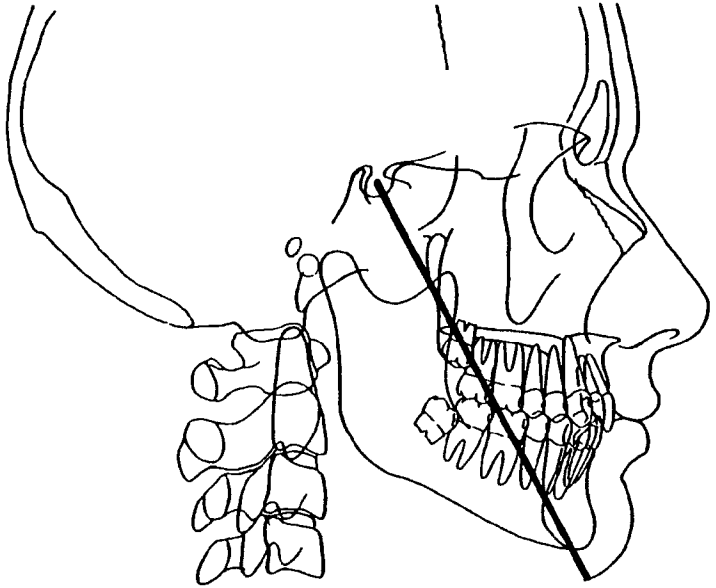
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
107	6	4.9	3.7	18.4	-2.3	3.5	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	144.2	***	147.8	***	135.7	***	***	***	***	**	*	***	**	**	***
INITIAL	139.3		142.2		132.5										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	141.7	143.3	144.7	147.7	148.6
	SD	5.7	6.2	6.7	7.5	6.9
	N	84	31	63	36	39
FEMALE	MEAN	132.2	132.2	130.5	133.4	140.0
	SD	4.6	4.6	4.7	7.0	6.7
	N	39	24	29	27	15



CALCULATION 070

MEASURE SIMP 46-87

NAME SELLA TO SOFT TISSUE MENTON

INITIAL TO FINAL

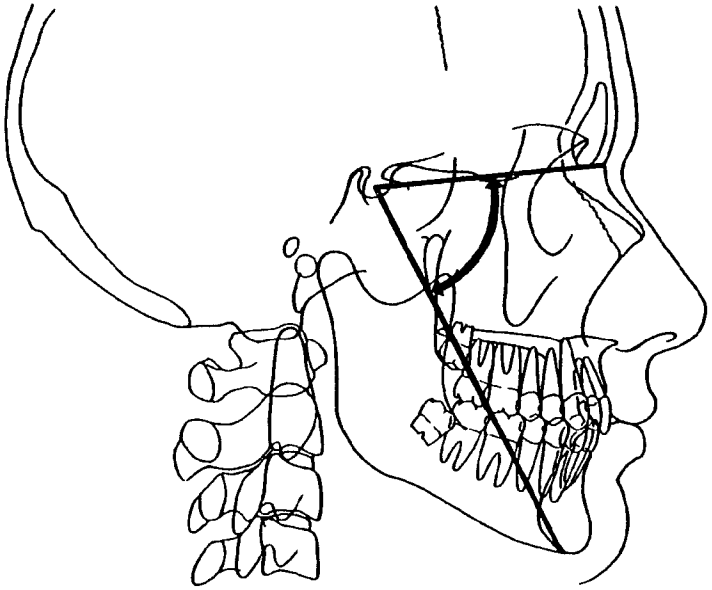
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
97	16	3.7	3.5	18.3	-4.0	2.7	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	142.7	***	146.5	***	133.9	***	***	***	**	*	*	***	*	*	***
INITIAL	139.0		142.0		131.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	141.5	143.2	144.9	147.0	146.2
	SD	5.9	6.6	7.0	8.2	7.2
	N	84	31	63	36	39
FEMALE	MEAN	131.5	131.3	129.8	131.9	137.8
	SD	4.6	4.4	5.4	7.6	6.8
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 071

MEASURE 3 PTA 54-46-1

NAME ANGLE NASION-SELLA-MENTON

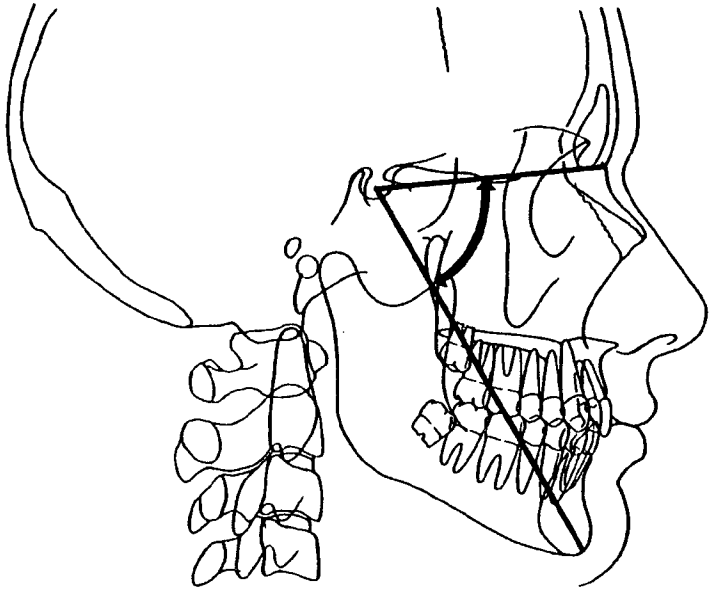
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
62	51	.1	.8	2.5	-2.9	.2	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	69.2	—	68.9	—	69.8	***	—	—	—	—	—	—	***	—	—
INITIAL	69.0		68.9		69.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	69.1	69.1	69.2	68.1	68.9
	SD	3.4	3.0	2.7	3.7	4.1
	N	84	31	63	36	39
FEMALE	MEAN	69.4	69.3	70.0	68.4	69.5
	SD	3.2	3.0	3.2	2.3	3.0
	N	39	24	29	27	15



CALCULATION 072

MEASURE 3 PTA 54-46-2

NAME ANGLE NASION-SELLA-GNATHION

INITIAL TO FINAL

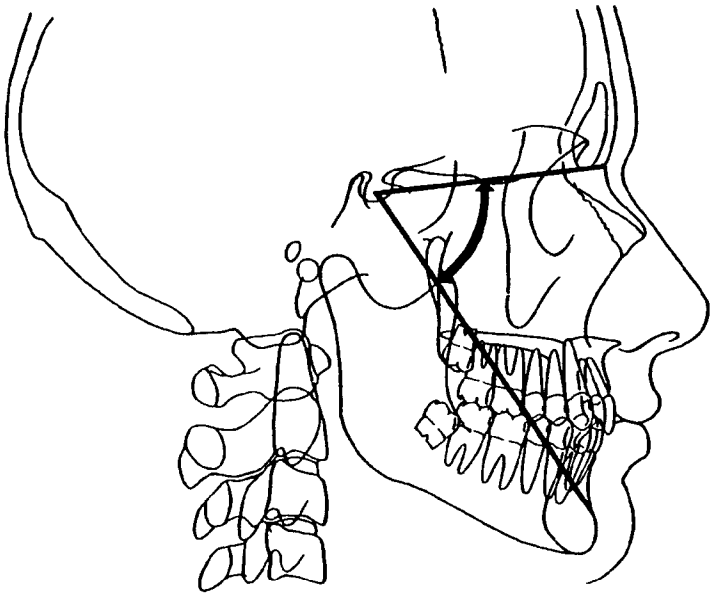
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
70	43	.2	.8	3.0	-2.2	.2	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	67.1	*	66.9	—	67.6	***	—	—	—	—	—	—	***	—	—
INITIAL	66.9		66.9		67.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	67.0	67.1	67.2	66.0	66.8
	SD	3.3	2.9	2.8	3.8	4.0
	N	84	31	63	36	39
FEMALE	MEAN	67.2	67.0	67.7	66.3	67.3
	SD	3.0	2.7	2.8	2.3	3.0
	N	39	24	29	27	15



CALCULATION 073

MEASURE 3 PTA 54-46-3

NAME ANGLE NASION-SELLA-POGONION

INITIAL TO FINAL

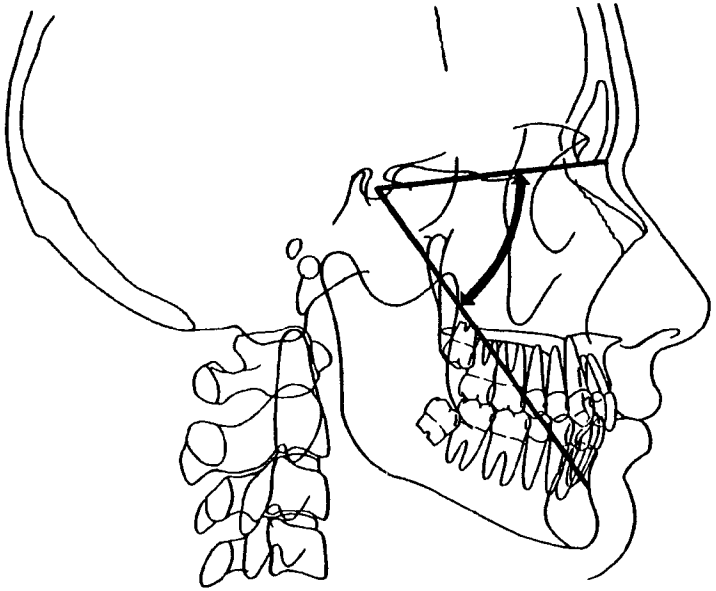
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
72	41	.3	.8	3.5	-1.5	.4	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	64.4	***	64.3	—	64.7	***	—	—	—	—	—	—	***	—	—
INITIAL	64.1		64.1		64.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	64.2	64.4	64.5	63.2	64.1
	SD	3.3	3.0	2.9	3.9	4.1
	N	84	31	63	36	39
FEMALE	MEAN	64.1	63.9	64.7	63.3	64.5
	SD	3.0	2.6	2.7	2.3	3.0
	N	39	24	29	27	15



CALCULATION 074

MEASURE 3PTA 54-46-4

NAME ANGLE NASION-SELLA-B POINT

INITIAL TO FINAL

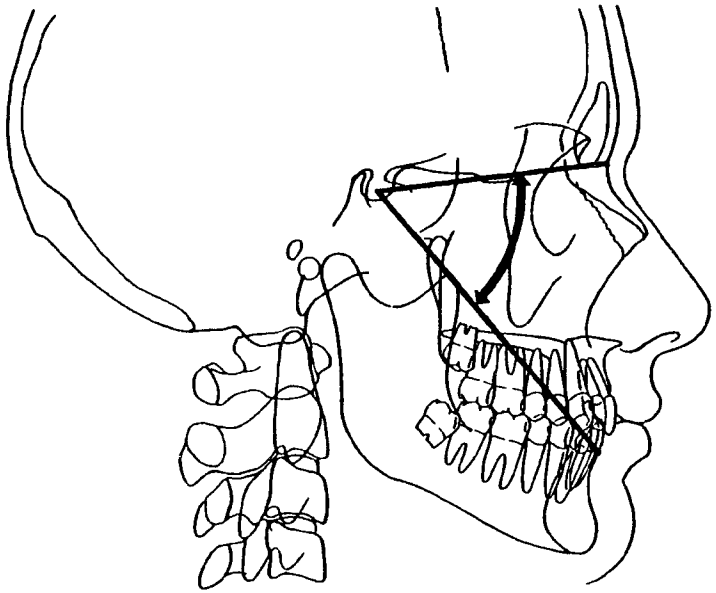
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
72	41	.2	.9	2.4	-2.5	.3	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	61.1	*	61.0	–	61.5	***	–	–	–	–	–	–	***	–	***
INITIAL	61.0		61.0		60.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	61.0	61.2	61.4	60.0	60.7
	SD	3.2	2.9	2.9	4.2	4.3
	N	84	31	63	36	39
FEMALE	MEAN	60.9	60.6	61.5	60.3	61.1
	SD	3.0	2.7	2.7	2.3	2.7
	N	39	24	29	27	15



CALCULATION 075

MEASURE 3PTA 54-46-5

NAME ANGLE NASION-SELLA-INFRADENTALE

INITIAL TO FINAL

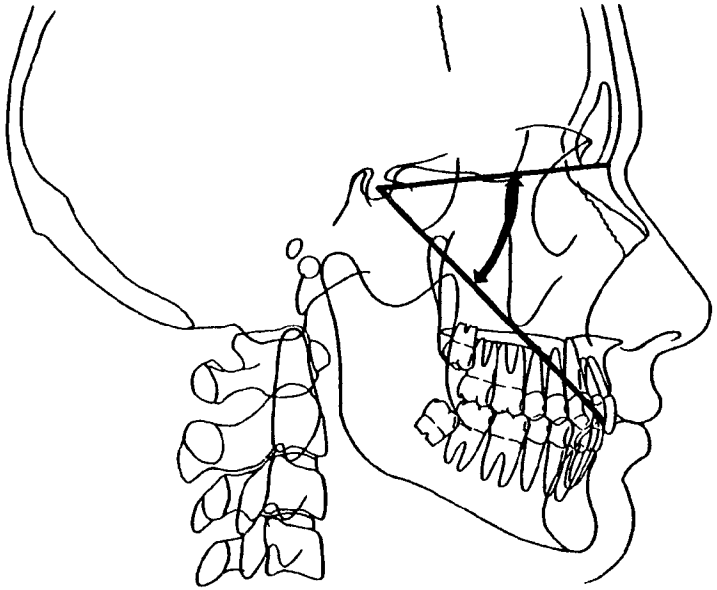
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
66	47	.2	.7	2.6	-1.7	.3	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	56.7	*	56.6	—	57.1	**	—	—	—	—	—	—	***	NA	NA
INITIAL	56.6		56.5		56.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	56.6	56.7	57.0	55.8	56.5
	SD	2.9	2.9	2.7	4.0	3.9
	N	84	31	63	36	39
FEMALE	MEAN	56.6	56.4	57.1	56.1	56.8
	SD	2.4	2.4	2.4	2.3	2.2
	N	39	24	29	27	15



CALCULATION 076

MEASURE 3PTA 54-46-6

NAME ANGLE NASION-SELLA-LOWER INCISOR INCISAL EDGE

INITIAL TO FINAL

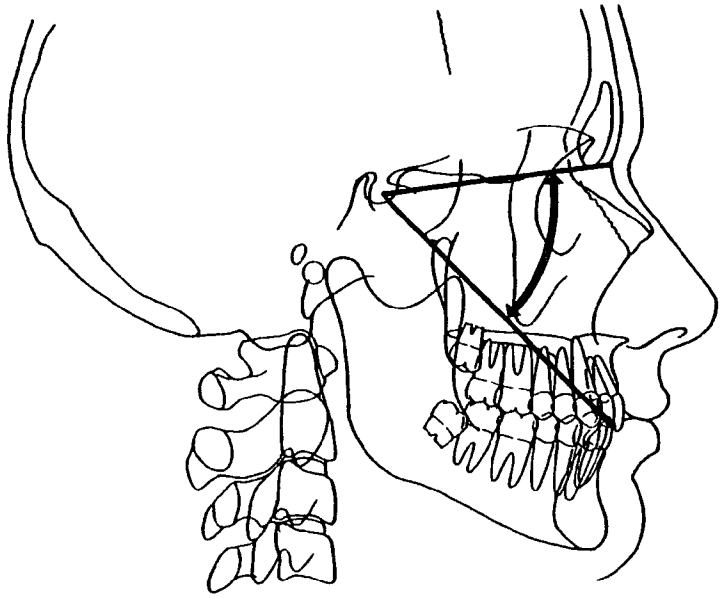
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
64	49	.2	.6	2.0	-1.7	.3	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	51.9	*	51.8	—	52.0	*	—	—	—	—	—	—	***	NA	NA
INITIAL	51.7		51.7		51.8										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	51.8	52.0	52.4	51.2	51.7
	SD	2.9	3.0	2.7	3.7	3.6
	N	84	31	63	36	39
FEMALE	MEAN	51.5	51.3	51.9	51.2	51.8
	SD	2.4	2.5	2.7	2.1	2.3
	N	39	24	29	27	15



CALCULATION 077

MEASURE 3PTA 54-46-7

NAME ANGLE NASION-SELLA-ANTERIOR DOWNS POINT

INITIAL TO FINAL

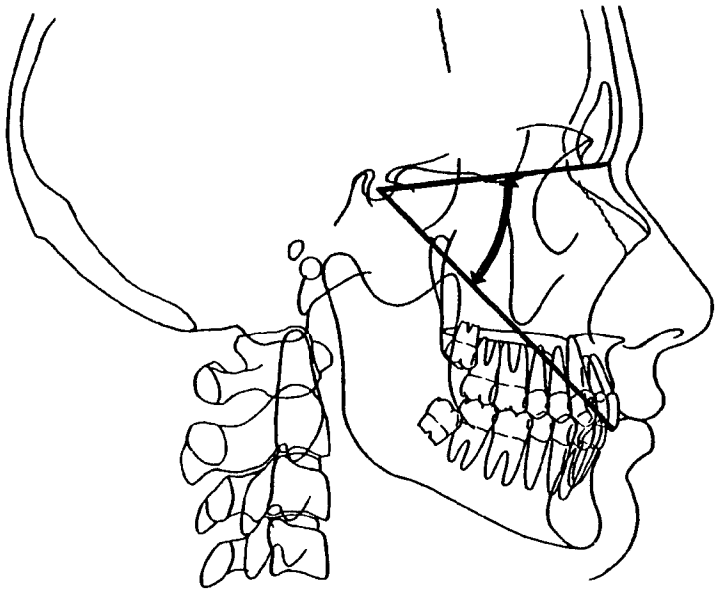
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
63	50	.1	.7	1.9	-2.1	.3	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	52.1	*	52.1	—	52.2	—	—	—	—	—	—	—	***	NA	NA
INITIAL	52.0		52.0		52.0										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	52.1	52.3	52.6	51.4	52.1
	SD	2.9	3.0	2.7	3.6	3.5
	N	84	31	63	36	39
FEMALE	MEAN	51.8	51.5	52.3	51.5	52.0
	SD	2.4	2.4	2.5	2.1	2.4
	N	39	24	29	27	15



CALCULATION 078

MEASURE 3PTA 54-46-8

NAME ANGLE NASION-SELLA-UPPER INCISOR INCISAL EDGE

INITIAL TO FINAL

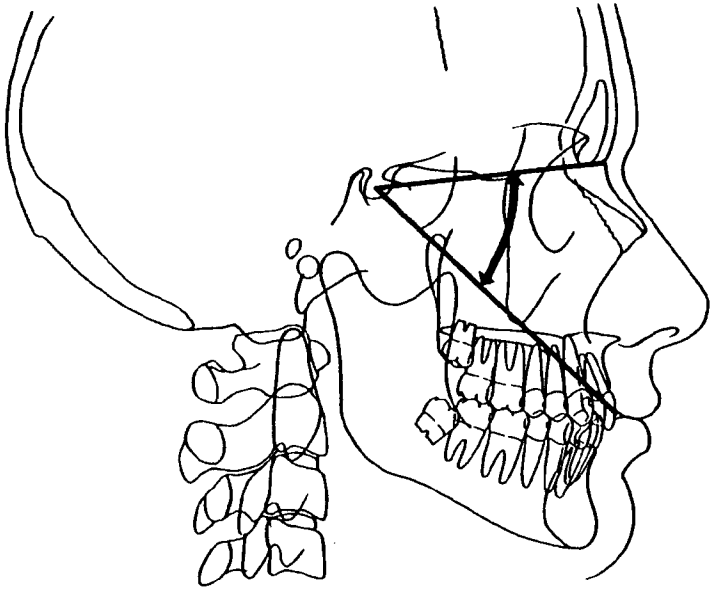
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
60	53	.1	.7	2.0	-2.6	.2	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	52.2	—	52.2	—	52.2	—	—	—	—	—	—	—	***	NA	NA
INITIAL	52.1		52.1		52.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	52.2	52.4	52.6	51.5	52.3
	SD	2.8	2.9	2.7	3.5	3.5
	N	84	31	63	36	39
FEMALE	MEAN	51.9	51.6	52.4	51.7	51.9
	SD	2.4	2.5	2.5	2.2	2.4
	N	39	24	29	27	15



CALCULATION 079

MEASURE 3PTA 54-46-9

NAME ANGLE NASION-SELLA-LABIAL OF UPPER INCISOR

INITIAL TO FINAL

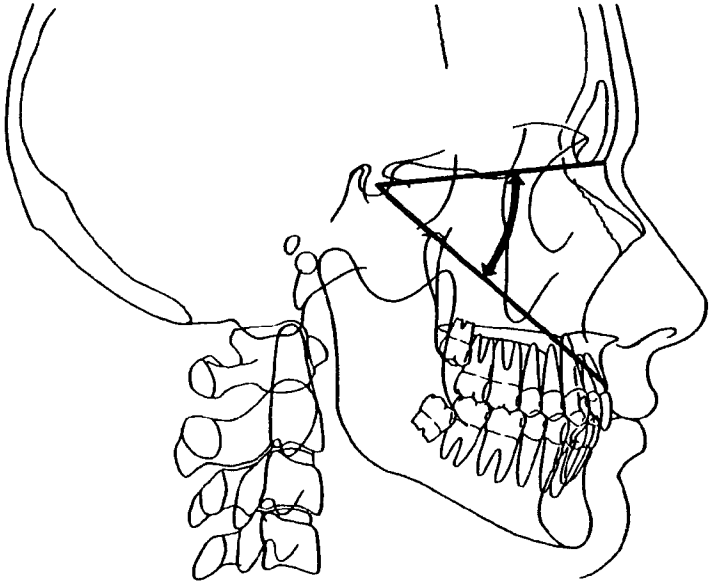
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
87	26	.5	.7	2.4	-1.1	1.0	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	49.4	***	49.4	***	49.4	***	—	*	—	—	*	*	***	NA	NA
INITIAL	48.9		48.9		48.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	49.0	49.1	49.6	48.6	49.3
	SD	2.4	2.6	2.4	3.5	3.4
	N	84	31	63	36	39
FEMALE	MEAN	48.7	48.6	49.1	48.7	49.0
	SD	2.3	2.4	2.7	1.9	2.1
	N	39	24	29	27	15



CALCULATION 080

MEASURE 3PTA 54-46-10

NAME ANGLE NASION-SELLA-SUPRADENTALE

INITIAL TO FINAL

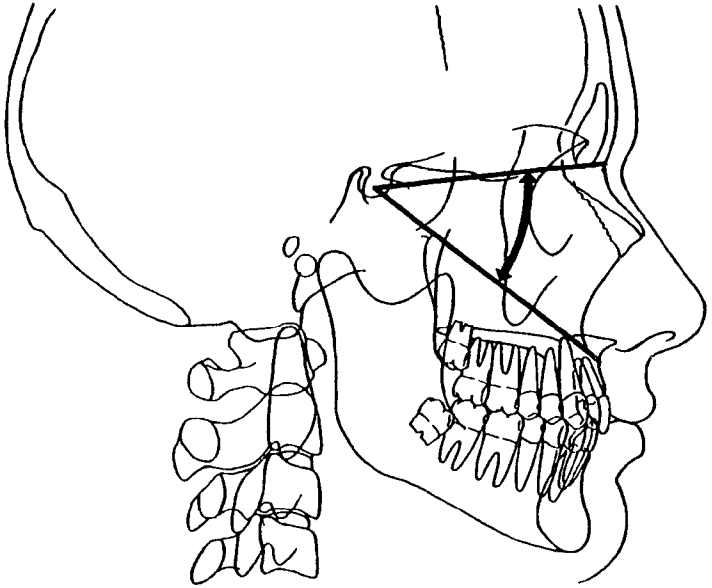
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
64	49	.1	.6	1.5	-1.8	.3	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	47.0	*	47.0	—	47.1	*	—	—	—	—	—	*	***	NA	NA
INITIAL	46.9		46.9		46.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	47.0	47.1	47.6	46.4	46.9
	SD	2.5	2.7	2.4	3.3	3.2
	N	84	31	63	36	39
FEMALE	MEAN	46.7	46.4	47.1	46.5	46.8
	SD	2.3	2.4	2.4	2.0	2.2
	N	39	24	29	27	15



CALCULATION 081

MEASURE 3PTA 54-46-11

NAME ANGLE NASION-SELLA-A POINT

INITIAL TO FINAL

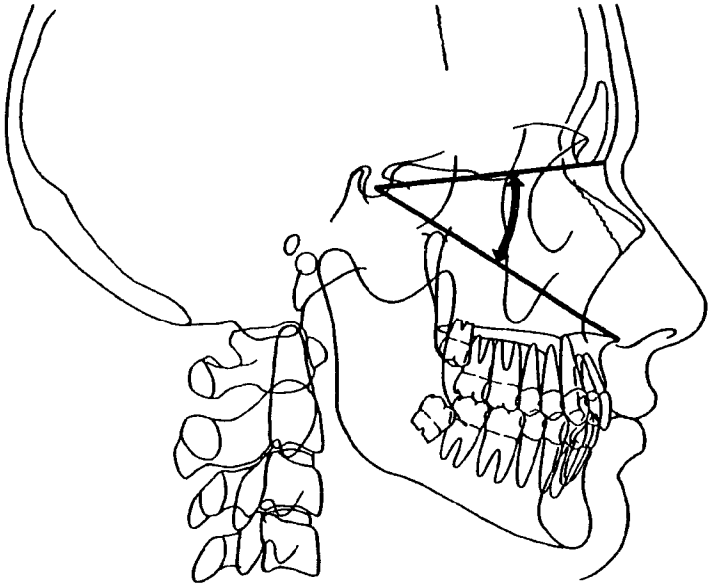
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
45	68	-.1	.7	2.2	-2.3	-.3	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	43.4	—	43.5	—	43.3	—	—	—	*	—	—	—	***	—	***
INITIAL	43.5		43.6		43.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	43.7	43.8	44.3	43.0	43.1
	SD	2.3	2.6	2.3	3.3	3.1
	N	84	31	63	36	39
FEMALE	MEAN	43.2	43.1	43.3	42.7	42.8
	SD	2.3	2.4	2.4	1.8	1.9
	N	39	24	29	27	15



CALCULATION 082

MEASURE 3PTA 54-46-12

NAME ANGLE NASION-SELLA-ANS

INITIAL TO FINAL

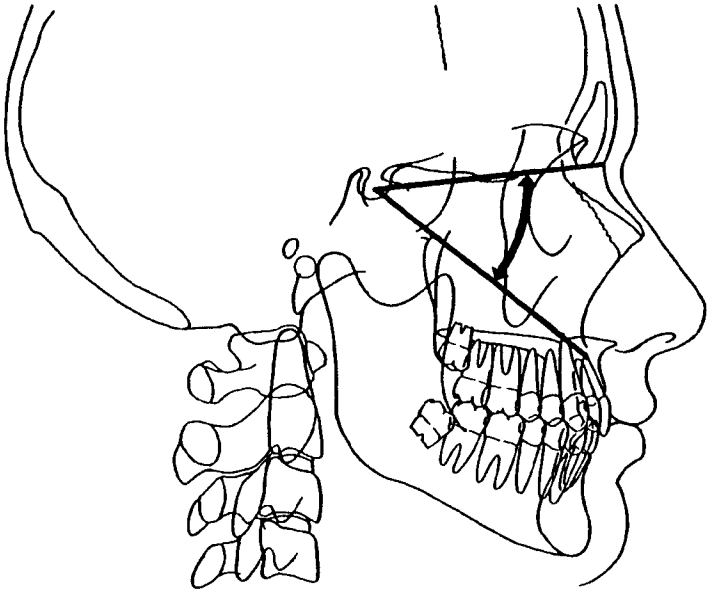
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
51	62	0	.6	1.5	-2.2	-.1	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	37.7	—	37.8	—	37.5	—	—	**	**	—	—	—	**	*	—
INITIAL	37.7		37.8		37.5										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	37.7	37.9	38.6	37.8	37.6
	SD	2.0	2.4	2.2	2.6	2.7
	N	84	31	63	36	39
FEMALE	MEAN	37.3	37.3	37.4	37.1	37.1
	SD	1.8	1.7	2.0	1.6	1.7
	N	39	24	29	27	15



CALCULATION 083

MEASURE 3PTA 54-46-13

NAME ANGLE NASION-SELLA-UPPER INCISOR ROOT APEX

INITIAL TO FINAL

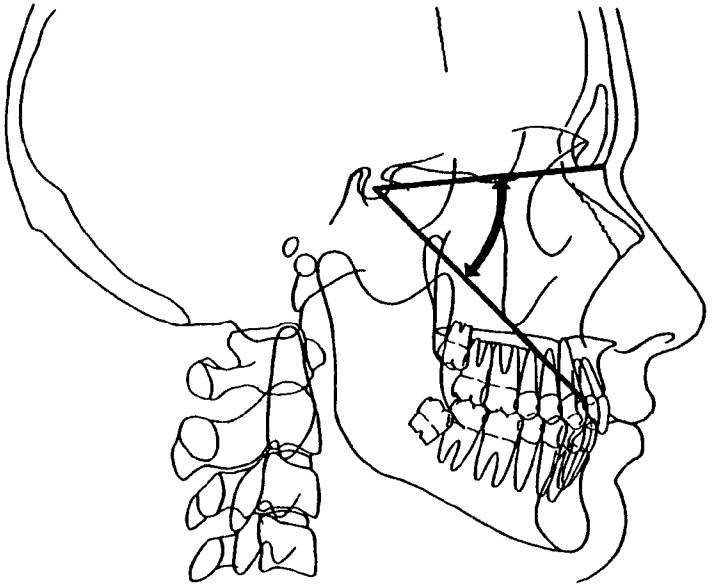
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
50	63	0	.8	2.3	-1.6	0	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	44.6	—	44.6	—	44.7	—	—	**	***	*	—	*	***	NA	NA
INITIAL	44.6		44.6		44.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	44.6	44.7	45.4	44.0	44.3
	SD	2.4	2.8	2.6	3.8	3.5
	N	84	31	63	36	39
FEMALE	MEAN	44.5	44.4	44.5	43.6	44.5
	SD	2.6	2.7	3.0	2.3	2.3
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 084

MEASURE 3PTA 54-46-14

NAME ANGLE NASION-SELLA-UPPER INCISOR
LINGUAL BONY
CONTACT AREA

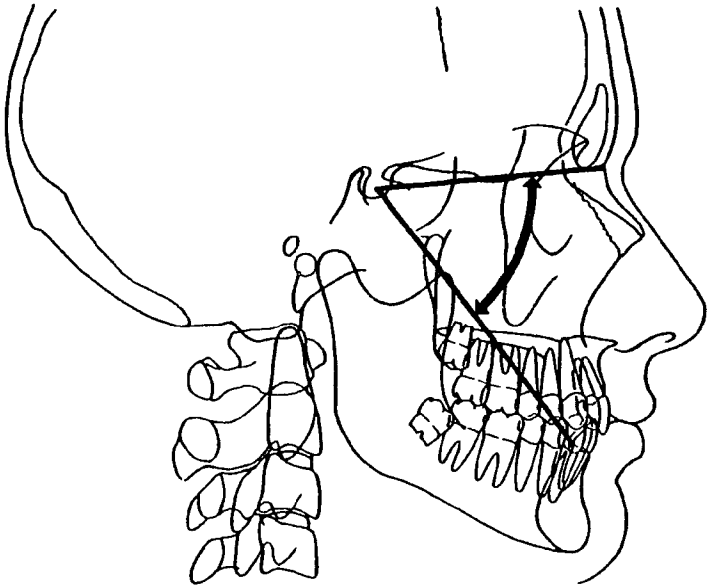
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
55	58	0	.6	1.8	-1.8	0	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	50.7	—	50.6	—	50.9	—	—	*	*	—	—	—	***	NA	NA
INITIAL	50.7		50.7		50.8										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	50.8	50.8	51.4	50.0	50.4
	SD	2.5	2.8	2.5	3.5	3.4
	N	84	31	63	36	39
FEMALE	MEAN	50.6	50.4	50.9	50.3	50.4
	SD	2.4	2.5	2.6	2.0	2.2
	N	39	24	29	27	15



CALCULATION 085

MEASURE 3PTA 54-46-15

NAME ANGLE NASION-SELLA-LOWER INCISOR LINGUAL BONY CONTACT POINT

INITIAL TO FINAL

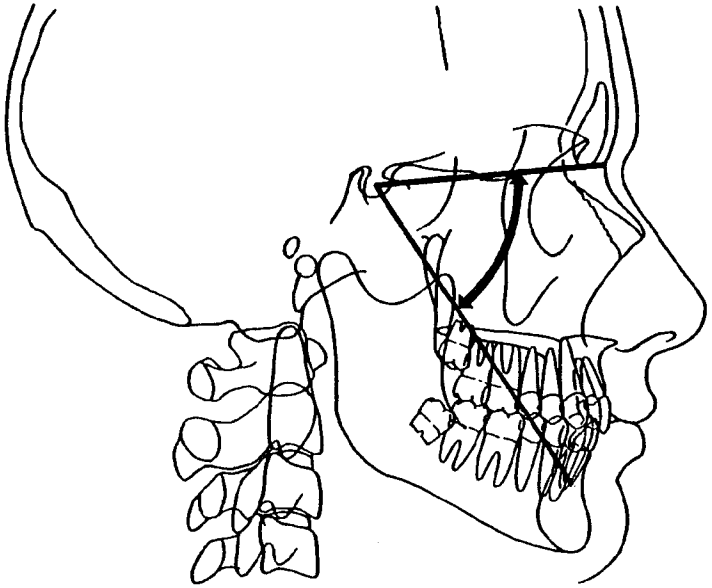
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
59	54	.1	.9	2.3	-2.1	.1	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	57.9	—	57.8	—	58.2	—	—	—	—	—	—	—	***	NA	NA
INITIAL	57.8		57.8		58.0										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	57.9	57.9	58.3	56.9	57.7
	SD	3.1	3.1	2.8	3.9	4.0
	N	84	31	63	36	39
FEMALE	MEAN	57.8	57.6	58.2	57.4	57.7
	SD	2.5	2.5	2.7	2.1	2.5
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 086

MEASURE 3PTA 54-46-16

NAME ANGLE NASION-SELLA-LOWER INCISOR ROOT APEX

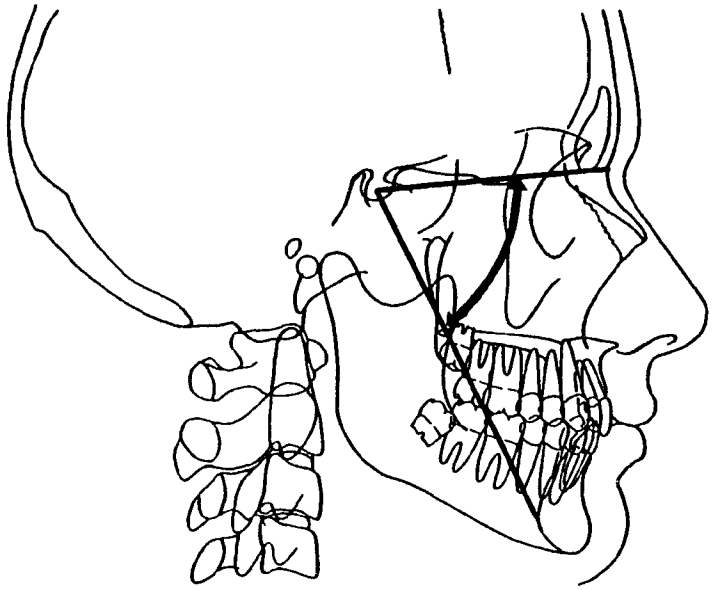
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
49	64	-.2	1.0	3.1	-2.7	-.3	.96

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	63.3	*	63.2	*	63.6	—	—	—	—	—	—	—	***	NA	NA
INITIAL	63.5		63.4		63.6										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	63.6	63.6	63.7	62.3	63.0
	SD	3.3	3.0	2.7	3.6	3.9
	N	84	31	63	36	39
FEMALE	MEAN	63.5	63.5	64.1	62.8	63.2
	SD	2.6	2.6	2.8	2.2	2.6
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 087

MEASURE 3PTA 54-46-17

NAME ANGLE NASION-SELLA-LINGUAL SYMPHYSEAL POINT

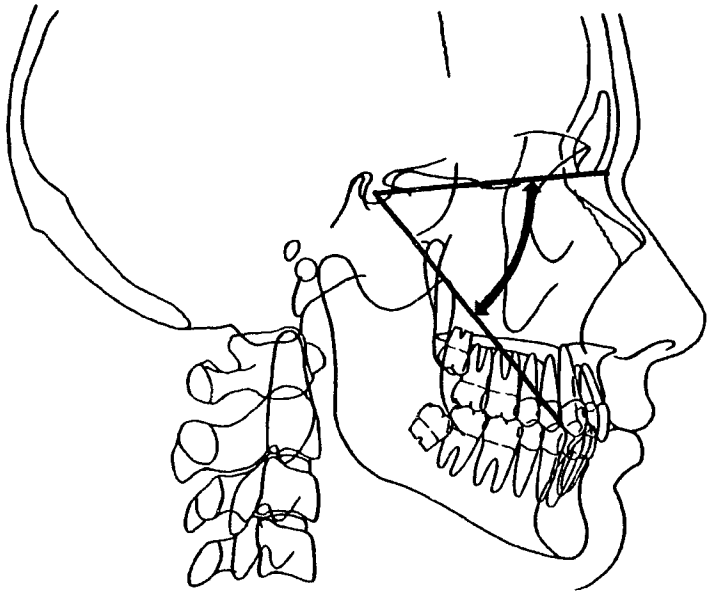
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
62	51	.1	.8	2.4	-2.2	.2	.98

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	69.3	—	69.1	—	69.5	**	—	—	—	—	—	—	***	—	***
INITIAL	69.1		69.1		69.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	69.2	69.3	69.4	68.3	69.1
	SD	3.4	2.9	2.9	3.9	4.1
	N	84	31	63	36	39
FEMALE	MEAN	69.1	69.1	69.3	68.3	69.5
	SD	2.7	2.5	2.5	2.1	2.9
	N	39	24	29	27	15



CALCULATION 088

MEASURE 3PTA 54-46-18

NAME ANGLE NASION-SELLA-PREMOLAR MESIAL CONTACT POINT

INITIAL TO FINAL

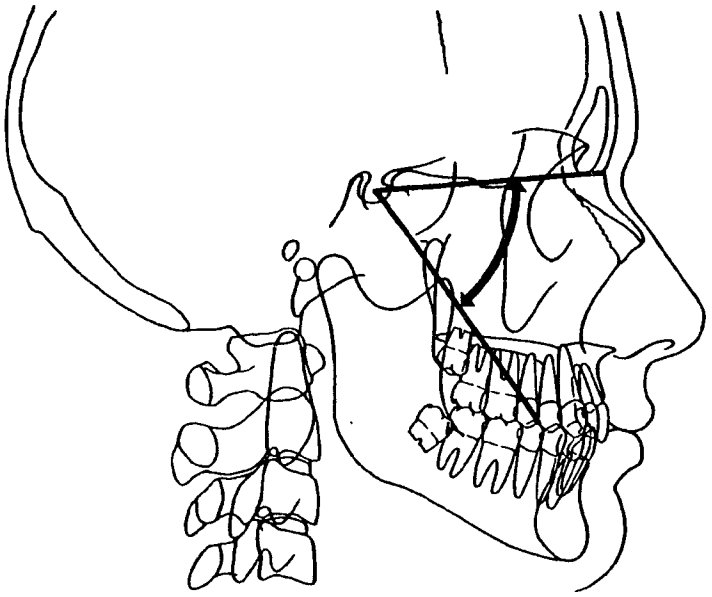
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
57	56	0	.8	2.7	-2.3	0	.98

INITIAL TO FINAL

	UNTREATED												TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	56.0	—	56.0	—	56.2	—	—	***	***	*	—	—	***	NA	NA
INITIAL	56.1		56.0		56.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	56.0	56.1	56.6	55.3	55.7
	SD	2.9	2.9	2.6	3.7	3.4
	N	84	31	63	36	39
FEMALE	MEAN	56.1	56.0	56.4	55.4	55.6
	SD	2.4	2.5	2.6	2.0	2.1
	N	39	24	29	27	15



CALCULATION 089

MEASURE 3PTA 54-46-19

NAME ANGLE NASION-SELLA-PREMOLAR DISTAL CONTACT POINT

INITIAL TO FINAL

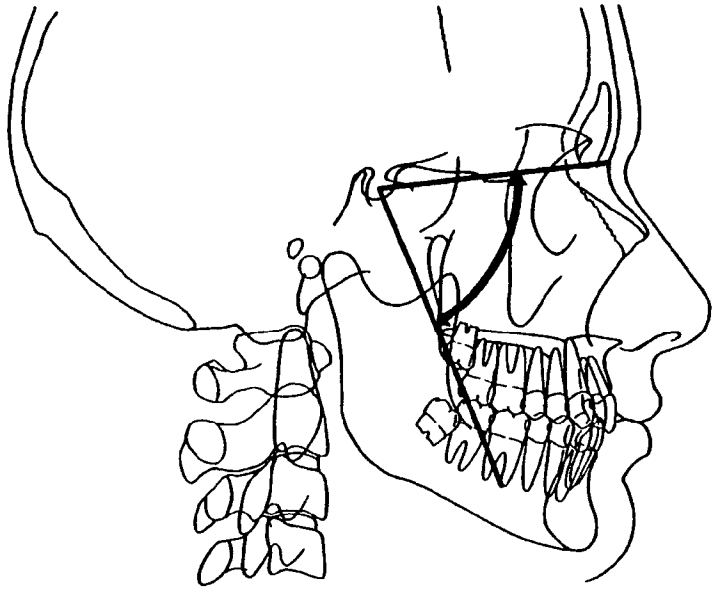
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
54	59	0	.9	2.6	-3.2	-.1	.97

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	59.2	—	59.1	—	59.3	—	—	**	***	**	*	—	***	NA	NA
INITIAL	59.2		59.1		59.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	59.3	59.5	59.7	58.4	58.8
	SD	2.9	2.9	2.5	3.8	3.4
	N	84	31	63	36	39
FEMALE	MEAN	59.2	59.2	59.7	58.6	58.7
	SD	2.6	2.6	2.6	1.9	2.2
	N	39	24	29	27	15



CALCULATION 090

MEASURE 3PTA 54-46-20

NAME ANGLE NASION-SELLA-LOWER MOLAR ROOT APEX

INITIAL TO FINAL

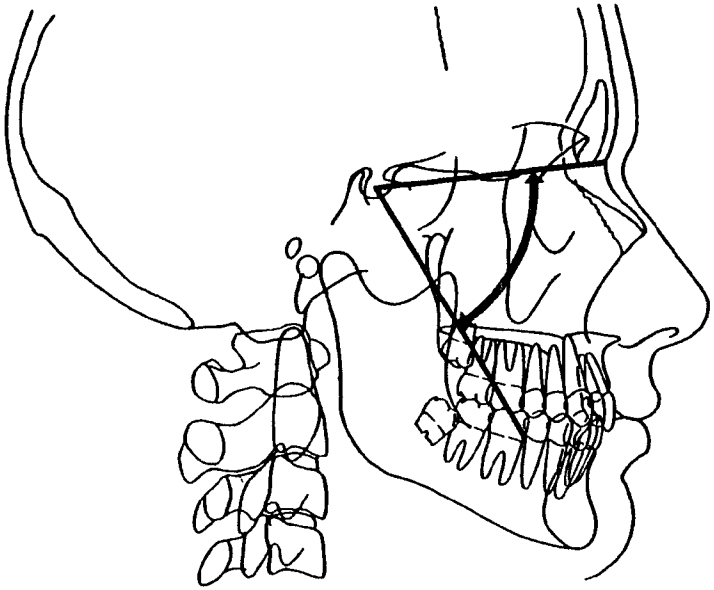
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
32	81	-.7	1.0	1.4	-3.8	-.9	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	72.8	***	72.5	***	73.5	***	*	***	**	—	—	*	**	NA	NA
INITIAL	73.4		73.1		74.2										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	73.4	73.4	72.7	71.4	72.6
	SD	2.9	2.7	2.6	3.5	3.8
	N	84	31	63	36	39
FEMALE	MEAN	74.2	74.0	74.2	72.7	73.1
	SD	2.9	2.7	2.7	2.0	2.9
	N	39	24	29	27	15



CALCULATION 091

MEASURE 3PTA 54-46-21

NAME ANGLE NASION-SELLA-LOWER MOLAR MESIAL CEJ

INITIAL TO FINAL

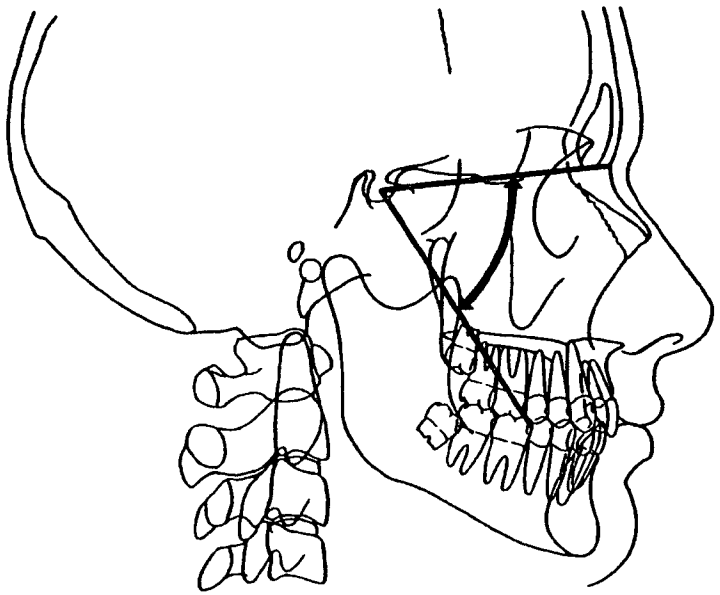
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
40	73	-.3	.9	1.9	-3.4	-.5	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	65.8	***	65.7	**	66.1	—	—	**	*	—	—	—	***	NA	NA
INITIAL	66.1		66.0		66.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	66.1	66.3	66.0	64.7	65.9
	SD	2.9	2.8	2.4	3.4	3.6
	N	84	31	63	36	39
FEMALE	MEAN	66.4	66.3	66.7	65.3	65.5
	SD	2.7	2.5	2.5	1.8	2.5
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 092

MEASURE 3PTA 54-46-22

NAME ANGLE NASION-SELLA-LOWER MOLAR MESIAL CONTACT

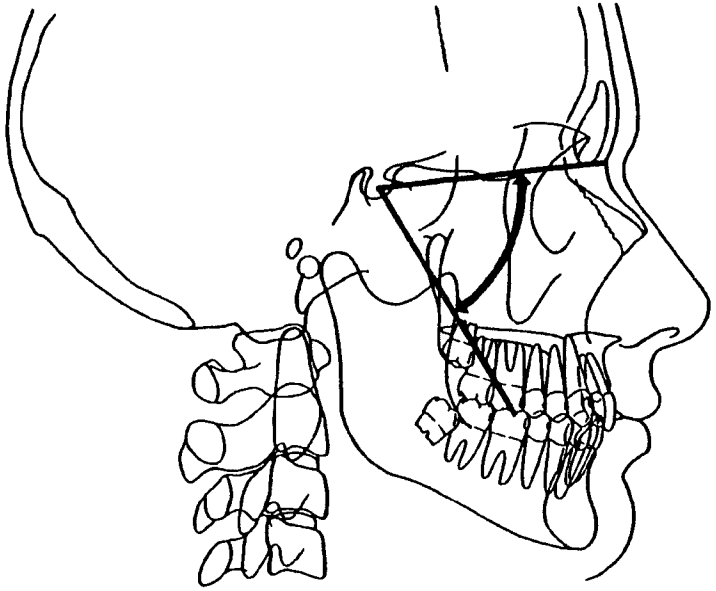
INITIAL TO FINAL

UNTREATED						
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
40	73	-.4	.9	2.1	-2.9	-.6	.98

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	63.5	***	63.4	***	63.7	*	—	**	—	—	—	*	***	NA	NA
INITIAL	63.9		63.8		64.0										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	64.0	64.2	63.9	62.5	63.5
	SD	2.9	2.8	2.5	3.4	3.6
	N	84	31	63	36	39
FEMALE	MEAN	64.0	64.0	64.3	62.8	63.0
	SD	2.6	2.6	2.5	1.7	2.4
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 093

MEASURE 3PTA 54-46-23

NAME ANGLE NASION-SELLA-UPPER MOLAR MESIAL CUSP TIP

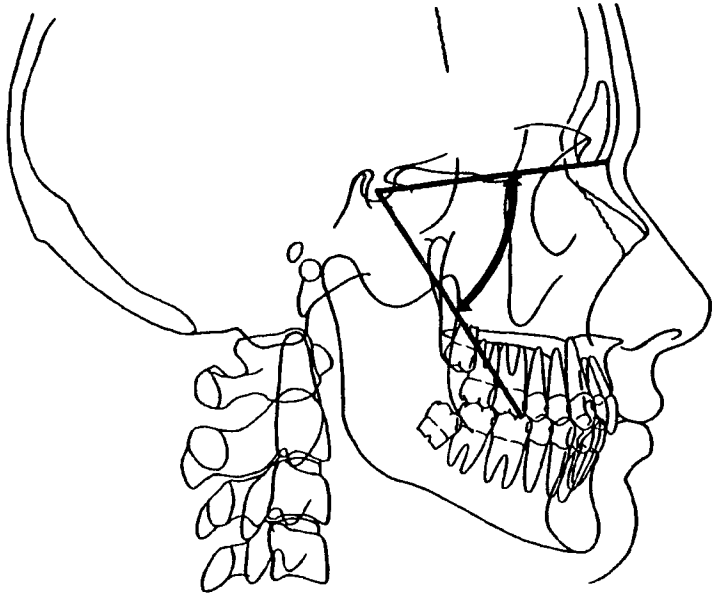
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
32	81	-.4	.9	2.1	-3.3	-.6	.98

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	64.2	***	64.2	***	64.3	**	—	***	**	**	*	—	***	NA	NA
INITIAL	64.7		64.6		64.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	64.8	65.0	64.8	63.4	64.3
	SD	3.1	3.0	2.6	3.7	3.6
	N	84	31	63	36	39
FEMALE	MEAN	64.8	64.6	64.9	63.5	63.6
	SD	2.8	2.9	2.8	1.8	2.3
	N	39	24	29	27	15



CALCULATION 094

MEASURE 3PTA 54-46-24

NAME ANGLE NASION-SELLA-POSTERIOR DOWNS POINT

INITIAL TO FINAL

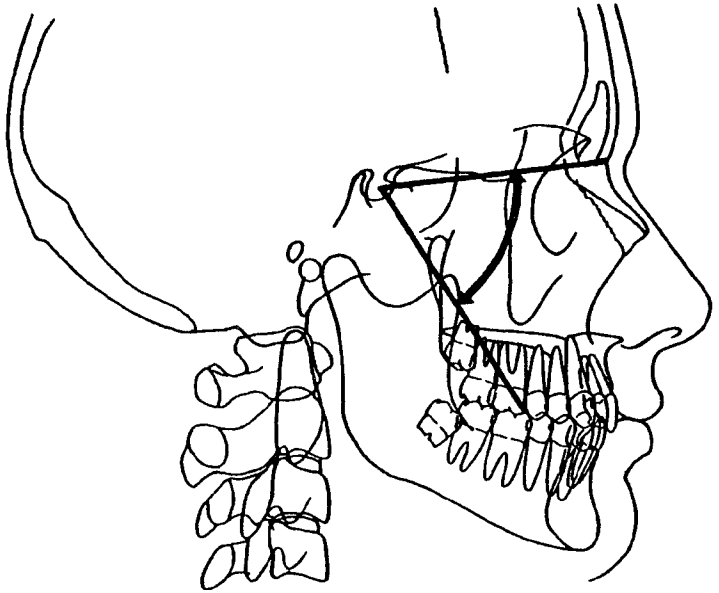
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
27	86	-.4	.9	1.8	-4.0	-.7	.96

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	63.7	***	63.7	***	63.7	**	—	***	*	—	*	—	***	NA	NA
INITIAL	64.1		64.0		64.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	64.2	64.5	64.2	62.8	63.7
	SD	3.0	2.9	2.6	3.7	3.6
	N	84	31	63	36	39
FEMALE	MEAN	64.1	64.0	64.3	63.0	63.0
	SD	2.6	2.7	2.7	1.6	2.4
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 095

MEASURE 3PTA 54-46-25

NAME ANGLE NASION-SELLA-LOWER MOLAR MESIAL CUSP TIP

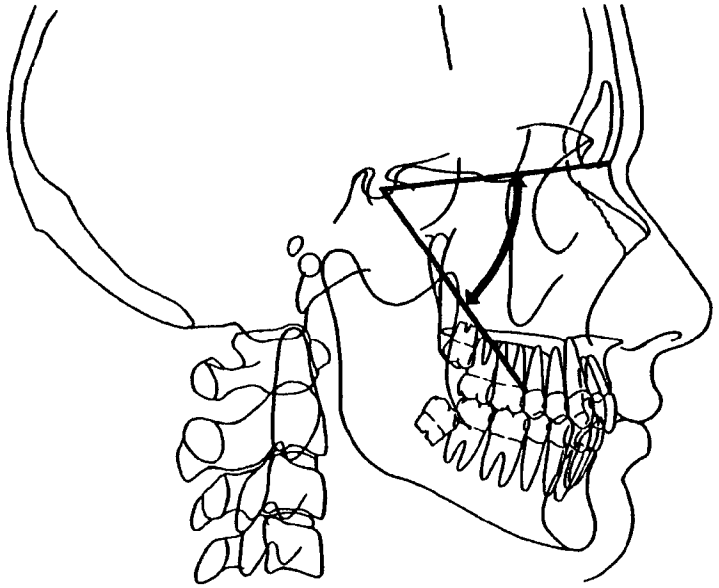
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
35	78	-.5	.9	2.2	-3.7	-.7	.98

	UNTREATED												TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+		T P	T UNTX	T P	T UNTX
FINAL	63.0	***	63.0	***	63.0	**	—	**	*	—	—		**	***	NA	NA
INITIAL	63.4		63.4		63.4											

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	63.6	63.9	63.5	62.0	63.2
	SD	2.9	2.9	2.7	3.5	3.7
	N	84	31	63	36	39
FEMALE	MEAN	63.4	63.3	63.5	62.2	62.3
	SD	2.5	2.6	2.4	1.5	2.4
	N	39	24	29	27	15



CALCULATION 096

MEASURE 3PTA 54-46-26

NAME ANGLE NASION-SELLA-UPPER MOLAR MESIAL CEJ

INITIAL TO FINAL

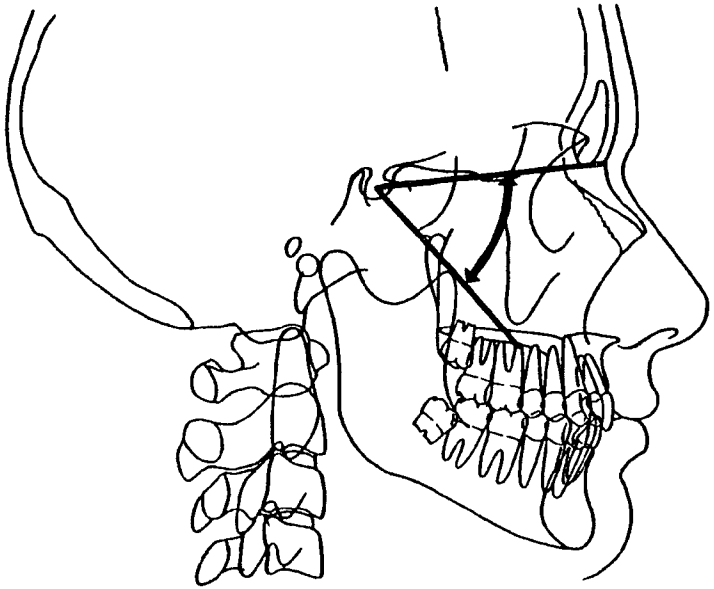
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
41	72	-.2	.9	2.7	-3.0	-.4	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	59.4	**	59.5	—	59.4	*	—	**	*	**	*	**	***	NA	NA
INITIAL	59.7		59.6		59.8										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	59.8	60.0	60.2	58.7	59.2
	SD	2.8	2.8	2.6	3.9	3.6
	N	84	31	63	36	39
FEMALE	MEAN	59.5	59.5	60.0	58.7	58.5
	SD	2.5	3.0	2.8	2.0	2.3
	N	39	24	29	27	15



CALCULATION 097

MEASURE 3PTA 54-46-27

NAME ANGLE NASION-SELLA-UPPER MOLAR ROOT APEX

INITIAL TO FINAL

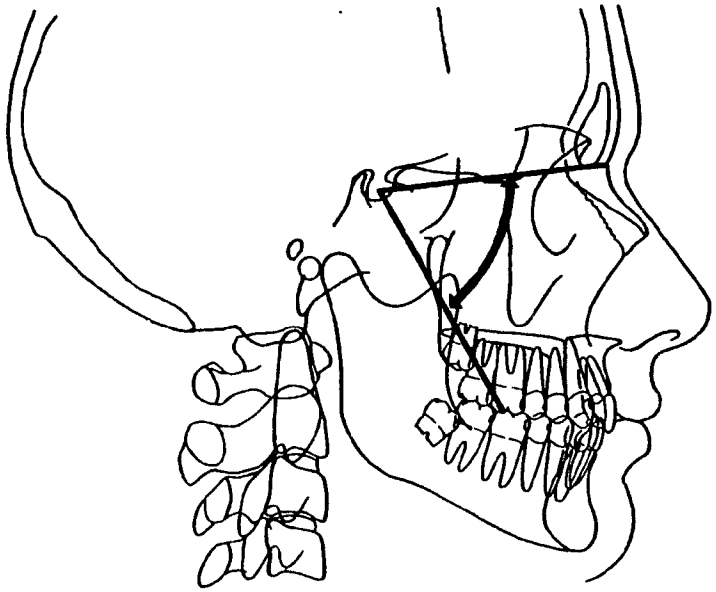
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
64	49	.2	1.3	3.9	-3.0	.3	.95

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	53.8	—	54.1	*	53.1	—	—	—	*	*	—	—	***	NA	NA
INITIAL	53.6		53.7		53.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	53.6	54.1	54.5	53.3	54.0
	SD	2.8	3.0	2.9	4.6	3.9
	N	84	31	63	36	39
FEMALE	MEAN	52.9	53.0	54.4	52.4	51.9
	SD	2.9	3.3	3.2	2.5	2.1
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 098

MEASURE 3PTA 54-46-28

NAME ANGLE NASION-SELLA-UPPER MOLAR DISTAL CUSP TIP

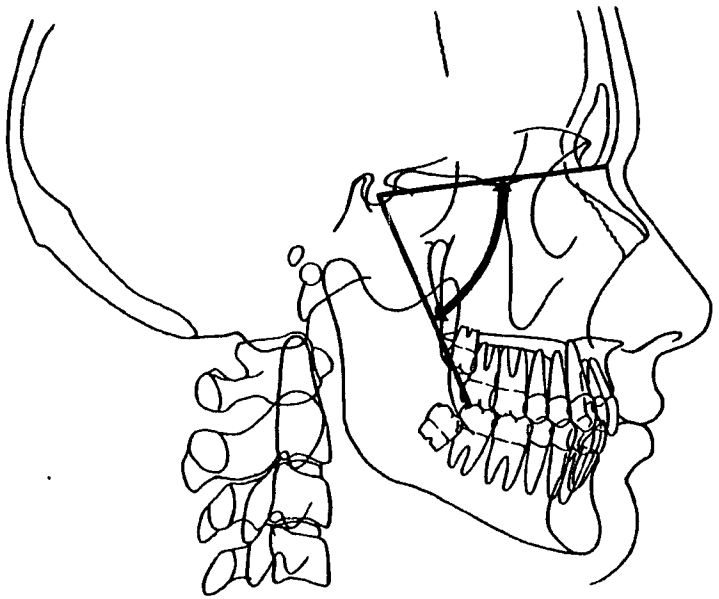
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
32	81	-.6	.9	1.5	-3.5	-.8	.94

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	67.7	***	67.7	***	67.9	***	—	***	***	*	—	*	***	NA	NA
INITIAL	68.3		68.1		68.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	68.4	68.5	68.5	67.0	67.5
	SD	3.1	2.9	2.6	3.8	3.7
	N	84	31	63	36	39
FEMALE	MEAN	68.6	68.6	69.2	67.5	66.7
	SD	2.8	3.2	2.7	1.9	2.3
	N	39	24	29	27	15



CALCULATION 099

MEASURE 3PTA 54-46-29

NAME ANGLE NASION-SELLA-FUNCTIONAL OCCLUSAL PLANE POINT

INITIAL TO FINAL

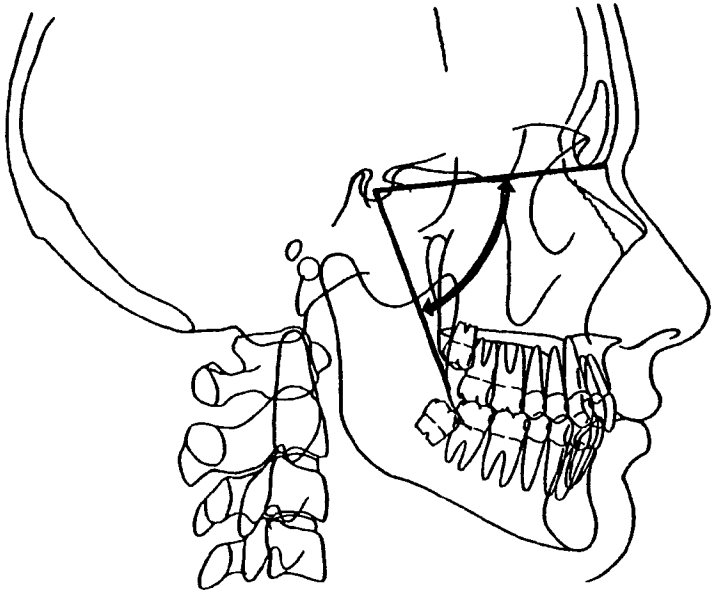
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
42	71	-.4	1.1	2.3	-5.4	-.5	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	73.5	***	73.4	*	73.7	***	—	***	***	**	—	—	***	NA	NA
INITIAL	73.9		73.6		74.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	73.9	74.3	74.1	72.6	73.5
	SD	3.4	3.1	2.8	4.1	3.9
	N	84	31	63	36	39
FEMALE	MEAN	74.1	74.5	75.0	73.3	72.3
	SD	3.1	3.2	2.9	2.1	3.2
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 100

MEASURE 3PTA 54-46-30

NAME ANGLE NASION-SELLA-ANTERIOR BORDER OF RAMUS POINT

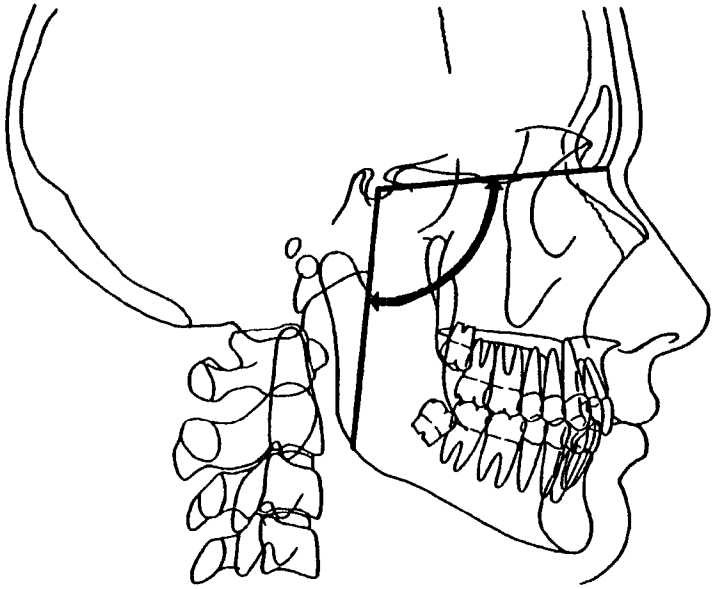
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
79	34	.7	1.3	5.3	-2.8	1.0	.97

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	78.2	***	78.4	***	77.9	**	—	—	—	—	—	**	***	—	***
INITIAL	77.5		77.7		77.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	77.8	78.4	78.4	77.5	78.8
	SD	3.3	3.1	3.0	3.8	4.1
	N	84	31	63	36	39
FEMALE	MEAN	77.0	77.4	77.5	77.0	77.5
	SD	3.0	3.1	3.3	2.0	2.7
	N	39	24	29	27	15



CALCULATION 101

MEASURE 3 PTA 54-46-31

NAME ANGLE NASION-SELLA-GONION

INITIAL TO FINAL

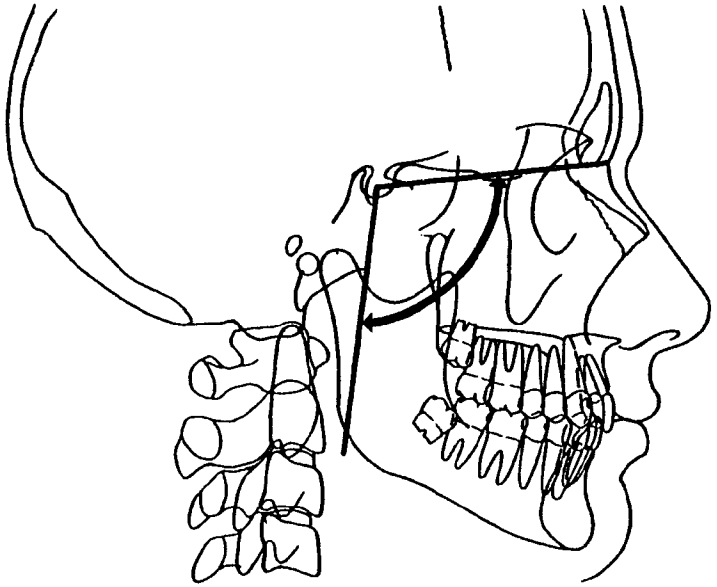
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
45	68	-.3	.9	1.6	-3.5	-.3	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	102.0	**	101.6	***	102.8	***	—	—	—	—	—	—	—	—	—
INITIAL	102.2		102.2		102.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	102.5	102.3	102.3	101.4	102.2
	SD	3.9	4.0	3.9	4.0	4.1
	N	84	31	63	36	39
FEMALE	MEAN	102.5	102.6	103.8	103.3	101.4
	SD	4.0	4.1	4.7	2.3	3.5
	N	39	24	29	27	15



CALCULATION 102

MEASURE 3 PTA 54-46-32

NAME ANGLE NASION-SELLA-GONION INTERSECTION

INITIAL TO FINAL

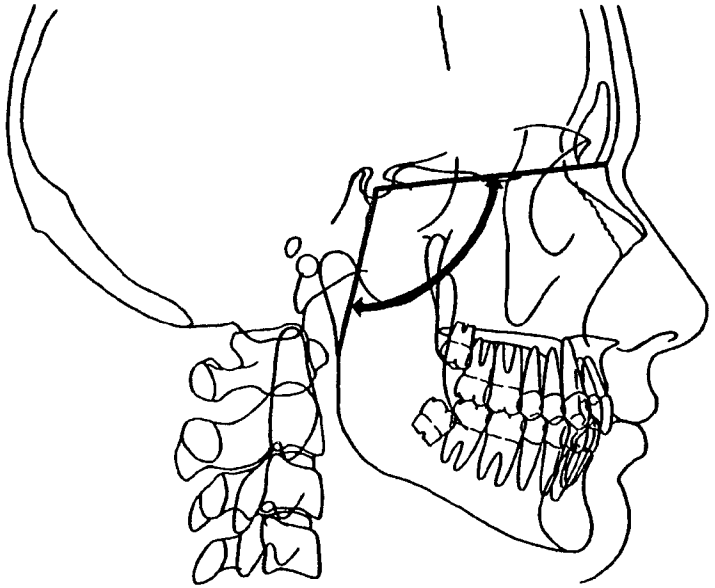
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
50	63	-.2	.9	2.5	-4.3	-.2	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	103.6	—	103.3	***	104.3	**	—	—	—	—	—	—	—	—	—
INITIAL	103.8		103.8		103.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	104.1	104.0	104.0	103.3	104.0
	SD	4.0	4.0	4.0	3.8	4.0
	N	84	31	63	36	39
FEMALE	MEAN	104.0	104.2	105.6	104.9	103.0
	SD	4.1	4.3	4.9	2.6	3.6
	N	39	24	29	27	15



CALCULATION 103

MEASURE 3 PTA 54-46-33

NAME ANGLE NASION-SELLA-POSTERIOR BORDER OF THE RAMUS

INITIAL TO FINAL

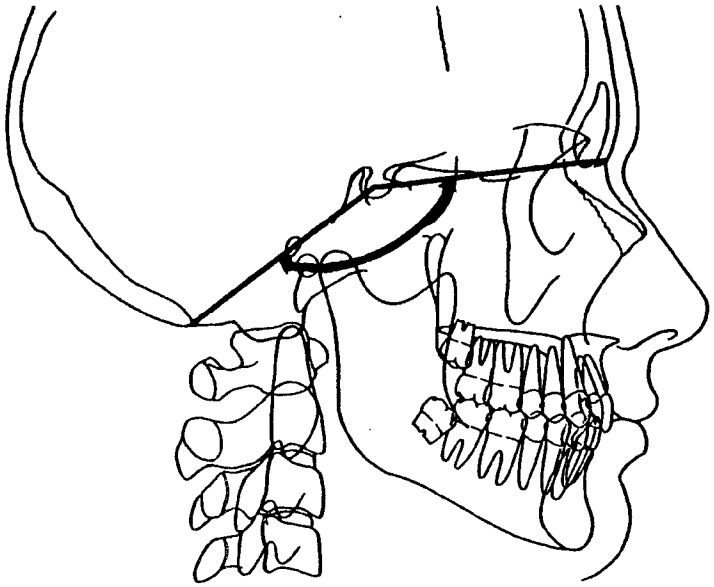
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
36	77	-.5	1.0	2.2	-4.8	-.4	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	107.7	***	107.4	***	108.5	—	—	*	—	—	—	—	—	—	***
INITIAL	108.2		108.1		108.5										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	108.3	108.3	108.0	107.3	108.4
	SD	4.3	4.2	4.3	4.1	4.2
	N	84	31	63	36	39
FEMALE	MEAN	108.8	108.6	109.1	109.3	107.4
	SD	4.2	4.1	4.3	2.7	3.5
	N	39	24	29	27	15



CALCULATION 104

MEASURE 3 PTA 54-46-38

NAME ANGLE NASION-SELLA-OPISTHION

INITIAL TO FINAL

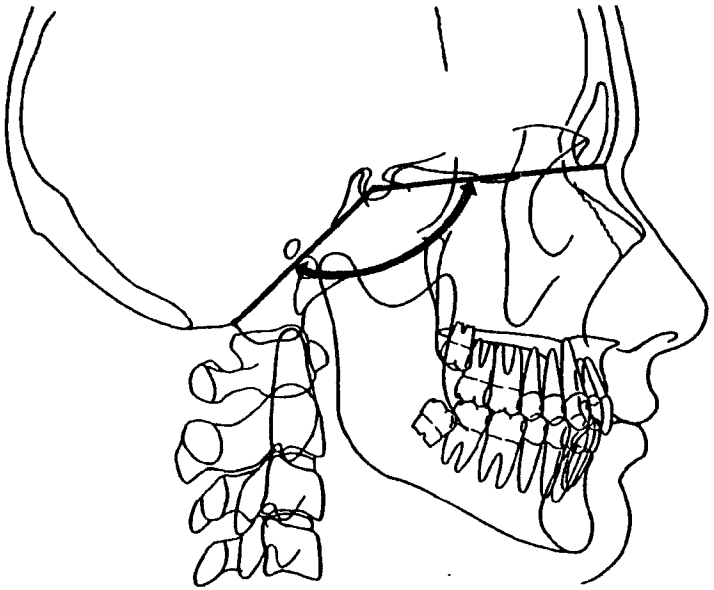
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
40	73	-.4	1.0	1.8	-3.0	-.2	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	152.0	***	151.9	***	152.0	—	—	***	***	*	*	—	—	*	—
INITIAL	152.3		152.3		152.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	152.2	153.0	151.8	151.8	152.7
	SD	4.4	4.4	4.5	4.2	4.9
	N	84	31	63	36	39
FEMALE	MEAN	152.2	153.4	154.1	154.2	149.0
	SD	5.5	5.2	4.7	4.9	6.0
	N	39	24	29	27	15



CALCULATION 105

MEASURE 3 PTA 54-46-39

NAME ANGLE NASION-SELLA-BOLTON POINT

INITIAL TO FINAL

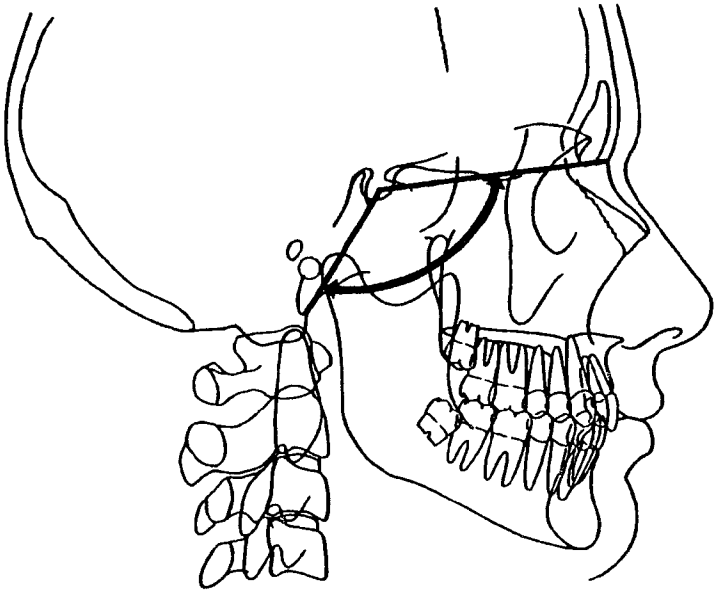
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
41	72	-.4	1.5	5.0	-4.5	-.3	.95

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	143.4	**	143.2	**	144.0	—	—	*	**	—	—	—	—	—	—
INITIAL	143.8		143.6		144.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	143.7	144.5	142.9	142.4	144.3
	SD	4.3	4.7	4.3	3.9	4.7
	N	84	31	63	36	39
FEMALE	MEAN	143.9	144.6	144.8	146.0	141.9
	SD	4.8	4.6	4.1	4.8	5.2
	N	39	24	29	27	15



CALCULATION 106

MEASURE 3 PTA 54-46-40

NAME ANGLE NASION-SELLA-BASION

INITIAL TO FINAL

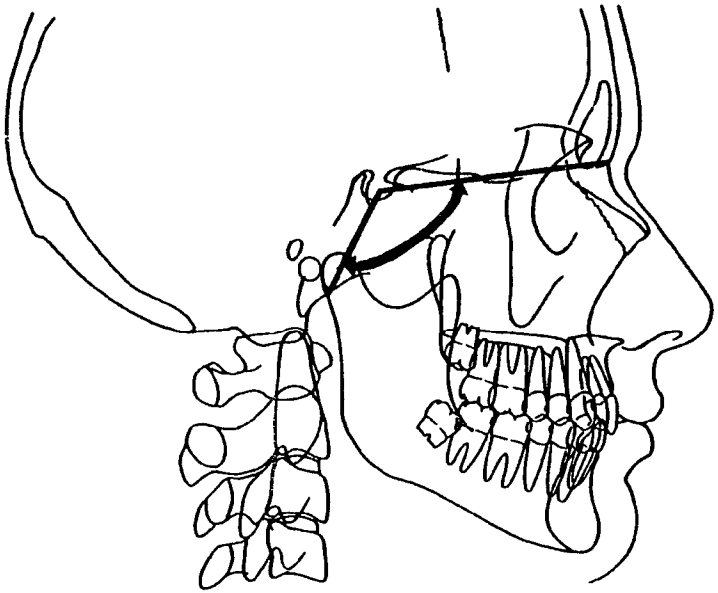
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
54	59	-.1	1.4	4.5	-4.9	-.1	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	128.1	—	127.9	—	128.6	—	—	—	—	—	—	*	—	—	—
INITIAL	128.3		128.0		128.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	127.9	129.1	127.9	126.9	129.4
	SD	5.0	5.9	5.3	4.7	5.1
	N	84	31	63	36	39
FEMALE	MEAN	128.7	129.5	129.5	129.8	126.8
	SD	5.8	5.5	4.5	5.3	6.2
	N	39	24	29	27	15



CALCULATION 107

MEASURE 3 PTA 54-46-41

NAME ANGLE NASION-SELLA-POSTERIOR ARTICULARE

INITIAL TO FINAL

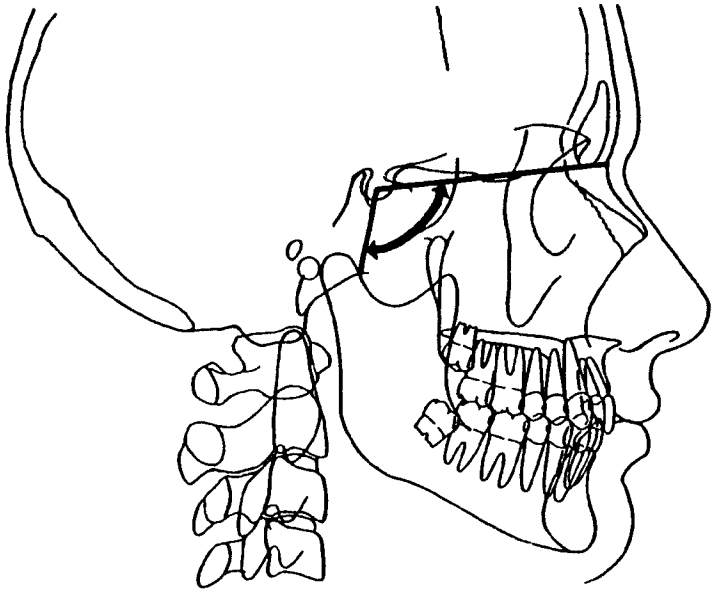
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
64	49	.3	1.5	4.3	-3.0	.3	.96

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	124.5	*	124.3	—	124.8	*	—	—	—	—	—	—	—	—	—
INITIAL	124.1		124.1		124.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	124.2	125.5	124.5	122.9	125.8
	SD	5.1	5.1	4.7	4.3	5.0
	N	84	31	63	36	39
FEMALE	MEAN	123.7	124.0	123.1	126.8	123.2
	SD	4.8	4.8	4.2	6.0	5.9
	N	39	24	29	27	15



CALCULATION 108

MEASURE 3 PTA 54-46-42

NAME ANGLE NASION-SELLA-ANTERIOR ARTICULARE

INITIAL TO FINAL

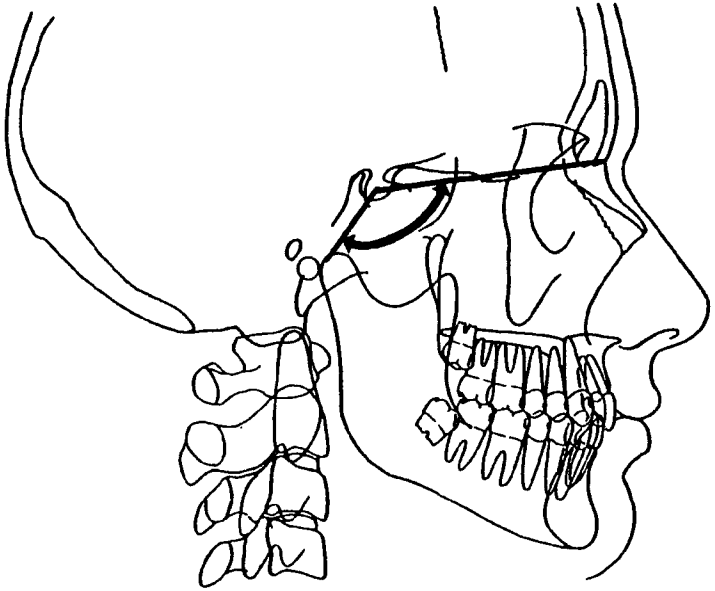
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
40	73	-.7	2.8	5.6	-17.2	-.6	.96

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	110.1	**	110.2	***	110.0	—	—	—	—	—	—	—	—	*	—
INITIAL	110.9		111.3		109.8										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	111.7	111.8	110.8	108.1	112.8
	SD	6.4	6.4	5.9	6.0	5.9
	N	84	31	63	36	39
FEMALE	MEAN	109.3	109.2	107.3	111.8	108.8
	SD	4.7	4.7	4.5	7.0	5.6
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 109

MEASURE 3 PTA 54-46-43

NAME ANGLE NASION-SELLA CONDYLION

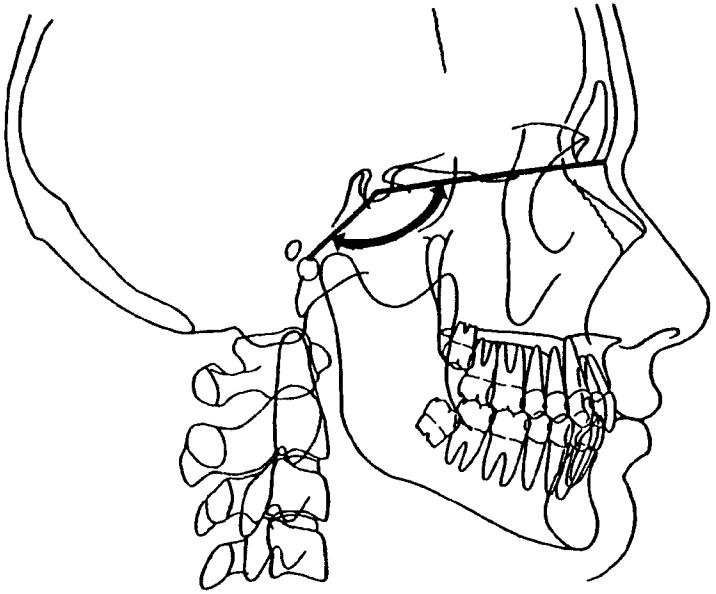
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
63	50	.6	2.5	9.6	-6.0	.5	.91

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	135.1	**	134.6	—	136.2	*	—	—	—	—	—	**	*	*	—
INITIAL	134.5		134.3		135.0										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	135.1	135.7	134.4	133.3	136.1
	SD	6.2	7.1	5.9	5.5	6.3
	N	84	31	63	36	39
FEMALE	MEAN	134.6	135.1	135.4	139.7	133.0
	SD	7.0	7.4	7.0	6.7	7.3
	N	39	24	29	27	15



CALCULATION 110

MEASURE 3 PTA 54-46-44

NAME ANGLE NASION-SELLA-PORION

INITIAL TO FINAL

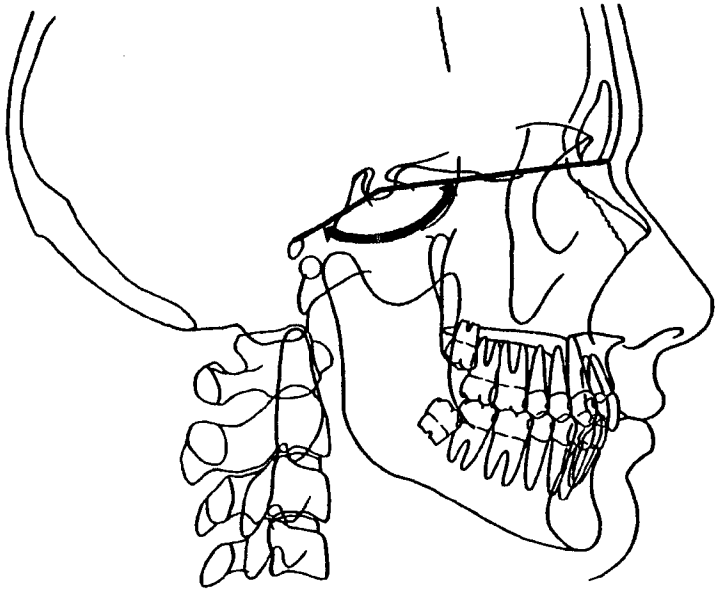
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
49	64	-.9	6.8	21.4	-16.2	-.6	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	141.8	—	140.1	—	144.2	—	—	—	—	—	—	—	**	—	—
INITIAL	142.7		142.3		143.6										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	142.0	143.9	143.6	139.6	142.8
	SD	9.5	8.4	8.3	8.4	10.9
	N	84	31	63	36	39
FEMALE	MEAN	144.4	145.8	144.3	148.4	141.4
	SD	9.5	11.0	11.7	11.0	9.9
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 111

MEASURE 3 PTA 54-46-45

NAME ANGLE NASION-SELLA-ANATOMIC PORION

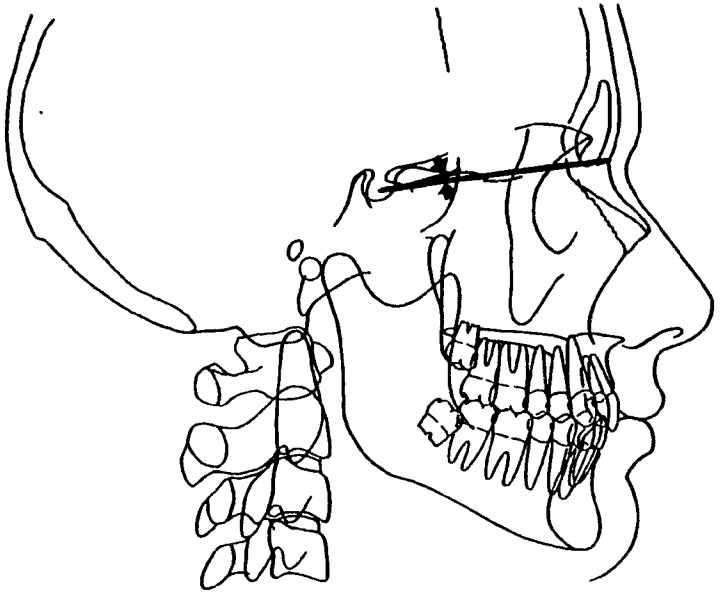
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
49	64	-.5	7.0	19.0	-18.0	-.3	.95

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	157.9	—	156.8	—	160.6	—	*	—	—	—	—	—	**	—	—
INITIAL	158.5		158.0		159.6										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	159.1	161.2	159.4	155.0	157.5
	SD	9.1	9.1	9.0	7.8	11.1
	N	84	31	63	36	39
FEMALE	MEAN	160.0	161.6	161.3	165.8	156.4
	SD	9.0	8.0	7.7	9.5	10.9
	N	39	24	29	27	15



CALCULATION 112

MEASURE 3 PTA 54-46-47

NAME ANGLE NASION-SELLA-ETHMOID REGISTRATION POINT

INITIAL TO FINAL

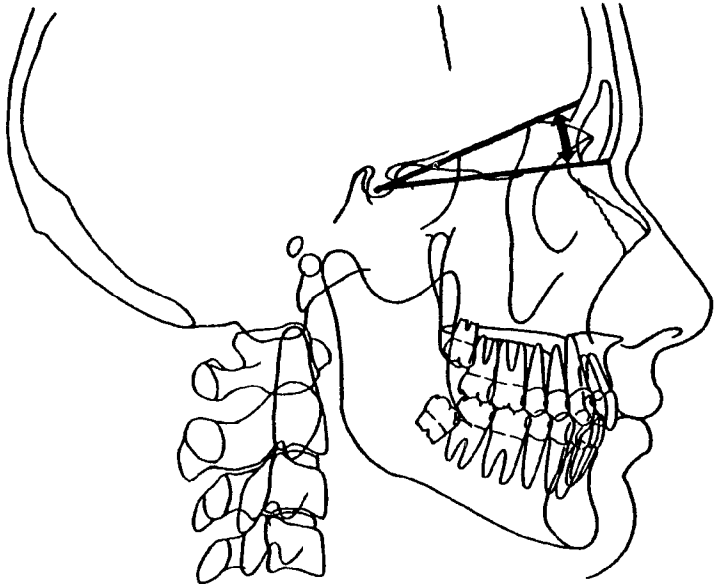
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
55	58	0	1.0	2.7	-2.9	NA	.87

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	5.0	—	4.8	—	5.6	—	—	—	—	—	—	—	—	—	—
INITIAL	5.0		4.8		5.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	4.9	5.4	5.3	4.7	4.8
	SD	4.1	4.0	3.7	3.8	3.9
	N	84	31	63	36	39
FEMALE	MEAN	5.3	4.9	5.7	5.7	6.4
	SD	3.2	3.7	4.1	4.0	3.0
	N	39	24	29	27	15



CALCULATION 113

MEASURE 3 PTA 54-46-48

NAME ANGLE NASION-SELLA-INTERNAL ASPECT OF FRONTAL BONE AT GLABELLA

INITIAL TO FINAL

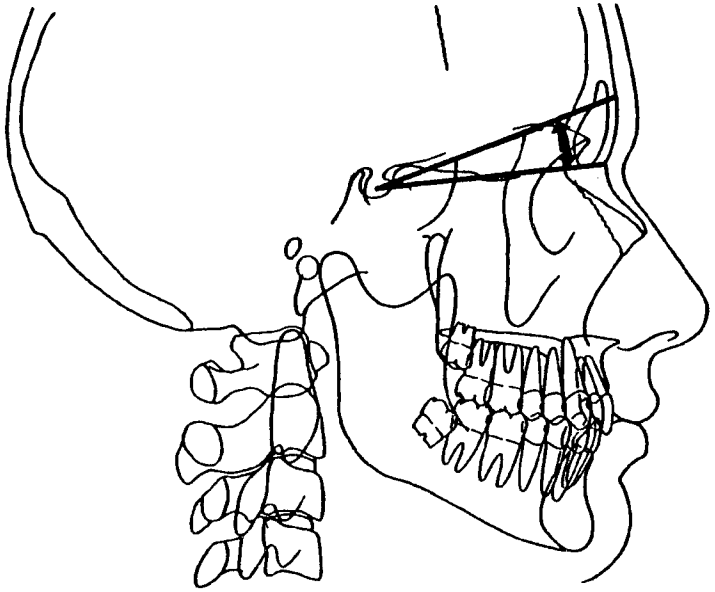
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
58	55	.1	1.1	3.4	-4.1	1.7	.93

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	10.8	—	10.7	*	11.2	—	**	—	—	—	—	—	—	—	***
INITIAL	10.7		10.4		11.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	10.6	10.7	10.6	10.6	11.0
	SD	1.7	1.7	1.8	1.6	1.6
	N	84	31	63	36	39
FEMALE	MEAN	11.6	11.4	11.2	11.4	12.2
	SD	2.2	2.4	1.8	1.8	2.0
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 114

MEASURE 3 PTA 54-46-49

NAME ANGLE NASION-SELLA-GLABELLA

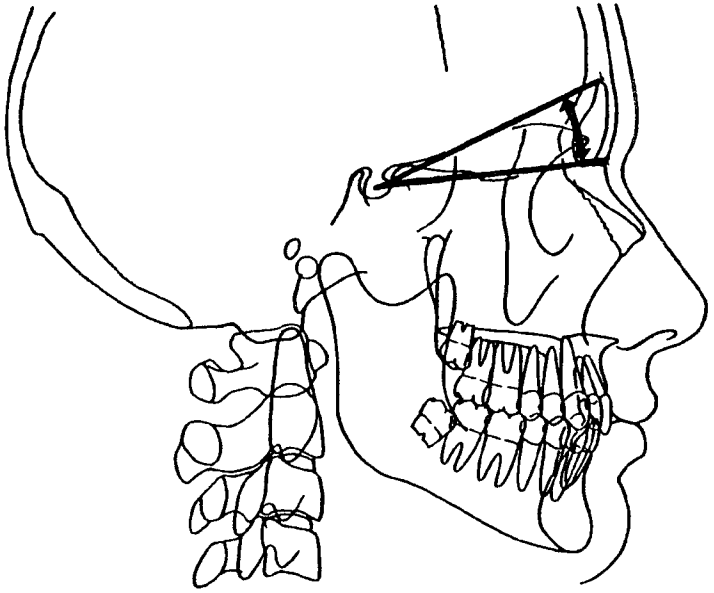
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
40	73	-.3	1.1	2.6	-5.3	-2.5	.94

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	7.1	**	6.9	—	7.6	*	***	—	—	—	—	—	—	—	**
INITIAL	7.4		7.0		8.2										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	7.3	7.2	7.0	7.1	7.1
	SD	1.7	1.8	1.7	1.4	1.6
	N	84	31	63	36	39
FEMALE	MEAN	8.2	8.1	7.8	7.9	8.5
	SD	1.9	2.1	1.6	1.9	1.9
	N	39	24	29	27	15



CALCULATION 115

MEASURE 3 PTA 54-46-50

NAME ANGLE NASION-SELLA-FRONTAL SINUS SUPERIOR

INITIAL TO FINAL

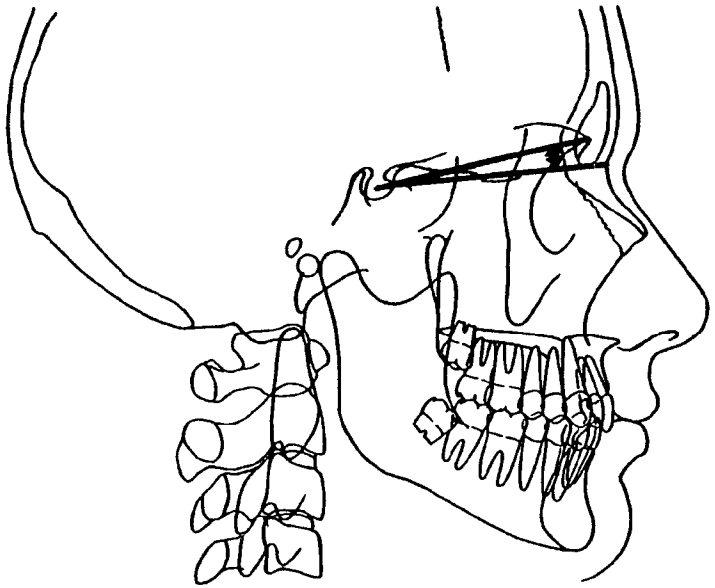
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
95	18	1.7	1.9	8.3	-2.3	11.4	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	19.2	***	19.8	***	17.9	***	—	***	—	—	—	***	**	*	—
INITIAL	17.5		18.0		16.5										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	18.1	18.7	19.8	17.4	20.8
	SD	5.8	5.9	5.5	7.5	6.9
	N	84	31	63	36	39
FEMALE	MEAN	16.3	16.1	17.6	18.1	18.6
	SD	5.0	5.3	4.2	4.1	6.0
	N	39	24	29	27	15



CALCULATION 116

MEASURE 3 PTA 54-46-51

NAME ANGLE SELLA-NASION-SUPRAORBITALE

INITIAL TO FINAL

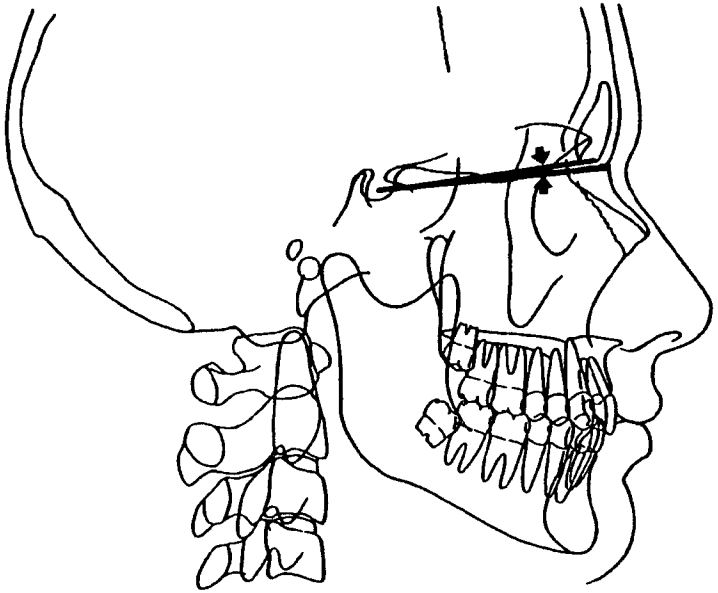
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
56	57	.1	.8	2.7	-2.7	4.8	.74

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	6.2	—	5.9	—	6.8	—	***	—	—	—	—	—	—	—	—
INITIAL	6.1		5.9		6.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	5.8	6.2	5.9	5.9	6.1
	SD	1.3	1.2	1.2	1.2	1.1
	N	84	31	63	36	39
FEMALE	MEAN	6.8	6.8	6.6	6.4	7.2
	SD	1.4	1.2	1.2	1.1	1.5
	N	39	24	29	27	15



CALCULATION 117

MEASURE 3 PTA 54-46-52

NAME ANGLE NASION-SELLA-FRONTAL SINUS INFERIOR

INITIAL TO FINAL

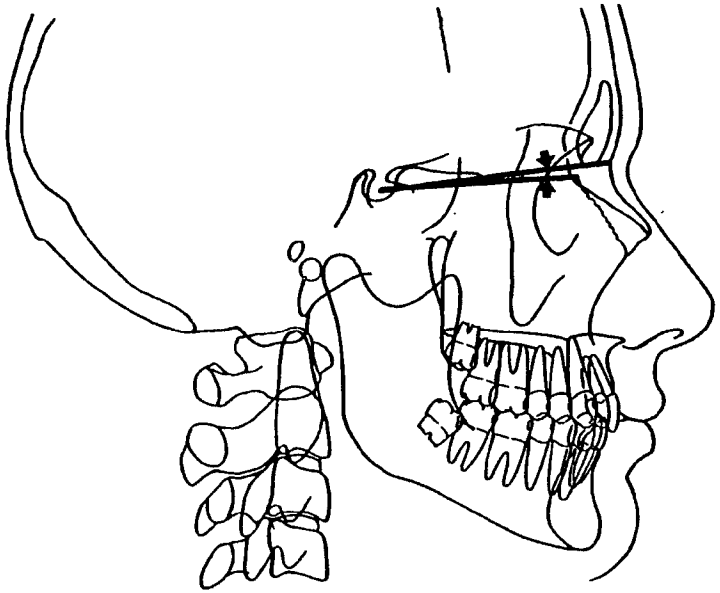
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
72	41	.5	1.8	6.4	-7.8	NA	.97

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	3.4	**	3.6	*	3.0	*	—	—	—	—	—	—	—	—	—
INITIAL	2.9		3.0		2.6										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	3.0	2.9	3.7	3.3	3.7
	SD	2.3	2.0	2.4	2.1	2.2
	N	84	31	63	36	39
FEMALE	MEAN	2.8	3.4	3.8	3.6	2.1
	SD	1.8	1.9	2.2	2.5	1.5
	N	39	24	29	27	15



CALCULATION 118

MEASURE 3 PTA 54-46-53

NAME ANGLE NASION-SELLA-FRONTOMAXILLARY NASAL SUTURE

INITIAL TO FINAL

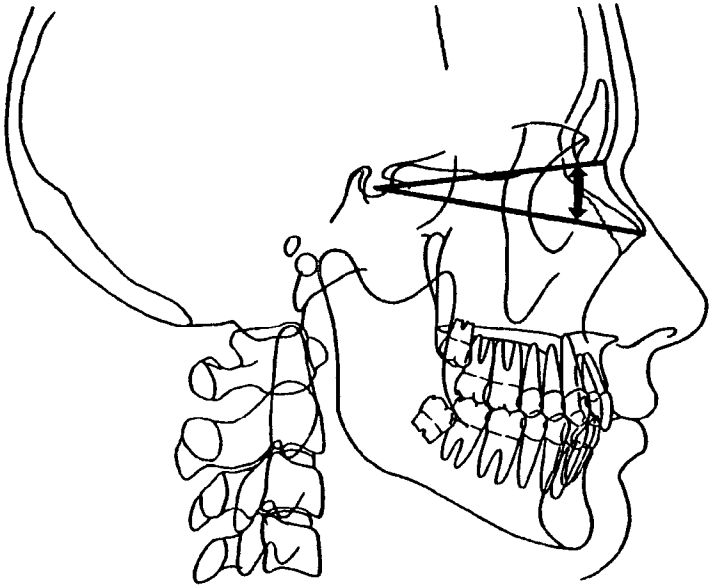
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
49	64	-.2	1.2	2.8	-3.7	6.4	.77

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	2.8	*	2.8	—	2.8	—	—	—	—	—	—	—	*	—	—
INITIAL	3.1		3.0		3.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	3.2	3.0	3.1	2.9	2.8
	SD	1.3	1.0	1.3	1.0	1.3
	N	84	31	63	36	39
FEMALE	MEAN	3.1	3.0	2.8	2.9	2.8
	SD	1.2	.9	1.2	1.1	1.4
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 119

MEASURE 3PTA 54-46-55

NAME ANGLE NASION-SELLA-NASAL TIP

INITIAL TO FINAL

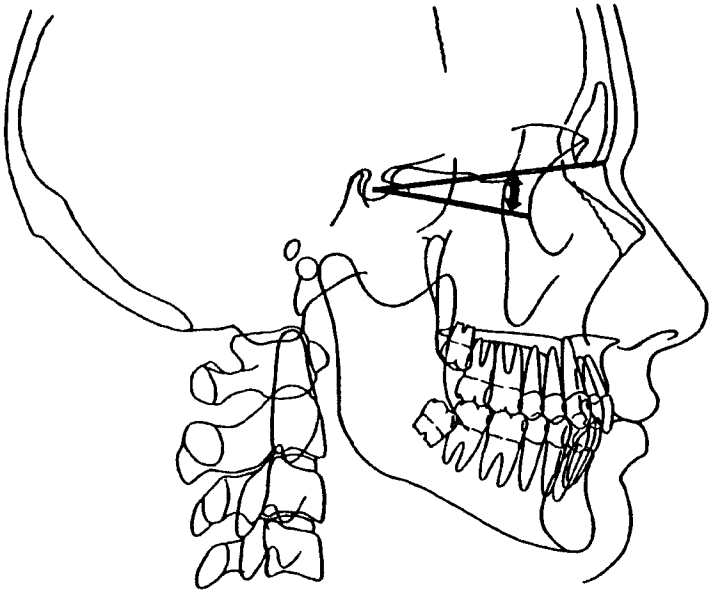
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
41	72	-.1	.7	4.1	-1.9	-.8	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	14.5	—	14.2	—	15.3	—	***	—	—	—	—	—	*	—	—
INITIAL	14.7		14.4		15.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	14.5	14.4	14.6	14.2	13.9
	SD	1.9	1.8	2.1	2.1	2.4
	N	84	31	63	36	39
FEMALE	MEAN	15.4	15.2	15.6	15.3	15.1
	SD	1.5	1.6	1.4	1.8	1.9
	N	39	24	29	27	15



CALCULATION 120

MEASURE 3PTA 54-46-56

NAME ANGLE NASION-SELLA-LATERAL ORBIT

INITIAL TO FINAL

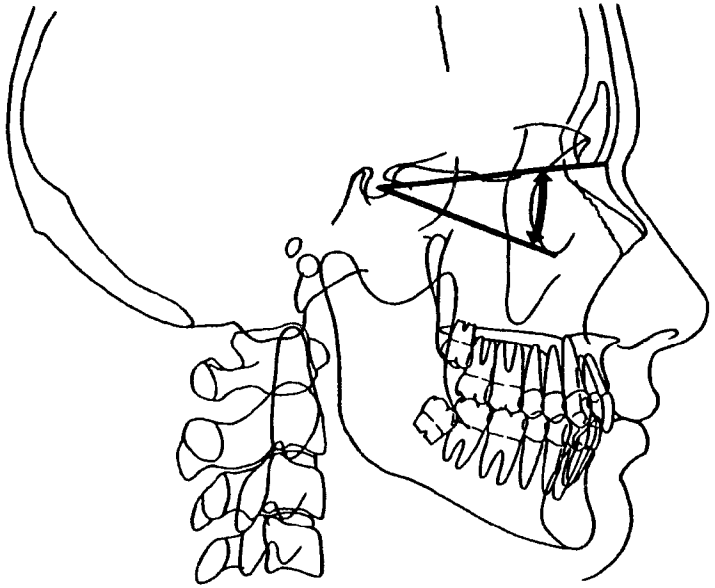
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
43	70	-.7	1.9	3.7	-5.3	-4.0	.81

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	14.5	***	15.0	***	13.4	*	**	*	*	**	—	***	—	*	—
INITIAL	15.2		15.6		14.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	15.6	15.6	15.3	15.6	15.1
	SD	2.8	3.3	2.8	2.8	2.8
	N	84	31	63	36	39
FEMALE	MEAN	14.1	14.0	13.9	12.7	12.7
	SD	2.3	2.6	2.8	1.8	2.9
	N	39	24	29	27	15



CALCULATION 121

MEASURE 3PTA 54-46-57

NAME ANGLE NASION-SELLA-ORBITALE

INITIAL TO FINAL

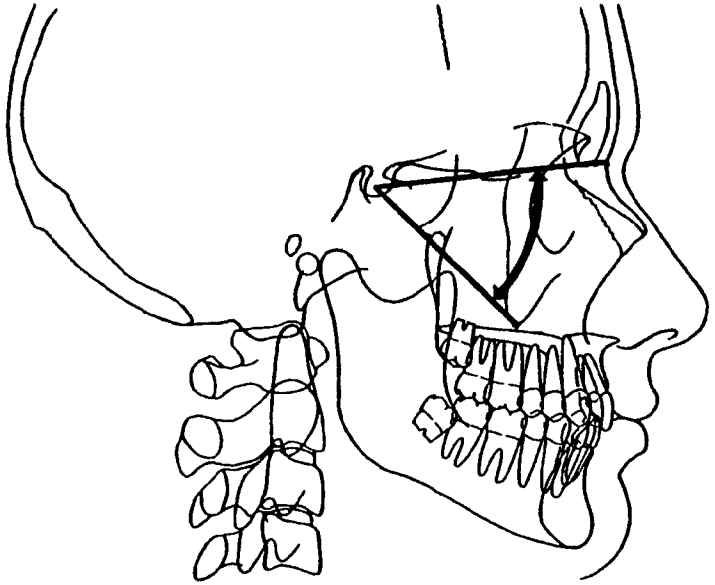
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
54	59	0	.8	2.3	-3.1	0	.95

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	26.7	—	26.8	—	26.5	—	—	—	—	—	—	—	***	—	*
INITIAL	26.7		26.8		26.5										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	26.8	27.2	27.0	26.4	26.9
	SD	2.5	2.9	2.4	2.3	2.7
	N	84	31	63	36	39
FEMALE	MEAN	26.4	26.5	26.2	26.0	25.9
	SD	2.1	2.2	2.3	1.3	1.8
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 122

MEASURE 3PTA 54-46-58

NAME ANGLE NASION-SELLA-INFERIOR ZYGOMA

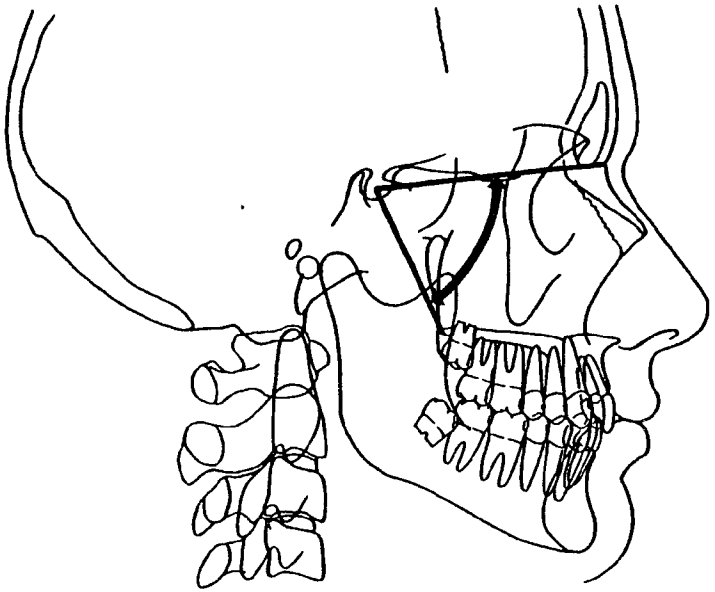
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
43	70	-.2	1.0	3.9	-2.4	-.4	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	50.3	*	50.4	**	50.2	—	—	—	—	—	—	—	***	*	—
INITIAL	50.6		50.7		50.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	50.5	50.9	50.9	50.1	50.1
	SD	3.2	3.6	3.0	3.7	3.2
	N	84	31	63	36	39
FEMALE	MEAN	50.5	50.3	51.1	49.6	49.5
	SD	3.0	3.0	2.7	1.6	2.9
	N	39	24	29	27	15



CALCULATION 123

MEASURE 3PTA 54-46-59

NAME ANGLE NASION-SELLA-PNS

INITIAL TO FINAL

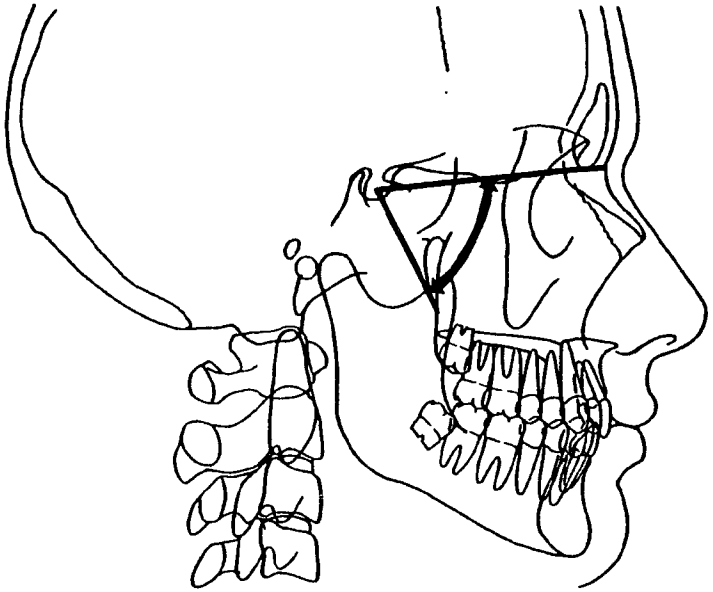
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
72	41	.5	1.7	4.1	-4.0	.7	.90

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	72.4	**	72.3	*	72.7	*	—	—	—	—	—	—	***	—	—
INITIAL	71.9		71.9		71.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	72.0	73.0	72.8	71.1	73.1
	SD	3.5	4.0	3.3	3.5	3.6
	N	84	31	63	36	39
FEMALE	MEAN	72.0	72.2	72.7	72.0	71.7
	SD	2.9	3.3	3.3	2.6	3.7
	N	39	24	29	27	15



CALCULATION 124

MEASURE 3PTA 54-46-60

NAME ANGLE NASION-SELLA-PTM INFERIOR

INITIAL TO FINAL

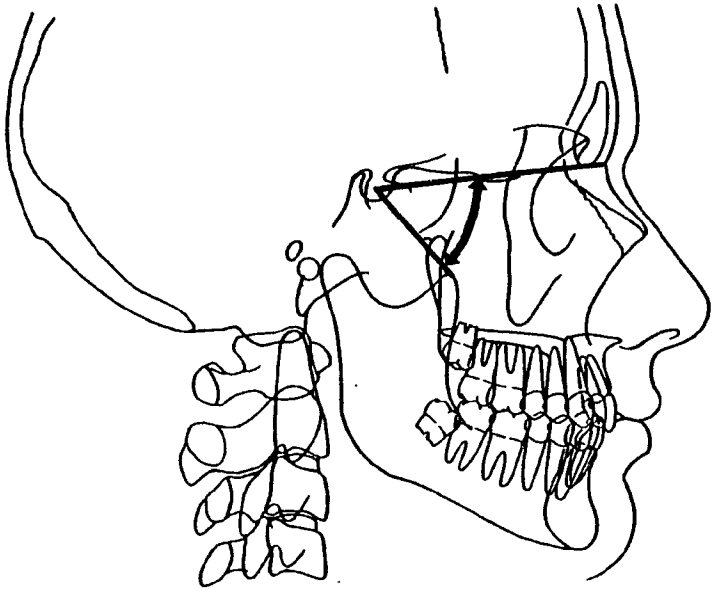
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
71	42	.3	1.2	3.5	-2.6	.5	.97

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	67.2	**	67.4	*	66.8	—	—	—	—	—	—	—	**	**	—
INITIAL	66.9		67.1		66.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	67.0	67.3	68.0	66.4	68.2
	SD	3.7	4.2	3.6	4.4	3.8
	N	84	31	63	36	39
FEMALE	MEAN	67.2	67.2	67.3	66.2	65.9
	SD	3.2	3.1	2.8	2.5	3.2
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 125

MEASURE 3PTA 54-46-61

NAME ANGLE NASION-SELLA-CORONOID PROCESS

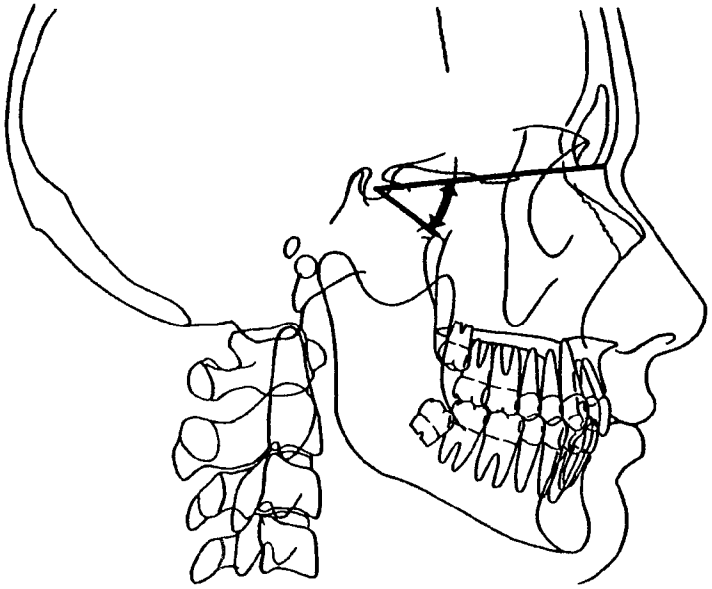
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
59	54	.3	2.6	7.6	-6.3	.7	.98

	UNTREATED												TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+		T P	T UNTX	T P	T UNTX
FINAL	55.8	—	56.2	—	55.1	—	—	—	—	—	—		—	—	*	—
INITIAL	55.5		55.8		54.8											

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	56.2	57.1	57.5	54.3	56.9
	SD	5.9	5.6	5.7	7.7	5.9
	N	84	31	63	36	39
FEMALE	MEAN	55.1	56.3	54.4	50.7	56.0
	SD	6.6	6.6	9.4	7.3	5.0
	N	39	24	29	27	15



CALCULATION 126

MEASURE 3PTA 54-46-62

NAME ANGLE NASION-SELLA-PTM SUPERIOR

INITIAL TO FINAL

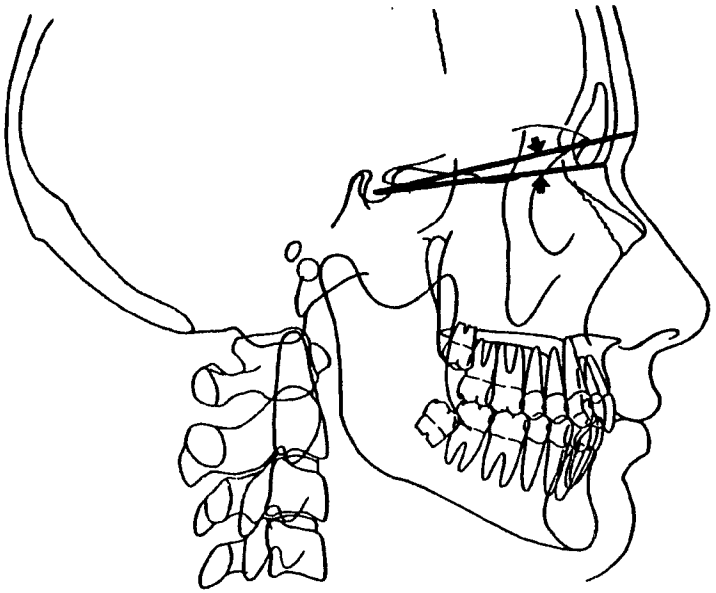
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
28	85	-1.7	2.7	4.7	-16.0	-3.7	.97

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	44.2	***	44.7	***	43.2	***	—	**	*	—	—	**	—	**	—
INITIAL	45.9		46.3		44.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	46.2	44.6	45.8	44.7	45.5
	SD	5.2	6.6	5.8	7.1	4.8
	N	84	31	63	36	39
FEMALE	MEAN	44.8	44.3	43.9	42.1	43.0
	SD	5.0	5.1	5.0	5.2	5.1
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 127

MEASURE 3PTA 54-46-75

NAME ANGLE NASION-SELLA-SOFT TISSUE GLABELLA

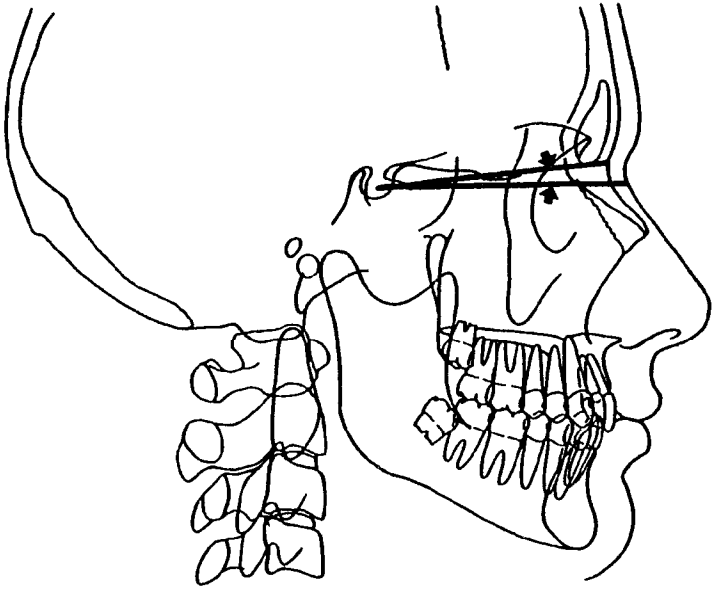
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
41	72	-.5	1.4	2.5	-6.6	-4.8	.88

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	5.9	***	5.7	***	6.3	*	**	—	—	—	—	*	—	—	**
INITIAL	6.4		6.1		6.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	6.4	6.2	6.0	5.9	5.8
	SD	1.8	1.6	1.5	1.5	1.4
	N	84	31	63	36	39
FEMALE	MEAN	7.0	6.9	6.6	6.8	7.1
	SD	2.1	2.0	1.6	2.1	2.1
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 128

MEASURE 3PTA 54-46-76

NAME ANGLE NASION-SELLA-SOFT TISSUE NASION

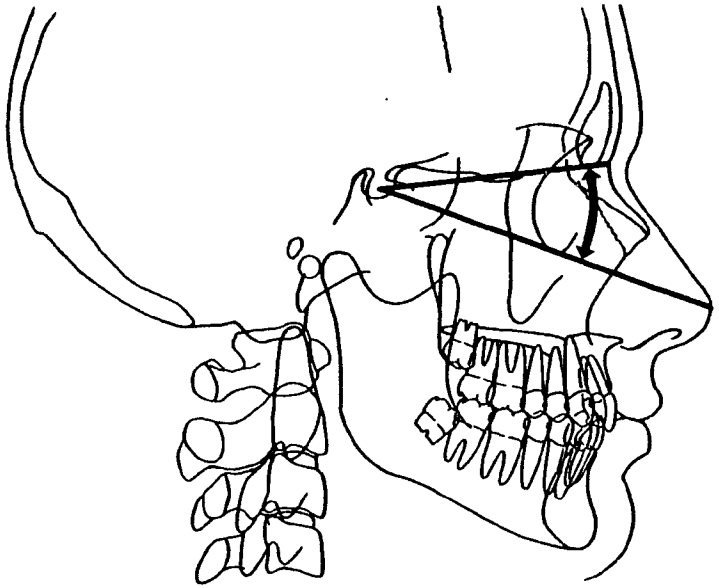
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
64	49	.4	1.8	5.0	-4.3	NA	.91

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	3.9	**	3.8	—	4.3	*	—	—	—	—	—	**	—	—	—
INITIAL	3.5		3.5		3.6										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	3.1	3.2	4.2	4.0	3.6
	SD	1.7	1.6	1.5	1.2	1.7
	N	84	31	63	36	39
FEMALE	MEAN	3.0	3.3	3.7	4.4	4.1
	SD	1.4	1.8	1.7	1.7	1.8
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 129

MEASURE 3PTA 54-46-77

NAME ANGLE NASION-SELLA-ANTERIOR NOSE POINT A

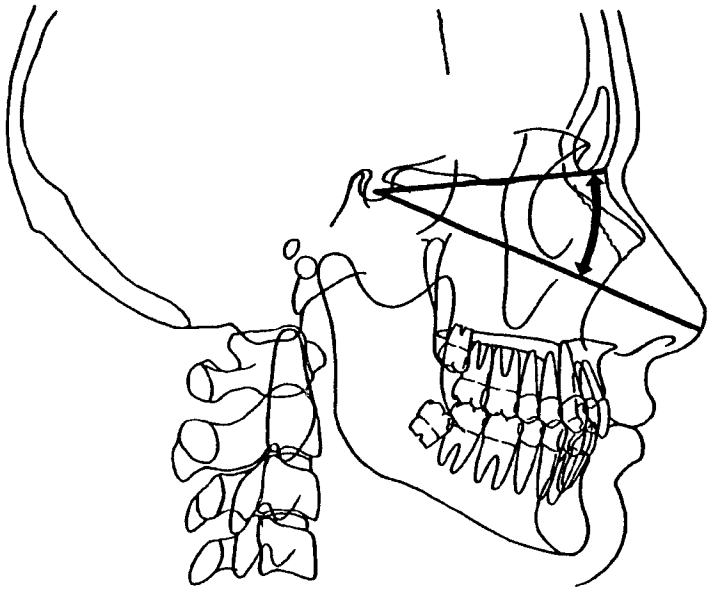
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
98	15	1.1	.9	3.1	-.8	4.3	.98

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	27.1	***	27.1	***	27.2	***	—	***	***	**	*	***	**	***	*
INITIAL	26.1		26.0		26.2										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	26.0	26.5	26.8	26.5	27.4
	SD	2.1	2.0	1.8	2.2	2.7
	N	84	31	63	36	39
FEMALE	MEAN	26.0	26.0	26.7	26.4	27.2
	SD	1.6	1.7	1.8	1.7	1.4
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 130

MEASURE 3PTA 54-46-78

NAME ANGLE NASION-SELLA-NOSE POINT B

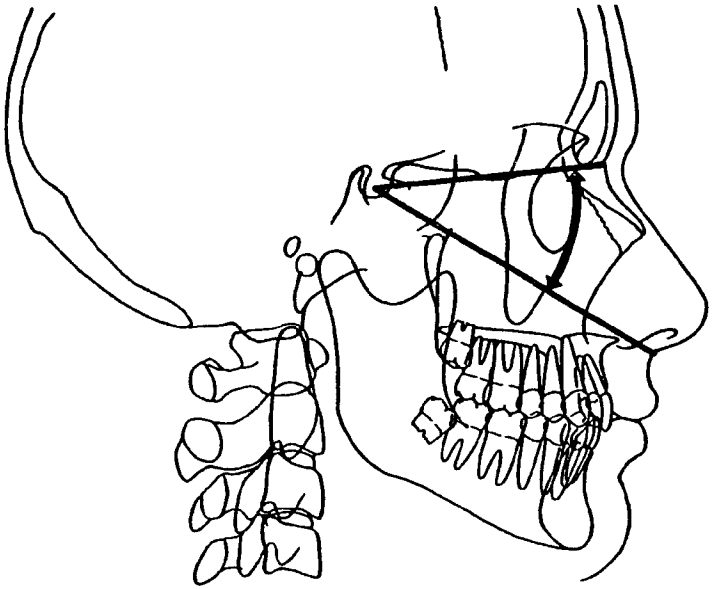
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
101	12	1.1	.9	3.2	-.9	3.9	.96

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	30.3	***	30.3	***	30.3	***	—	***	***	**	*	***	**	***	*
INITIAL	29.2		29.1		29.2										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	29.1	29.6	30.0	29.6	30.5
	SD	2.3	2.2	1.8	2.4	2.8
	N	84	31	63	36	39
FEMALE	MEAN	29.1	29.0	29.9	29.6	30.4
	SD	1.7	1.7	1.9	1.6	1.5
	N	39	24	29	27	15



CALCULATION 131

MEASURE 3PTA 54-46-79

NAME ANGLE NASION-SELLA-SUBNASALE

INITIAL TO FINAL

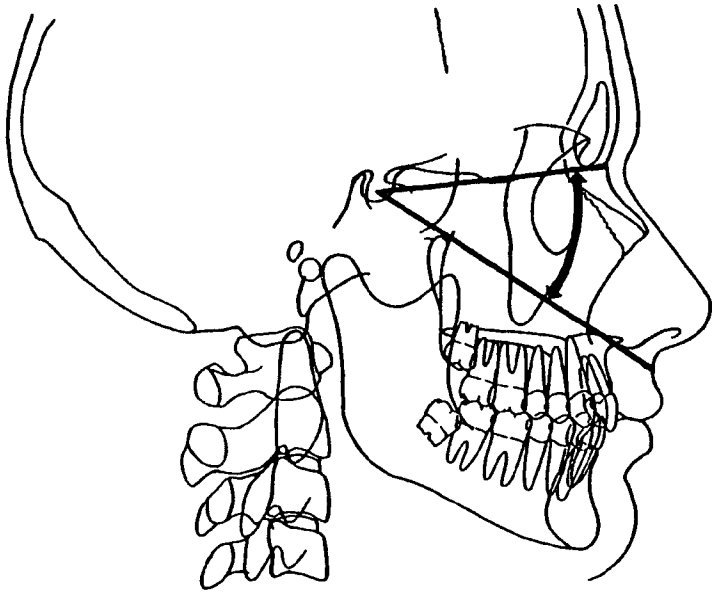
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
100	13	1.1	.9	3.0	-1.7	3.2	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	37.0	***	36.9	***	37.5	***	—	***	**	**	*	***	**	***	**
INITIAL	35.9		35.8		36.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	35.9	36.1	36.6	36.1	37.3
	SD	2.0	2.4	1.8	2.7	3.0
	N	84	31	63	36	39
FEMALE	MEAN	35.9	36.0	36.8	36.4	37.9
	SD	1.9	1.9	2.0	2.0	1.9
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 132

MEASURE 3PTA 54-46-80

NAME ANGLE NASION-SELLA-SOFT TISSUE A POINT

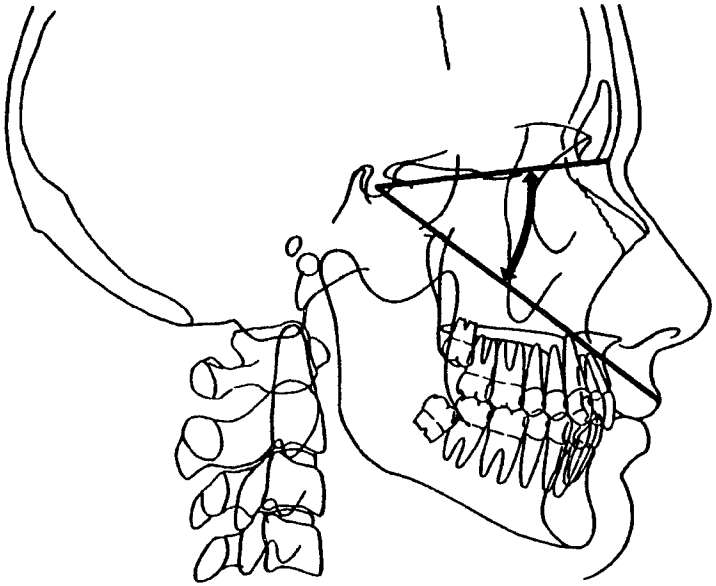
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
108	5	1.8	1.2	4.4	-.6	4.5	.97

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	42.5	***	42.5	***	42.4	***	—	***	***	***	*	***	***	**	—
INITIAL	40.7		40.6		40.8										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	40.5	40.6	41.7	42.0	42.7
	SD	2.4	2.7	2.2	3.2	3.3
	N	84	31	63	36	39
FEMALE	MEAN	40.4	40.5	41.6	41.6	42.4
	SD	2.3	2.3	2.5	2.0	2.6
	N	39	24	29	27	15



CALCULATION 133

MEASURE 3PTA 54-46-81

NAME ANGLE NASION-SELLA-UPPER LIP ANTERIOR

INITIAL TO FINAL

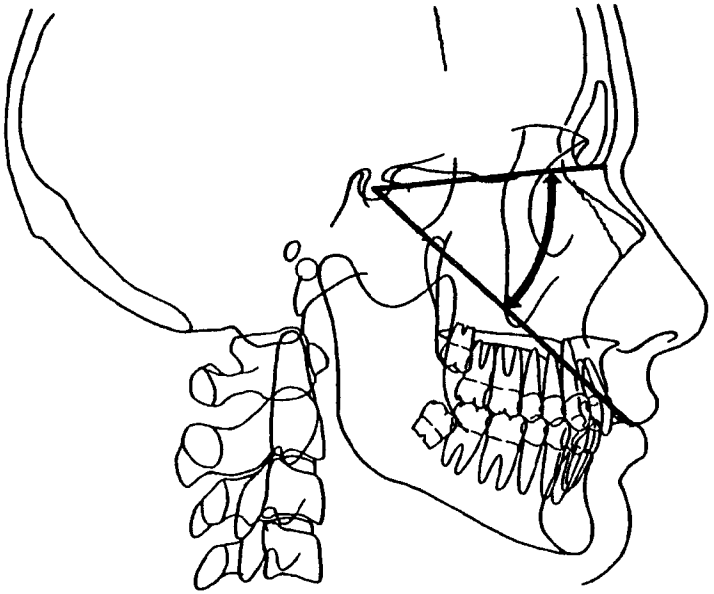
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
109	4	2.2	1.4	6.0	-.9	5.2	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	45.1	***	45.1	***	45.1	***	—	***	***	***	—	***	**	***	—
INITIAL	42.9		42.8		43.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	42.6	42.7	43.9	44.2	45.8
	SD	2.4	2.7	2.2	3.1	3.4
	N	84	31	63	36	39
FEMALE	MEAN	42.7	42.7	43.6	43.9	45.3
	SD	2.2	2.4	2.6	2.0	2.6
	N	39	24	29	27	15



CALCULATION 134

MEASURE 3PTA 54-46-82

NAME ANGLE NASION-SELLA-STOMION

INITIAL TO FINAL

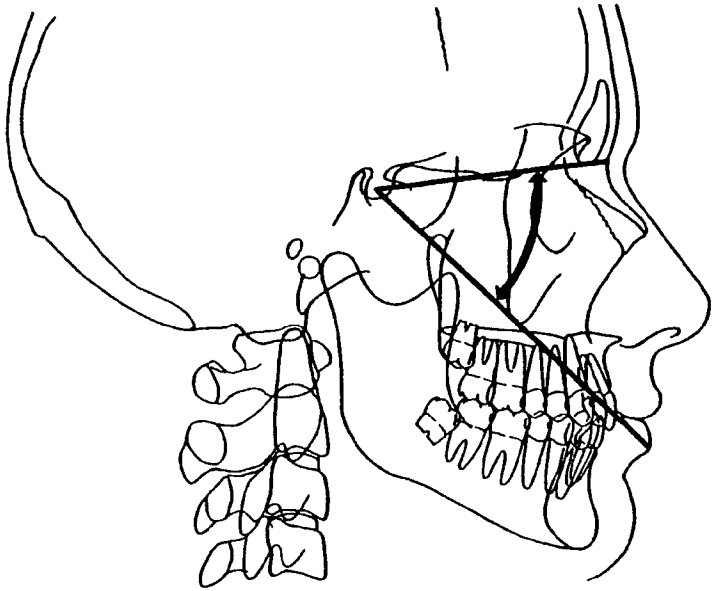
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
99	14	1.2	1.2	3.6	-1.4	2.6	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	49.1	***	49.0	***	49.4	***	—	***	**	**	—	***	***	*	—
INITIAL	47.9		47.8		48.0										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	47.9	47.8	48.5	48.2	49.4
	SD	2.5	2.5	2.3	3.2	3.7
	N	84	31	63	36	39
FEMALE	MEAN	47.8	47.8	48.6	48.3	49.6
	SD	2.2	2.1	2.3	2.2	2.4
	N	39	24	29	27	15



CALCULATION 135

MEASURE 3PTA 54-46-83

NAME ANGLE NASION-SELLA-LOWER LIP ANTERIOR

INITIAL TO FINAL

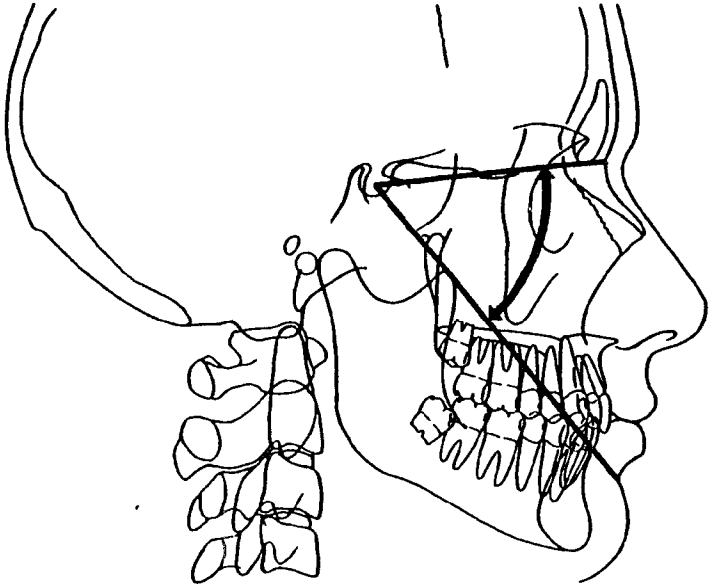
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
85	28	.8	1.2	3.6	-2.5	1.6	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	50.2	***	50.0	***	50.8	***	—	***	**	*	—	**	***	*	—
INITIAL	49.5		49.4		49.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	49.4	49.4	49.9	49.3	50.2
	SD	2.6	2.4	2.2	3.1	3.7
	N	84	31	63	36	39
FEMALE	MEAN	49.5	49.6	50.4	50.0	50.9
	SD	2.2	2.2	2.5	2.2	2.5
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 136

MEASURE 3PTA 54-46-84

NAME ANGLE NASION-SELLA-MENTAL SULCUS

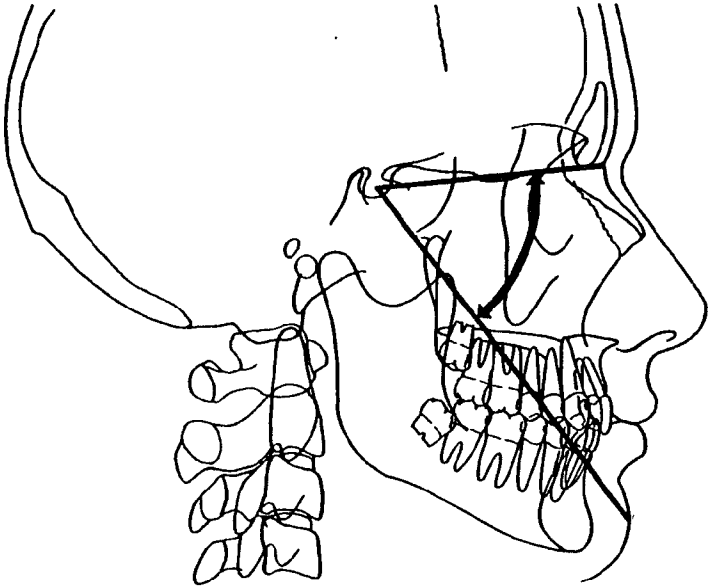
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
79	34	.5	1.0	3.1	-2.6	.8	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	56.9	***	56.6	**	56.9	***	—	**	—	—	—	—	***	—	—
INITIAL	56.4		56.5		56.2										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	56.4	56.6	57.0	56.1	56.8
	SD	2.9	2.8	2.6	3.5	4.1
	N	84	31	63	36	39
FEMALE	MEAN	56.2	56.2	57.3	55.8	56.6
	SD	2.7	2.4	2.6	2.5	2.5
	N	39	24	29	27	15



CALCULATION 137

MEASURE 3PTA 54-46-85

NAME ANGLE NASION-SELLA-SOFT TISSUE POGONION

INITIAL TO FINAL

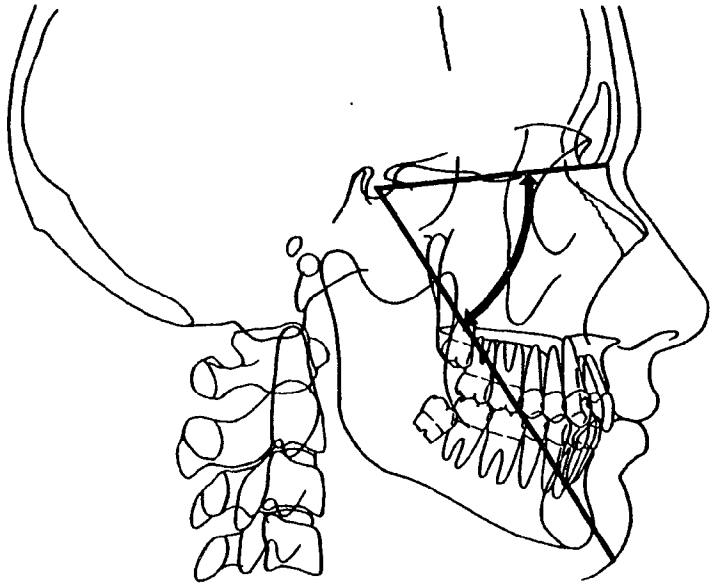
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
78	35	.5	1.3	3.3	-2.8	.9	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	59.4	***	59.3	**	59.7	***	—	**	*	—	—	—	***	—	—
INITIAL	58.9		59.0		58.8										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	58.9	58.9	59.3	58.5	59.5
	SD	3.0	2.9	2.6	3.4	4.0
	N	84	31	63	36	39
FEMALE	MEAN	58.7	58.8	59.9	58.8	59.3
	SD	2.7	2.4	2.9	2.2	2.5
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 138

MEASURE 3PTA 54-46-86

NAME ANGLE NASION-SELLA-SOFT TISSUE GNATHION

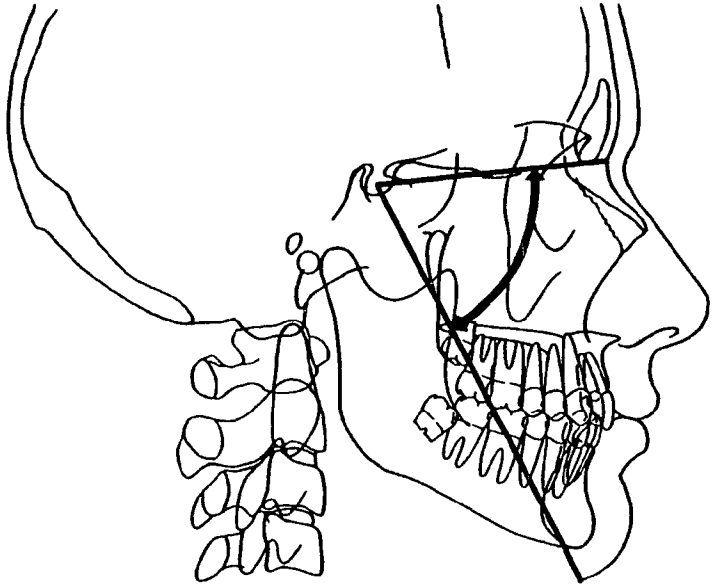
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
74	39	.5	1.2	4.0	-2.1	.9	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	63.9	***	63.8	**	64.3	***	—	***	**	*	*	—	***	—	—
INITIAL	63.4		63.4		63.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	63.5	63.5	63.6	62.9	63.9
	SD	3.3	2.8	2.6	3.3	4.0
	N	84	31	63	36	39
FEMALE	MEAN	63.3	63.2	64.2	63.2	64.0
	SD	3.0	2.3	3.0	2.3	2.7
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 139

MEASURE 3PTA 54-46-87

NAME ANGLE NASION-SELLA-SOFT TISSUE MENTON

INITIAL TO FINAL

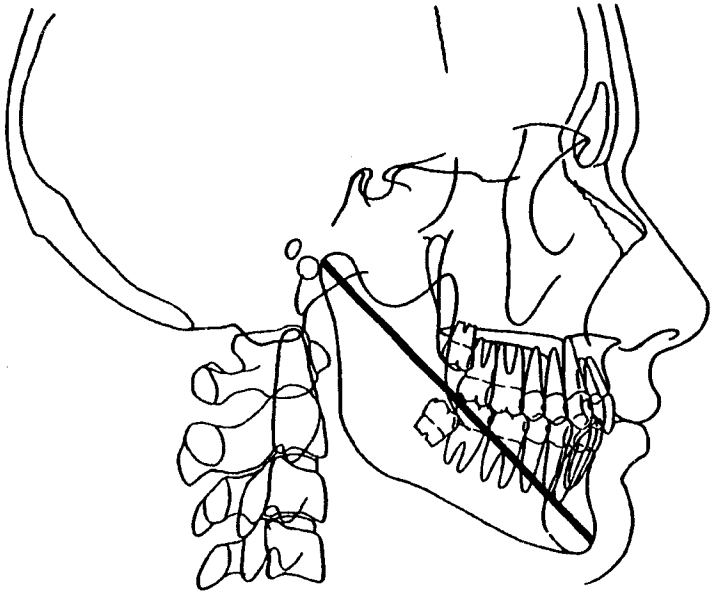
UNTREATED

GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
73	40	.5	1.5	5.2	-2.4	.8	.96

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	69.5	***	69.3	*	69.9	**	—	**	**	*	—	—	***	—	—
INITIAL	68.9		68.9		68.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	68.8	69.3	69.2	68.4	69.5
	SD	3.5	2.5	2.7	3.3	3.9
	N	84	31	63	36	39
FEMALE	MEAN	68.8	68.8	69.6	68.7	69.5
	SD	3.2	2.8	3.1	2.6	2.9
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 140

MEASURE SIMP 43-3

NAME CONDYLION TO POGONION

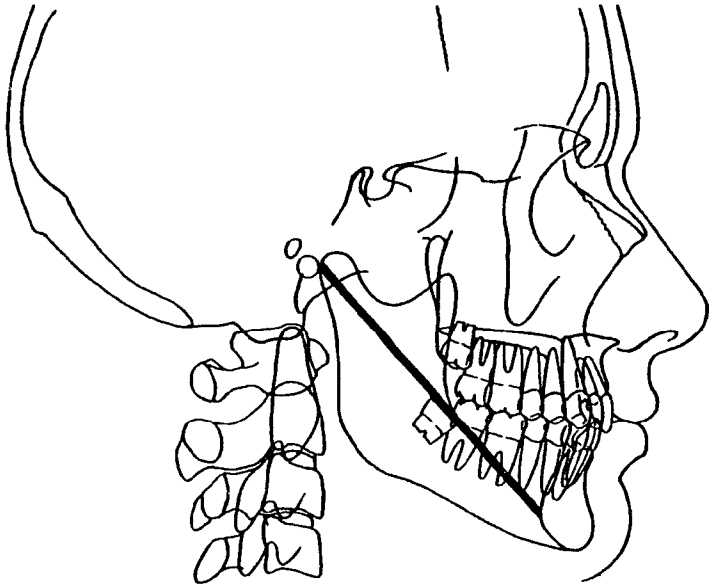
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
108	5	3.0	2.6	16.2	-1.5	2.5	.98

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	123.0	***	125.6	***	116.8	***	***	***	**	*	—	***	—	***	**
INITIAL	120.0		122.4		114.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	122.6	124.3	124.1	125.8	125.3
	SD	4.7	5.9	6.2	6.9	5.7
	N	84	31	63	36	39
FEMALE	MEAN	113.7	114.2	112.8	117.6	117.3
	SD	5.1	4.8	4.5	5.5	5.6
	N	39	24	29	27	15



CALCULATION 141

MEASURE SIMP 43-17

NAME CONDYLION TO LINGUAL SYMPHYSEAL POINT

INITIAL TO FINAL

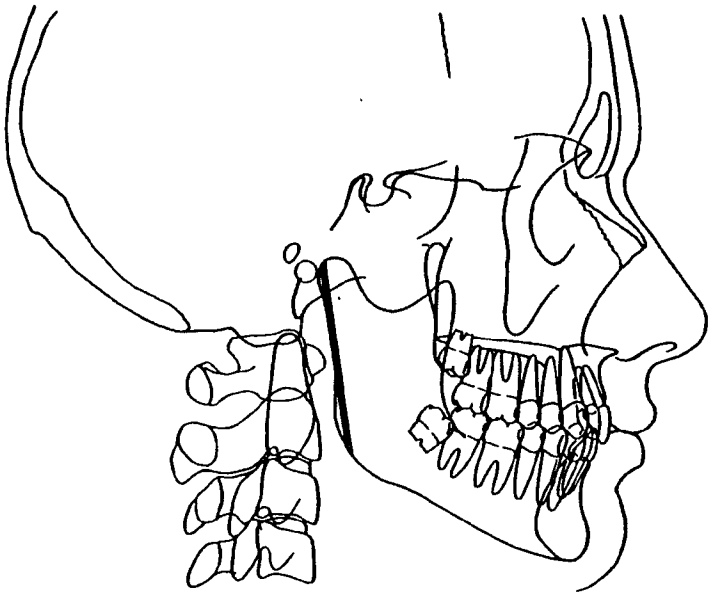
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
97	16	2.6	2.5	15.1	-1.4	2.5	.95

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	107.5	***	109.6	***	102.6	***	***	***	***	**	—	***	—	*	—
INITIAL	105.0		106.8		100.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	107.1	108.2	108.6	109.4	109.4
	SD	4.5	5.4	5.6	6.4	5.5
	N	84	31	63	36	39
FEMALE	MEAN	100.1	101.0	98.8	103.0	103.0
	SD	5.6	5.0	5.6	4.9	5.7
	N	39	24	29	27	15



CALCULATION 142

MEASURE SIMP 43-31

NAME CONDYLION TO GONION

INITIAL TO FINAL

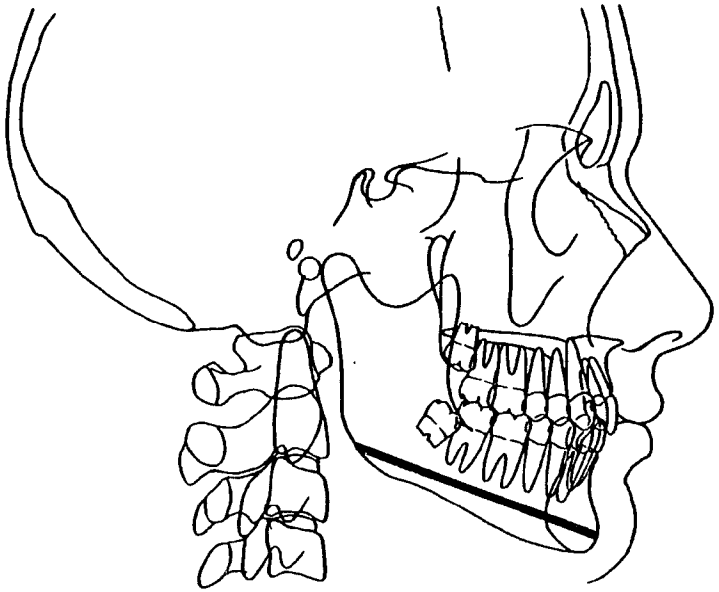
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
99	14	3.1	3.1	15.3	-2.2	5.2	.97

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	63.4	***	65.9	***	57.6	***	***	***	**	—	—	***	**	**	***
INITIAL	60.3		62.2		56.0										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	61.7	64.4	64.9	65.5	66.1
	SD	3.9	3.7	4.3	5.2	4.6
	N	84	31	63	36	39
FEMALE	MEAN	55.1	55.0	54.1	57.7	59.2
	SD	4.6	4.4	3.9	3.5	4.5
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 143

MEASURE SIMP 31-3

NAME GONION TO POGONION

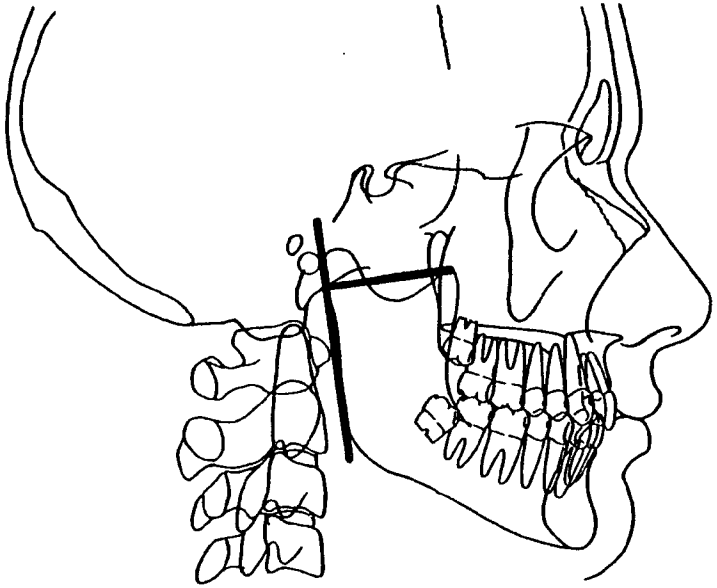
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
84	29	.9	1.2	5.2	-1.7	1.1	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	80.9	***	82.2	***	77.9	***	***	*	**	—	—	**	**	—	***
INITIAL	80.1		81.5		76.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	81.8	82.1	82.1	83.8	82.3
	SD	4.1	5.7	5.6	5.6	4.5
	N	84	31	63	36	39
FEMALE	MEAN	76.7	77.3	77.0	79.5	77.4
	SD	4.8	4.1	3.1	5.1	5.3
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 144

MEASURE PDIS 61 TO 41-32

NAME CORONOID POINT TO RAMAL PLANE

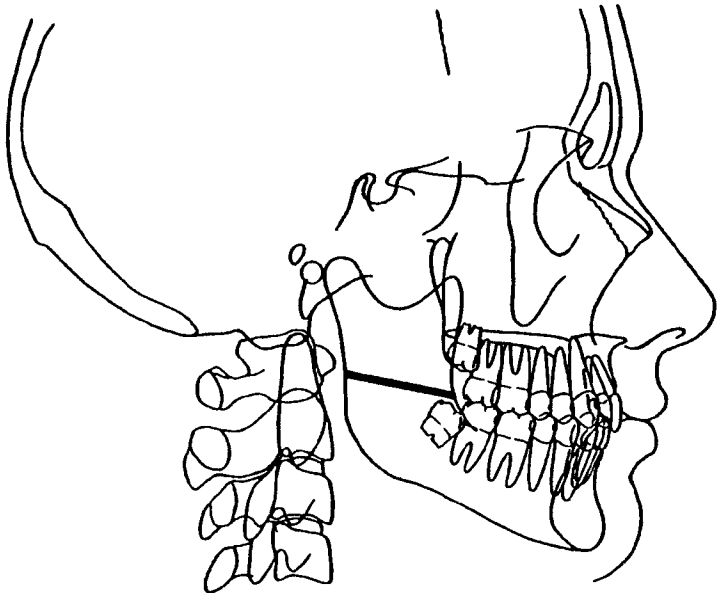
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
87	26	.9	1.8	5.4	-5.0	2.2	.97

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	42.8	***	43.9	***	40.2	**	***	—	*	*	—	—	**	—	—
INITIAL	41.9		43.0		39.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	42.0	43.0	43.2	43.8	44.7
	SD	9.5	2.4	2.7	2.7	2.8
	N	84	31	63	36	39
FEMALE	MEAN	39.2	38.3	37.1	41.6	41.4
	SD	2.9	3.1	2.4	3.0	3.0
	N	39	24	29	27	15



CALCULATION 145

MEASURE SIMP 33-30

NAME ANTERIOR BORDER OF RAMUS TO POSTERIOR BORDER OR RAMUS

INITIAL TO FINAL

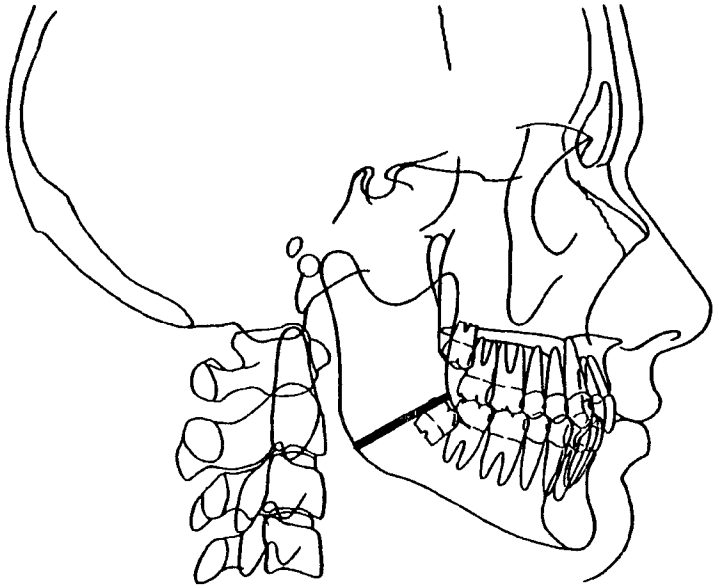
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
45	68	-.3	1.6	3.7	-6.0	-1.0	.93

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	35.1	*	35.7	**	33.7	—	***	—	—	—	—	—	***	NA	NA
INITIAL	35.4		36.1		33.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	36.0	36.0	36.2	36.7	36.0
	SD	2.7	3.2	3.3	4.0	3.5
	N	84	31	63	36	39
FEMALE	MEAN	34.1	33.5	33.7	35.4	33.8
	SD	3.2	3.2	3.4	3.0	2.4
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 146

MEASURE SIMP 31-30

NAME GONION TO ANTERIOR BORDER OF RAMUS

INITIAL TO FINAL

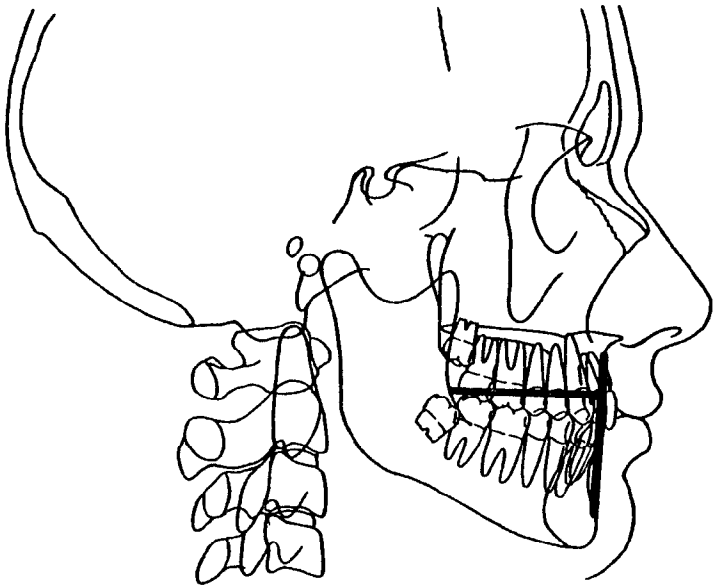
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
65	48	.2	1.3	3.1	-3.7	.5	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	35.3	—	36.3	—	32.9	—	***	*	**	*	—	—	***	NA	NA
INITIAL	35.1		36.1		32.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	35.9	36.3	36.8	37.0	36.8
	SD	3.0	3.7	4.5	4.3	3.2
	N	84	31	63	36	39
FEMALE	MEAN	32.5	32.0	32.5	34.0	33.4
	SD	3.3	3.2	3.5	2.8	3.3
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 147

MEASURE PDIS 30 TO 3-5

NAME ANTERIOR BORDER OF RAMUS TO LINE POGONION-INFRADENTALE

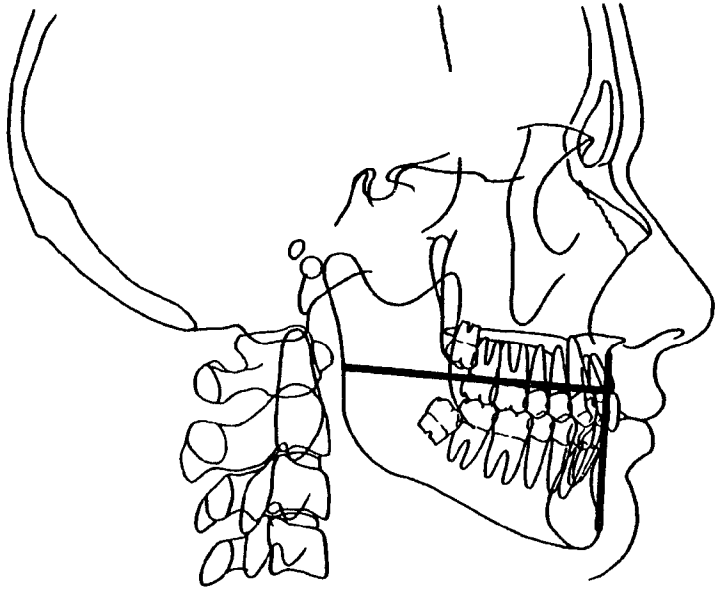
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
85	28	1.2	1.8	6.5	-2.7	2.5	.96

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	49.1	***	50.0	***	47.2	**	***	—	—	—	—	*	—	NA	NA
INITIAL	47.9		48.7		46.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	48.8	49.2	49.0	50.3	49.8
	SD	3.5	3.8	3.9	3.6	3.4
	N	84	31	63	36	39
FEMALE	MEAN	46.7	47.1	46.1	46.8	47.7
	SD	3.0	3.0	2.8	3.0	3.4
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 148

MEASURE PDIS 33 TO 3-5

NAME POSTERIOR BORDER OF RAMUS TO LINE POGONION-INFRADENTALE

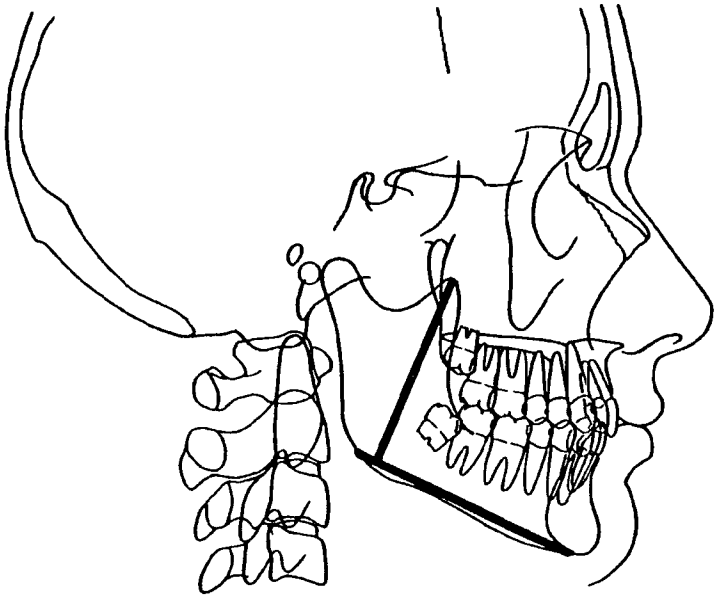
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
80	33	.8	1.4	5.1	-3.2	1.0	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	83.9	***	85.4	***	80.5	***	***	***	**	—	—	—	**	NA	NA
INITIAL	83.1		84.5		79.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	84.5	84.9	84.9	86.6	85.6
	SD	4.3	5.1	5.6	6.3	5.8
	N	84	31	63	36	39
FEMALE	MEAN	80.5	80.3	79.5	81.9	81.2
	SD	4.5	4.8	3.8	4.0	4.4
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 149

MEASURE PDIS 61 TO 31-1

NAME CORONOID POINT TO LINE GONION-MENTON

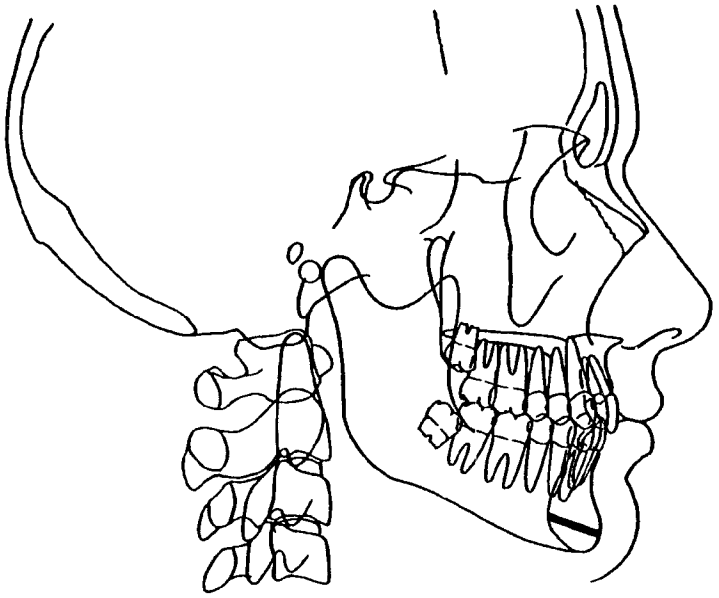
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
88	25	1.9	2.7	9.0	-5.0	3.1	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	64.3	***	66.8	***	58.5	**	***	*	—	—	—	**	**	—	***
INITIAL	62.4		64.4		57.5										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	63.6	65.1	65.7	67.8	66.8
	SD	5.2	5.5	5.1	5.7	5.2
	N	84	31	63	36	39
FEMALE	MEAN	56.9	55.8	56.4	60.7	59.3
	SD	4.9	4.4	4.8	5.0	5.3
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 150

MEASURE SIMP 17-3

NAME LINGUAL SYMPHYSEAL POINT-POGONION

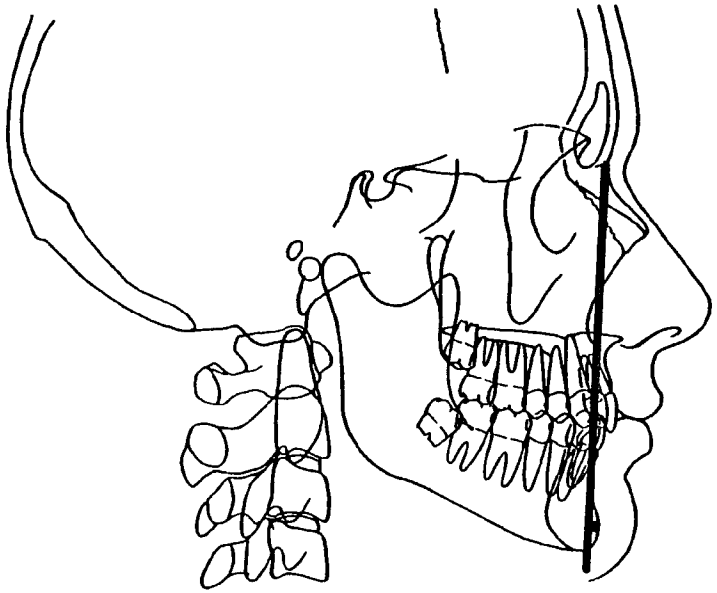
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
83	30	.4	.6	2.2	-1.1	2.3	.97

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	17.2	***	17.7	***	15.9	***	***	—	—	—	*	—	—	NA	NA
INITIAL	16.8		17.4		15.5										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	17.2	17.7	17.2	18.1	17.6
	SD	1.6	1.5	2.0	2.0	1.9
	N	84	31	63	36	39
FEMALE	MEAN	15.5	15.4	15.6	16.2	16.2
	SD	1.7	1.9	1.3	1.6	1.4
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 151

MEASURE PDIS 3 TO 54-4

NAME POGONION TO LINE NASION-B POINT

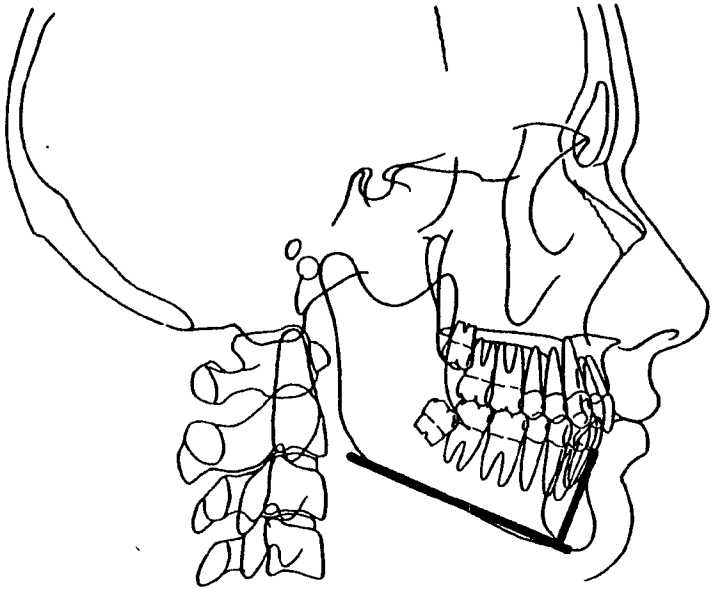
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
82	31	.2	.8	1.9	-6.2	NA	.78

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	3.5	**	3.7	—	3.1	***	**	—	—	—	—	*	—	*	***
INITIAL	3.3		3.6		2.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	3.5	3.9	3.6	3.6	3.8
	SD	1.6	1.9	1.9	2.5	1.8
	N	84	31	63	36	39
FEMALE	MEAN	2.3	2.5	2.6	3.1	3.0
	SD	1.6	1.8	2.1	1.4	1.7
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 152

MEASURE PDIS 5 TO 32-1

NAME INFRADENTALE TO MANDIBULAR PLANE

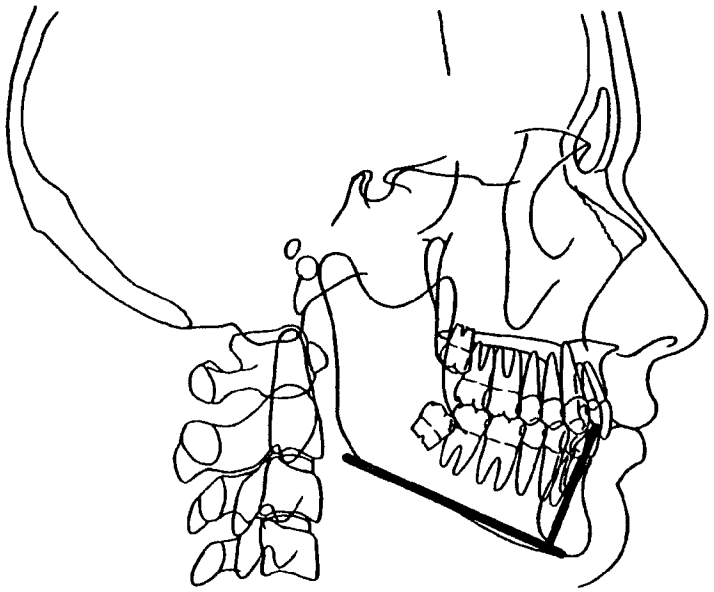
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
96	17	.9	1.1	4.1	-2.3	2.7	.98

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	33.6	***	34.6	***	31.2	***	***	***	***	***	*	***	**	NA	NA
INITIAL	32.7		33.7		30.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	33.6	34.3	34.2	34.4	34.6
	SD	2.3	2.1	2.8	2.8	2.6
	N	84	31	63	36	39
FEMALE	MEAN	30.6	30.7	30.3	30.4	32.0
	SD	1.8	1.8	1.9	2.9	2.6
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 153

MEASURE PDIS 6 TO 32-1

NAME LOWER INCISOR INCISAL EDGE TO MANDIBULAR PLANE

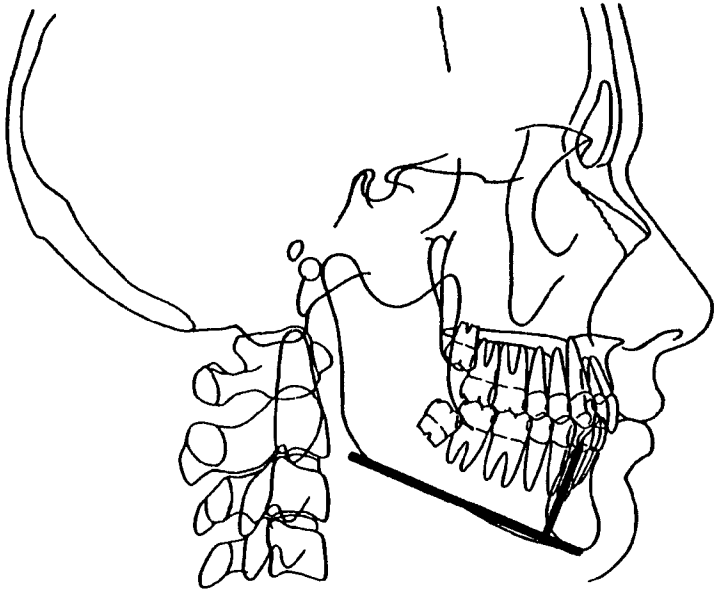
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
98	15	1.1	1.2	5.0	-3.0	2.5	.98

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	44.4	***	45.5	***	41.8	***	***	**	***	*	—	***	**	NA	NA
INITIAL	43.3		44.5		40.6										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	44.5	45.0	44.8	44.9	45.6
	SD	2.6	2.3	2.9	3.7	3.2
	N	84	31	63	36	39
FEMALE	MEAN	40.9	41.1	40.6	40.9	42.6
	SD	1.8	1.7	2.2	3.0	2.6
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 154

MEASURE PDIS 15 TO 32-1

NAME LOWER INCISOR LINGUAL BONY POINT TO MANDIBULAR PLANE

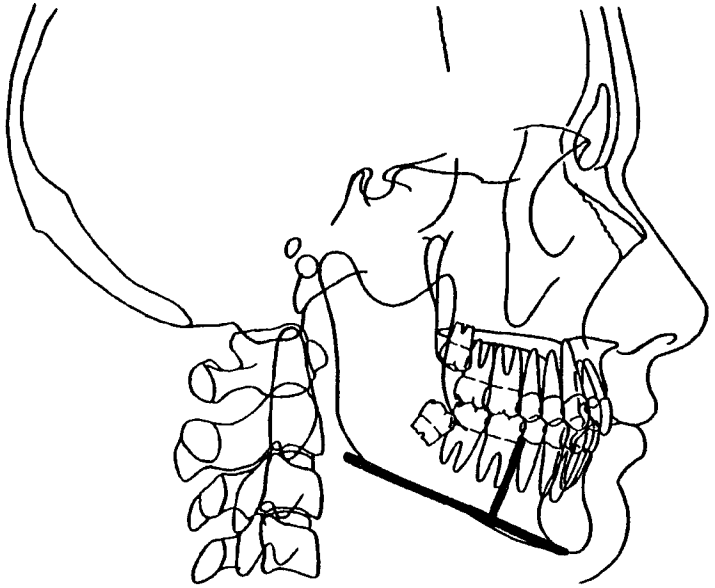
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
89	24	1.1	1.6	6.7	-3.6	3.4	.93

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	34.4	***	35.5	***	31.9	***	***	—	—	—	*	***	**	NA	NA
INITIAL	33.3		34.5		30.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	34.3	35.2	34.8	35.3	35.7
	SD	2.6	2.3	2.8	3.0	3.0
	N	84	31	63	36	39
FEMALE	MEAN	31.1	31.2	30.8	30.8	33.1
	SD	1.8	1.7	2.3	3.1	3.0
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 155

MEASURE PDIS 21 TO 32-1

NAME LOWER MOLAR MESIAL CEJ TO MANDIBULAR PLANE

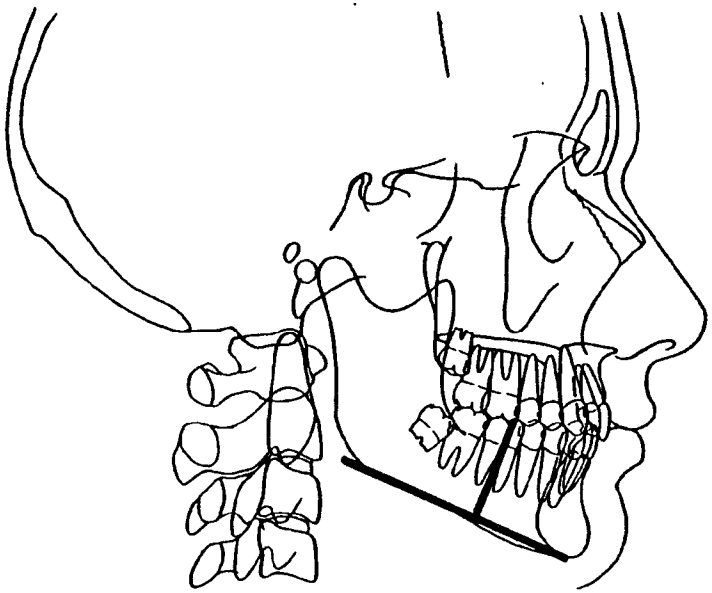
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
95	18	1.1	1.3	5.4	-3.5	4.2	.96

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	28.6	***	29.6	***	26.2	***	***	***	**	*	—	***	**	NA	NA
INITIAL	27.4		28.5		25.0										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	28.3	29.2	29.6	29.9	29.3
	SD	2.5	2.4	2.7	3.0	3.0
	N	84	31	63	36	39
FEMALE	MEAN	24.9	24.8	24.9	25.6	27.2
	SD	1.7	1.9	1.8	2.9	2.9
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 156

MEASURE PDIS 25 TO 32-1

NAME LOWER MOLAR MESIAL CUSP TIP TO MANDIBULAR PLANE

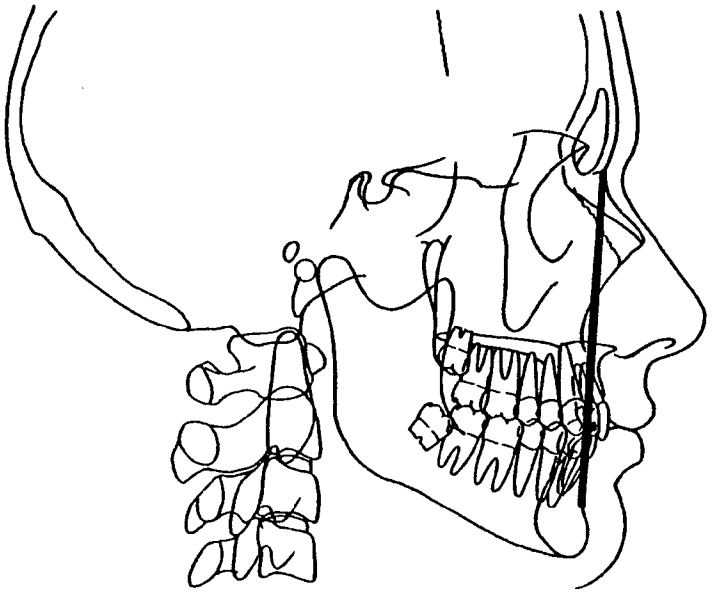
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
102	11	1.6	1.4	4.6	-2.2	4.6	.96

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	36.2	***	37.3	***	33.4	***	***	***	**	—	—	***	**	NA	NA
INITIAL	34.6		35.7		31.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	35.6	36.4	36.9	37.3	37.3
	SD	2.6	2.6	2.8	3.2	3.0
	N	84	31	63	36	39
FEMALE	MEAN	31.8	31.9	31.7	32.8	34.7
	SD	1.8	2.0	1.5	3.0	3.6
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 157

MEASURE PDIS 6 TO 54-4

NAME LOWER INCISOR INCISAL EDGE TO LINE NASION-B POINT

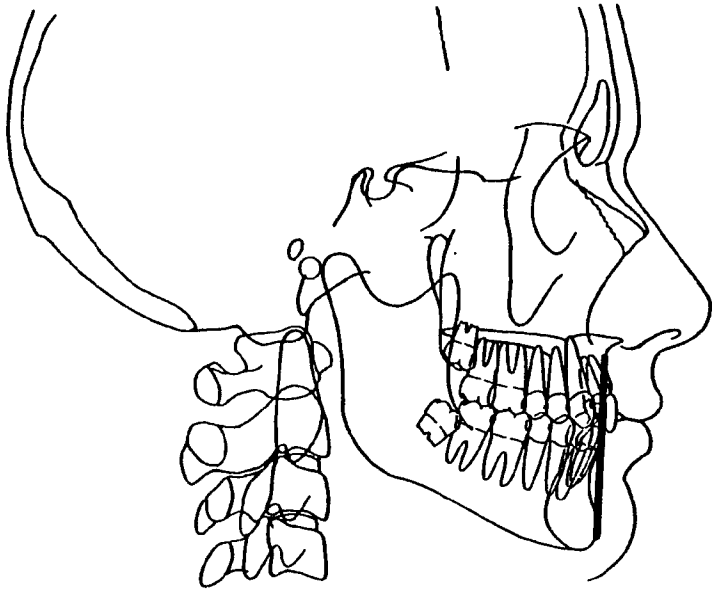
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
68	45	.1	1.9	3.9	-16.0	NA	.12

	UNTREATED												TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+		T P	T UNTX	T P	T UNTX
FINAL	4.7	—	4.5	—	5.2	***	—	—	—	—	—		—	*	NA	NA
INITIAL	4.7		4.7		4.5											

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	4.7	4.8	4.4	4.5	4.4
	SD	2.5	2.1	2.2	3.2	2.8
	N	84	31	63	36	39
FEMALE	MEAN	4.9	5.1	5.6	4.2	5.5
	SD	1.7	1.6	1.8	2.3	2.1
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 158

MEASURE PDIS 6 TO 11-3

NAME LOWER INCISOR INCISAL EDGE TO LINE A POINT POGONION

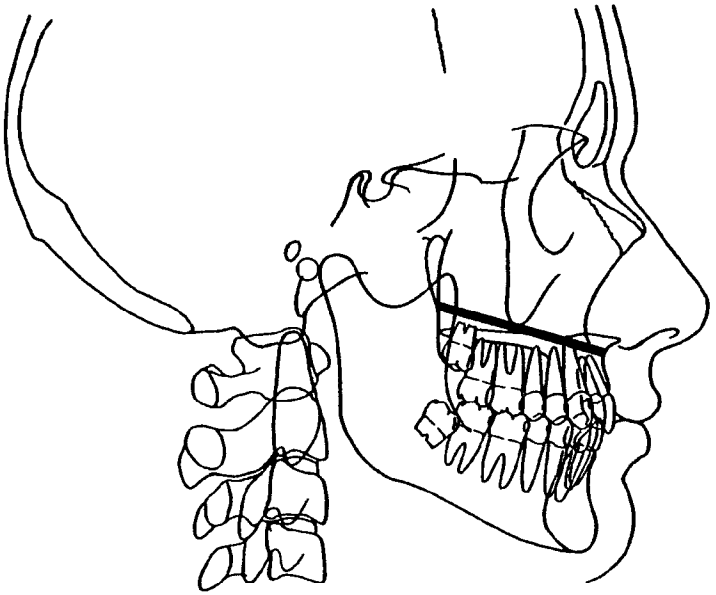
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
63	50	0	1.2	2.2	-8.4	NA	.97

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	1.5	—	1.3	—	2.0	—	—	—	—	—	*	—	—	NA	NA
INITIAL	1.5		1.3		1.8										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	1.5	1.4	1.2	.9	.7
	SD	2.5	2.3	2.3	2.7	3.0
	N	84	31	63	36	39
FEMALE	MEAN	2.0	2.3	2.0	1.0	1.9
	SD	2.1	2.1	2.6	2.3	1.8
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 159

MEASURE SIMP 60-11

NAME PTM INFERIOR TO A POINT

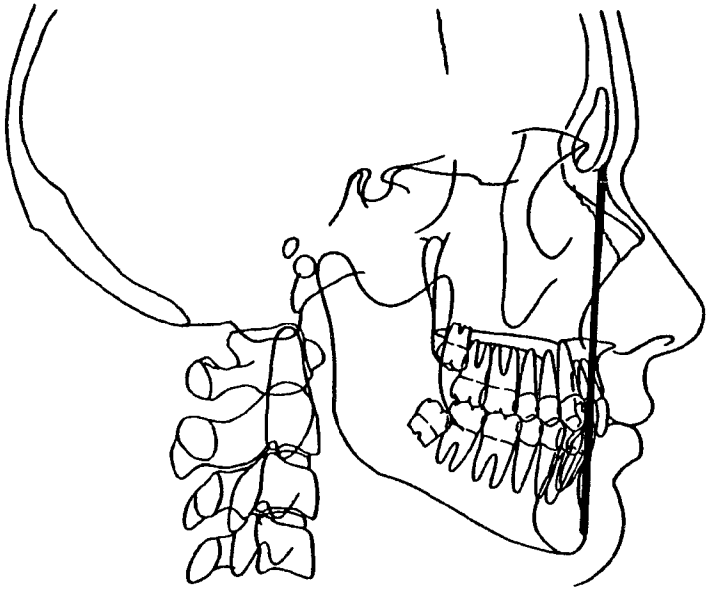
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
89	24	1.2	1.5	5.9	-2.9	2.0	.90

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	58.4	***	59.5	***	56.0	***	***	—	—	—	—	***	—	NA	NA
INITIAL	57.3		58.3		55.0										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	58.0	58.7	59.0	61.1	59.1
	SD	2.7	3.4	3.2	3.0	3.5
	N	84	31	63	36	39
FEMALE	MEAN	55.4	55.4	55.6	56.6	57.2
	SD	3.0	3.4	3.2	3.3	2.9
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 160

MEASURE PDIS 11 TO 54-3

NAME A POINT TO LINE NASION-POGONION

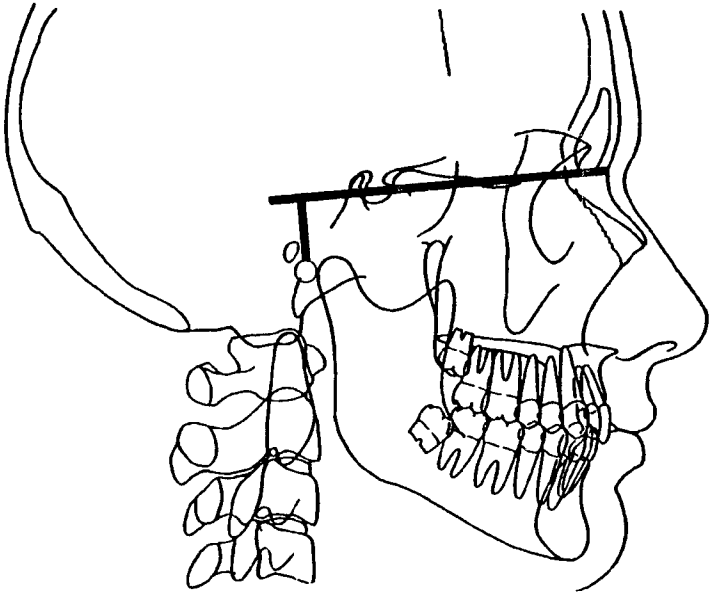
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
53	60	0	.9	3.5	-3.6	NA	.94

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	1.4	—	1.3	—	1.6	—	—	—	—	—	—	—	—	NA	NA
INITIAL	1.4		1.4		1.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	1.2	1.0	1.7	2.1	1.3
	SD	2.8	2.9	2.9	3.4	3.6
	N	84	31	63	36	39
FEMALE	MEAN	2.0	1.6	2.9	1.1	2.4
	SD	2.7	2.8	3.3	3.6	2.5
	N	39	24	29	27	15



CALCULATION 161

MEASURE PDIS 44 TO 54-46

NAME PORION TO SELLA-NASION

INITIAL TO FINAL

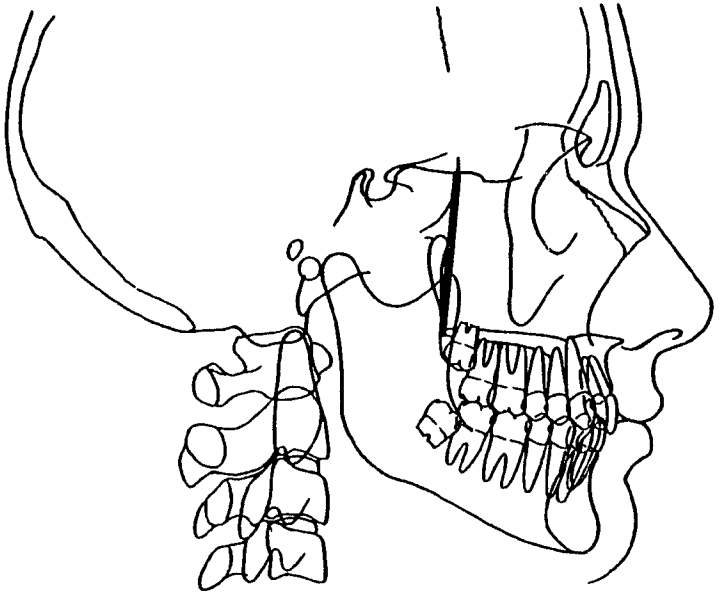
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
70	43	1.2	4.2	9.6	-9.7	8.5	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	20.5	**	21.5	***	18.2	—	***	*	—	—	—	*	*	—	—
INITIAL	19.3		19.9		17.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	20.3	19.0	19.6	21.6	21.0
	SD	5.5	5.3	5.0	5.6	7.0
	N	84	31	63	36	39
FEMALE	MEAN	17.3	16.2	17.2	15.7	20.0
	SD	5.6	5.7	6.1	6.3	6.3
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 162

MEASURE SIMP 47-59

NAME ETHMOID REGISTRATION POINT TO PNS

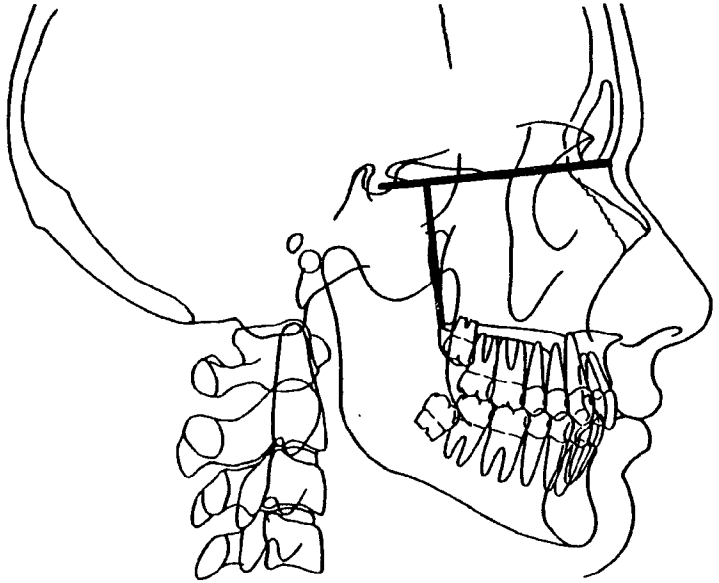
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
99	14	1.0	1.1	5.4	-1.6	2.1	.96

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	51.5	***	52.3	***	49.5	***	***	***	***	*	—	***	—	*	**
INITIAL	50.4		51.3		48.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	51.1	52.0	52.5	52.6	52.5
	SD	3.5	3.5	3.5	4.2	3.6
	N	84	31	63	36	39
FEMALE	MEAN	48.8	48.2	48.7	48.4	50.7
	SD	2.3	2.5	2.1	3.0	2.5
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 163

MEASURE PDIS 59 TO 54-46

NAME PNS TO SELLA-NASION

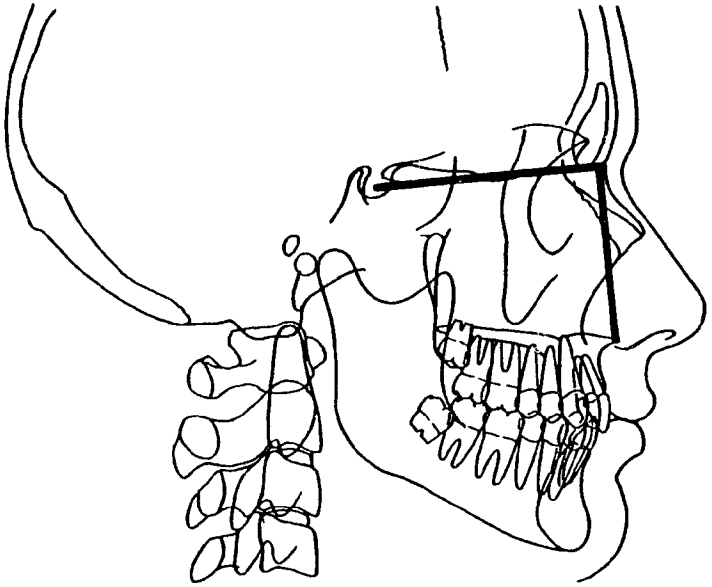
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
98	15	1.0	1.0	4.3	-1.6	2.1	.97

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	48.3	***	49.3	***	45.8	***	***	***	**	—	—	***	—	—	***
INITIAL	47.3		48.2		45.0										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	48.1	48.4	49.1	49.8	49.1
	SD	3.1	3.5	3.2	3.7	3.2
	N	84	31	63	36	39
FEMALE	MEAN	45.5	45.3	45.1	44.8	46.9
	SD	2.3	2.6	2.8	3.3	2.6
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 164

MEASURE PDIS 12 TO 54-46

NAME ANS TO SELLA-NASION

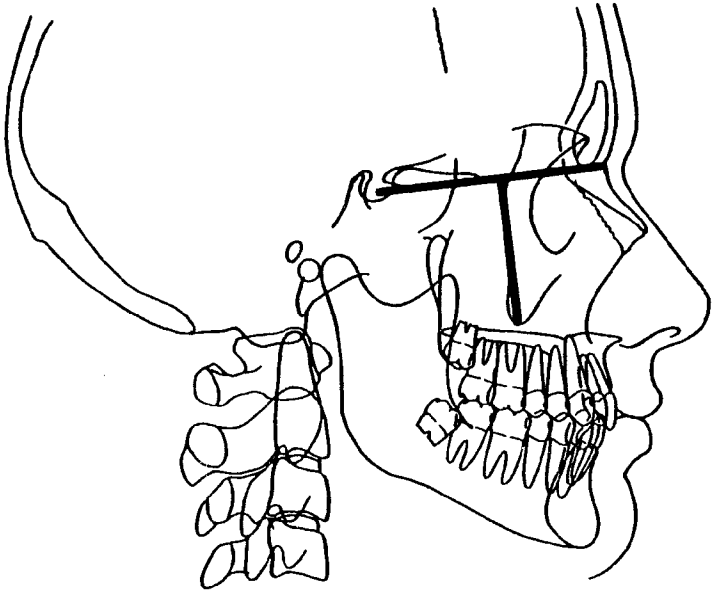
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
91	22	.9	1.2	6.0	-1.7	1.6	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	56.4	***	57.7	***	53.5	**	***	***	—	—	—	***	—	**	**
INITIAL	55.6		56.7		53.0										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	56.5	57.0	58.1	58.5	57.1
	SD	2.7	3.2	2.9	3.2	3.6
	N	84	31	63	36	39
FEMALE	MEAN	53.1	52.7	53.0	53.2	54.2
	SD	2.5	2.8	2.4	2.7	3.1
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 165

MEASURE PDIS 58 TO 54-46

NAME INFERIOR ZYGOMA TO SELLA-NASION

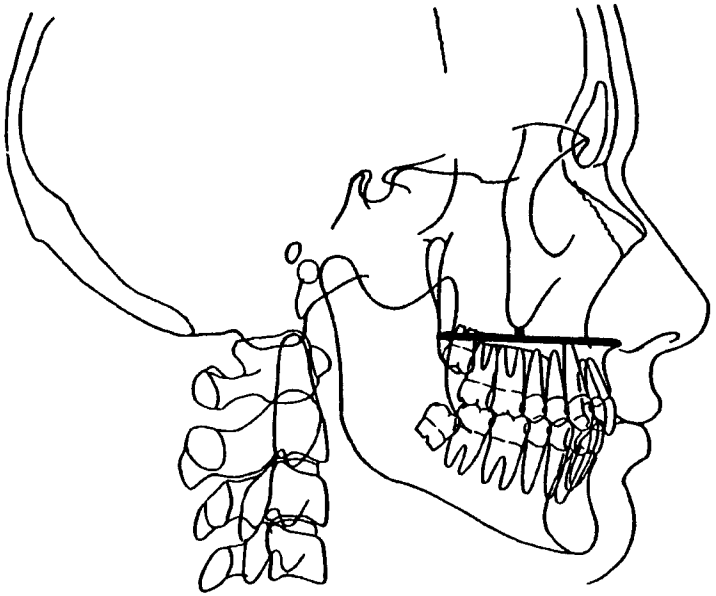
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
91	22	.7	1.3	7.0	-3.2	1.6	.96

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	48.8	***	49.7	***	46.6	***	***	**	—	—	—	***	—	—	**
INITIAL	48.1		49.0		45.8										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	48.8	49.2	49.9	50.5	49.4
	SD	3.2	4.3	4.2	4.5	3.8
	N	84	31	63	36	39
FEMALE	MEAN	46.0	45.7	46.1	46.7	47.0
	SD	2.7	3.0	2.6	3.0	2.8
	N	39	24	29	27	15



CALCULATION 166

MEASURE PDIS 58 TO 59-12

NAME INFERIOR ZYGOMA TO PALATAL PLANE

INITIAL TO FINAL

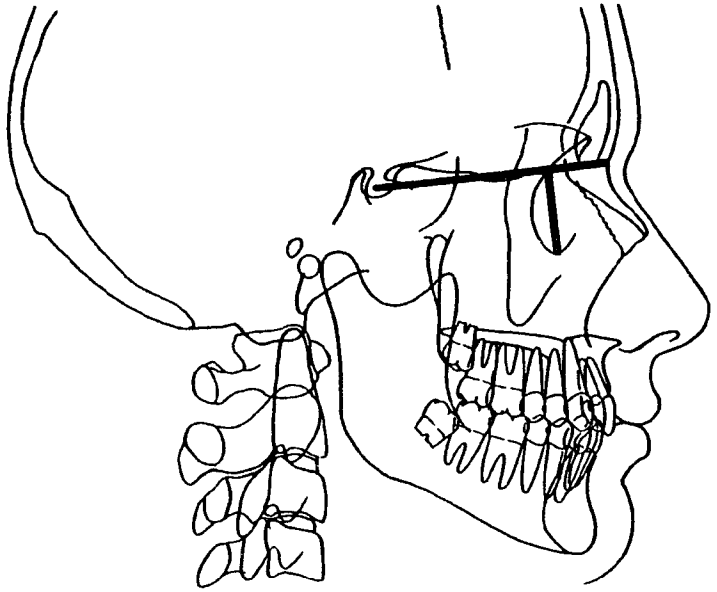
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
73	40	.3	1.1	3.0	-3.6	NA	.97

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	3.0	*	3.2	***	2.6	—	—	—	—	—	—	—	—	—	—
INITIAL	2.7		2.8		2.6										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	2.9	2.8	3.1	3.0	3.2
	SD	2.3	2.6	2.7	2.8	2.5
	N	84	31	63	36	39
FEMALE	MEAN	2.7	2.7	2.3	1.9	3.0
	SD	2.5	2.5	2.2	1.9	2.8
	N	39	24	29	27	15



CALCULATION 167

MEASURE PDIS 57 TO 54-46

NAME ORBITALE TO SELLA-NASION

INITIAL TO FINAL

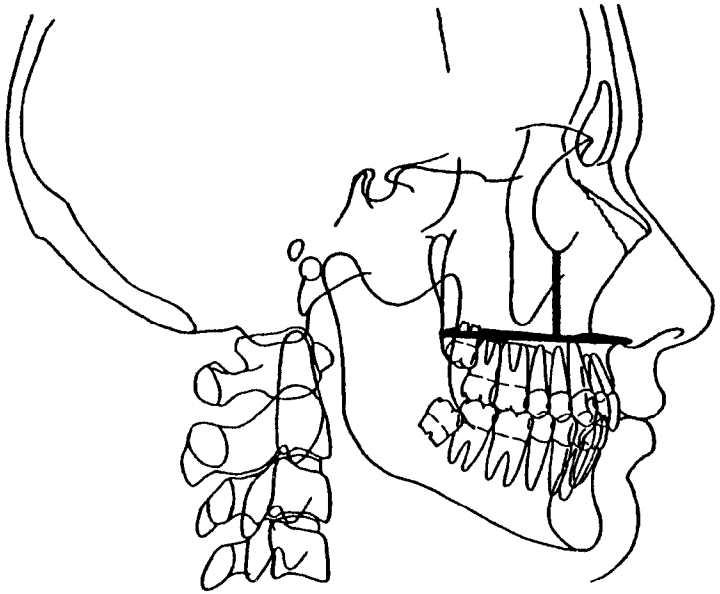
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
84	29	.5	.8	3.0	-2.0	1.8	.96

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	27.9	***	28.4	***	26.8	**	***	***	—	—	—	*	—	—	—
INITIAL	27.5		27.9		26.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	28.0	28.3	28.4	28.5	28.5
	SD	2.1	2.7	2.5	2.5	2.1
	N	84	31	63	36	39
FEMALE	MEAN	26.2	26.3	26.0	26.5	26.8
	SD	1.5	1.8	1.8	1.5	1.6
	N	39	24	29	27	15



CALCULATION 168

MEASURE PDIS 57 TO 59-12

NAME ORBITALE TO PALATAL PLANE

INITIAL TO FINAL

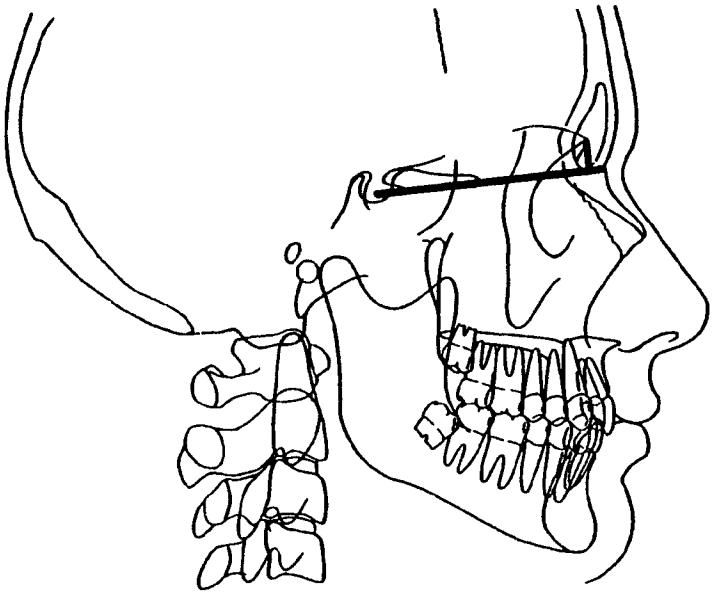
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
79	34	.5	1.1	4.0	-2.6	1.9	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	25.8	***	26.4	***	24.3	—	***	—	—	—	—	***	—	—	***
INITIAL	25.3		25.8		24.0										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	25.6	25.7	26.7	27.0	25.9
	SD	2.3	2.7	2.2	2.2	2.7
	N	84	31	63	36	39
FEMALE	MEAN	24.4	23.9	24.4	24.0	25.1
	SD	2.0	2.0	1.8	1.9	2.4
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 169

MEASURE PDIS 51 TO 46-54

NAME SUPRAORBITALE TO SELLA-NASION

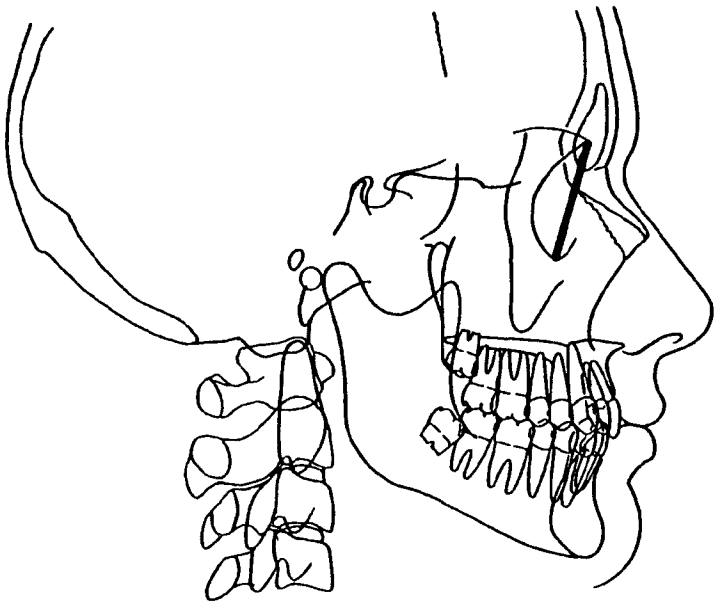
INITIAL TO FINAL

UNTREATED						
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
63	50	.2	1.0	3.5	-3.7	NA	.69

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	7.8	*	7.6	–	8.3	–	**	–	–	–	–	–	–	–	–
INITIAL	7.6		7.4		8.0										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	7.3	7.8	7.4	7.6	7.8
	SD	1.7	1.4	1.5	1.5	1.5
	N	84	31	63	36	39
FEMALE	MEAN	8.1	8.1	7.8	7.8	8.8
	SD	1.7	1.4	1.4	1.4	1.8
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 170

MEASURE SIMP 51-57

NAME SUPRAORBITALE TO ORBITALE

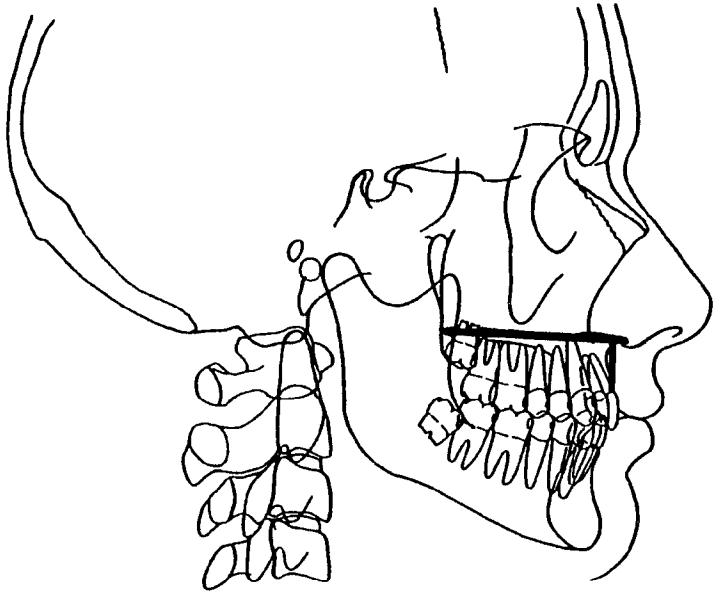
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
82	31	.7	1.4	5.0	-4.9	2.0	.92

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	38.4	***	39.9	***	38.2	**	***	—	—	—	—	—	—	*	—
INITIAL	38.7		39.1		37.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	39.2	40.0	40.0	39.7	40.2
	SD	2.7	3.4	3.2	3.5	2.8
	N	84	31	63	36	39
FEMALE	MEAN	37.6	37.6	36.7	37.5	38.4
	SD	2.5	2.6	2.4	2.3	2.2
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 171

MEASURE PDIS 10 TO 12-59

NAME SUPRADENTALE TO PALATAL PLANE

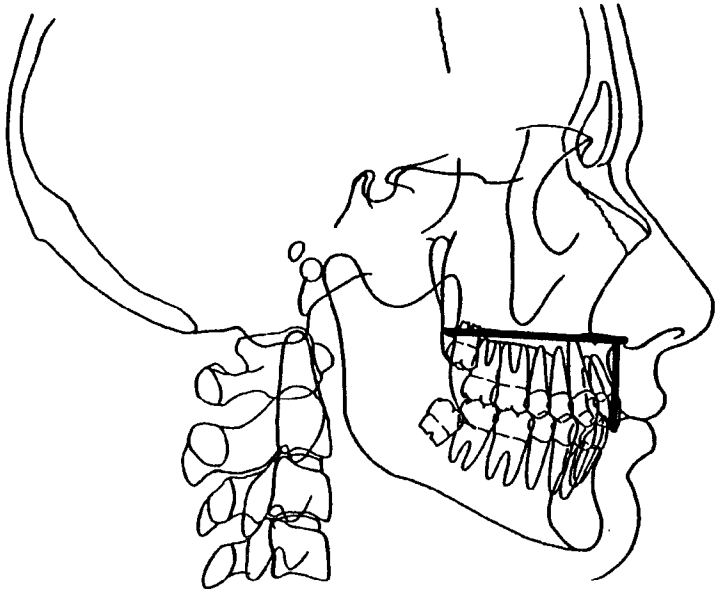
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
69	44	.5	1.2	3.8	-2.6	3.1	.96

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	16.9	***	16.9	**	16.7	***	—	—	—	—	—	—	—	NA	NA
INITIAL	16.4		16.6		15.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	16.6	16.7	16.4	16.5	17.1
	SD	2.7	2.6	2.7	3.4	3.3
	N	84	31	63	36	39
FEMALE	MEAN	15.9	15.3	16.3	16.4	17.4
	SD	1.9	1.7	1.5	2.9	2.5
	N	39	24	29	27	15



CALCULATION 172

MEASURE PDIS 8 TO 12-59

NAME UPPER INCISOR INCISAL EDGE TO PALATAL PLANE

INITIAL TO FINAL

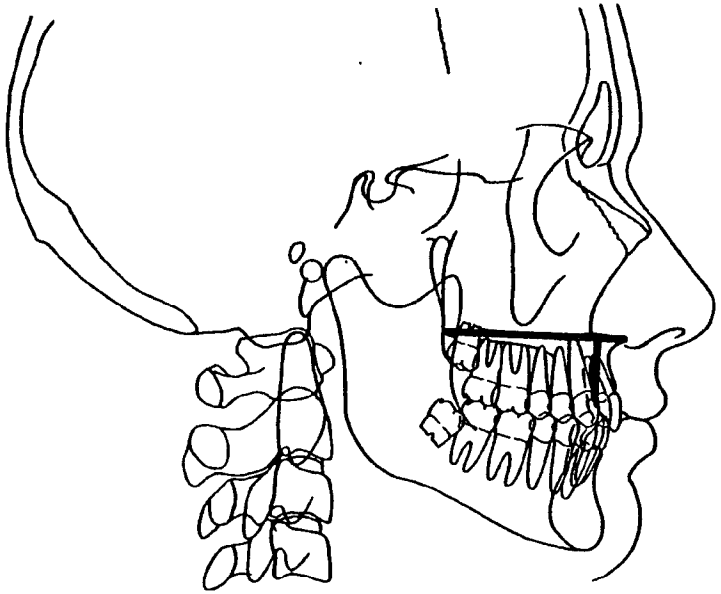
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
77	36	.7	1.2	4.5	-2.5	2.4	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	30.4	***	30.7	***	29.5	***	**	*	—	—	**	—	—	NA	NA
INITIAL	29.7		30.1		28.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	30.3	30.5	30.0	29.9	31.0
	SD	3.2	3.1	3.3	3.8	3.7
	N	84	31	63	36	39
FEMALE	MEAN	28.6	28.4	28.9	29.0	30.2
	SD	2.1	2.0	1.7	3.1	2.6
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 173

MEASURE PDIS 14 TO 12-49

NAME UPPER INCISOR LINGUAL BONY CONTACT POINT TO PALATAL PLANE

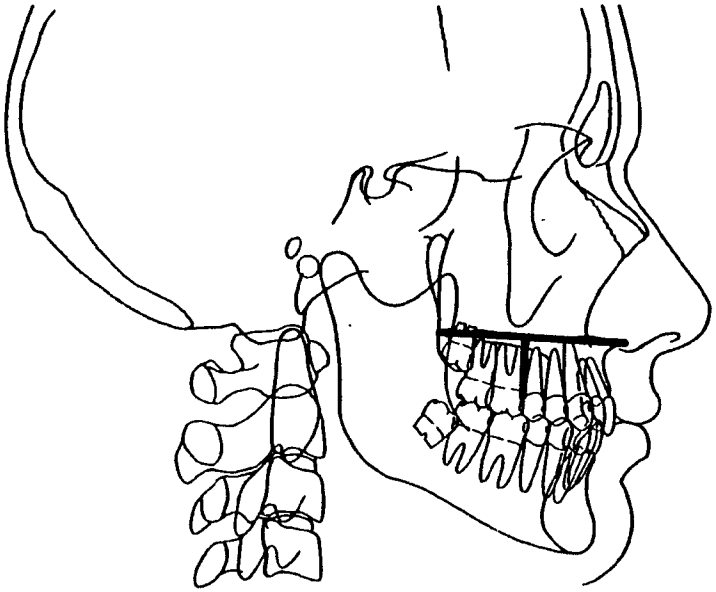
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
80	33	.6	1.1	4.5	-2.1	3.1	.96

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	19.7	***	19.9	***	19.4	**	—	—	—	—	—	—	—	NA	NA
INITIAL	19.2		19.3		19.8										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	19.5	19.7	19.7	19.4	19.9
	SD	2.5	2.4	2.6	3.4	3.3
	N	84	31	63	36	39
FEMALE	MEAN	18.7	18.4	18.9	19.1	19.8
	SD	1.9	1.9	1.5	2.6	2.1
	N	39	24	29	27	15



CALCULATION 174

MEASURE PDIS 26 TO 12-59

NAME UPPER MOLAR MESIAL CEJ TO PALATAL PLANE

INITIAL TO FINAL

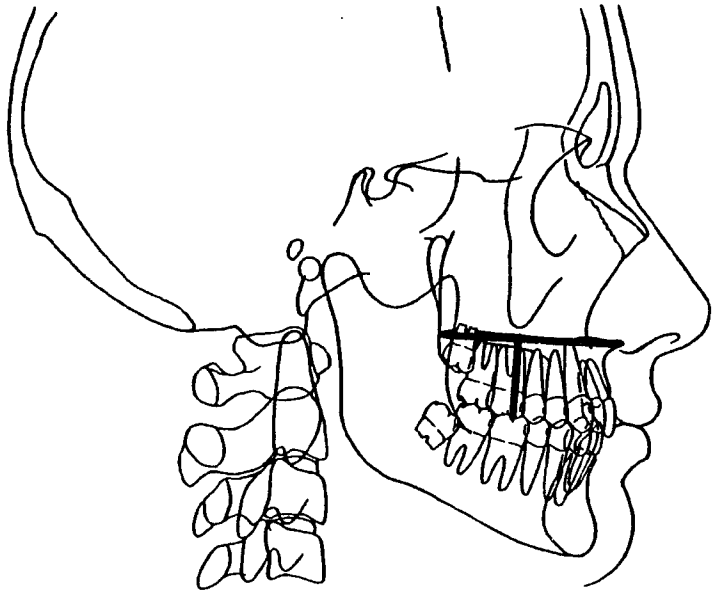
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
76	37	.6	1.2	3.6	-2.4	3.8	.89

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	17.6	***	18.1	***	16.3	—	***	—	—	—	—	—	—	NA	NA
INITIAL	17.0		17.4		16.0										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	17.5	17.8	17.9	17.8	18.0
	SD	2.2	2.5	2.7	3.5	3.1
	N	84	31	63	36	39
FEMALE	MEAN	15.6	15.4	15.1	15.9	16.8
	SD	1.9	1.6	1.8	2.2	1.8
	N	39	24	29	27	15



CALCULATION 175

MEASURE PDIS 23 TO 12-59

NAME UPPER MOLAR MESIAL CUSP TIP TO PALATAL PLANE

INITIAL TO FINAL

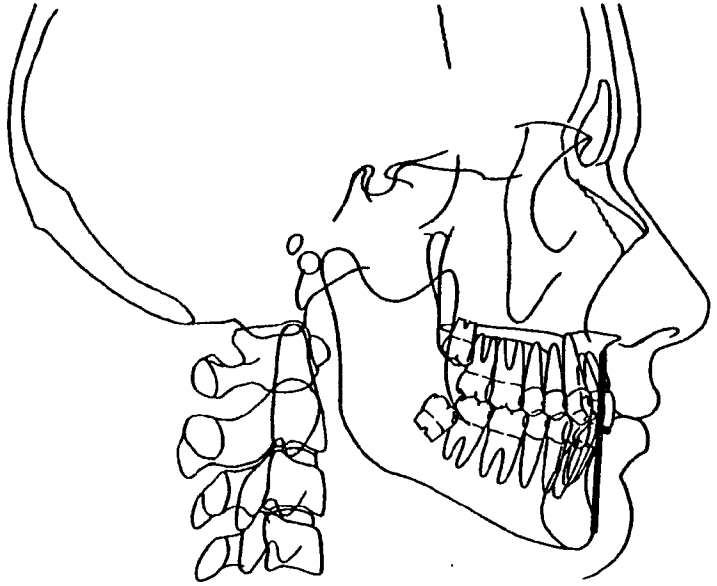
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
83	30	.7	1.2	3.6	-2.1	2.8	.88

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	25.7	***	26.4	***	24.0	*	***	—	—	—	—	*	—	NA	NA
INITIAL	25.0		25.6		23.6										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	25.5	26.1	26.1	25.9	26.3
	SD	2.2	2.5	2.7	3.8	3.1
	N	84	31	63	36	39
FEMALE	MEAN	23.3	23.3	22.8	23.5	24.7
	SD	2.0	1.6	1.7	2.2	1.7
	N	84	24	29	27	15



INITIAL TO FINAL

CALCULATION 176

MEASURE PDIS 8 TO 11-3

NAME UPPER INCISOR INCISAL EDGE TO LINE A POINT-POGONION

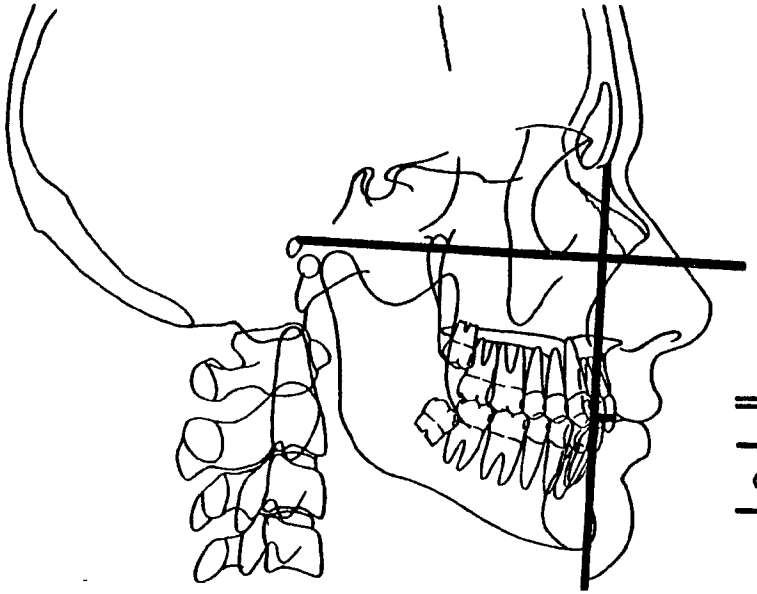
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
61	52	0	1.5	2.5	-13.1	NA	.98

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	5.0	—	4.8	—	5.6	**	—	—	—	—	—	—	—	NA	NA
INITIAL	5.0		5.0		5.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	5.0	5.0	4.7	4.5	4.5
	SD	2.5	2.7	2.3	2.4	3.3
	N	84	31	63	36	39
FEMALE	MEAN	5.4	5.5	5.4	4.7	5.7
	SD	2.4	2.3	3.1	2.2	2.1
	N	39	24	29	27	15



CALCULATION 177

MEASURE PDIS 9 TO NASION PERPENDICULAR (45)

NAME LABIAL SURFACE UPPER INCISOR TO NASION PERPENDICULAR USING ANATOMIC PORION

INITIAL TO FINAL

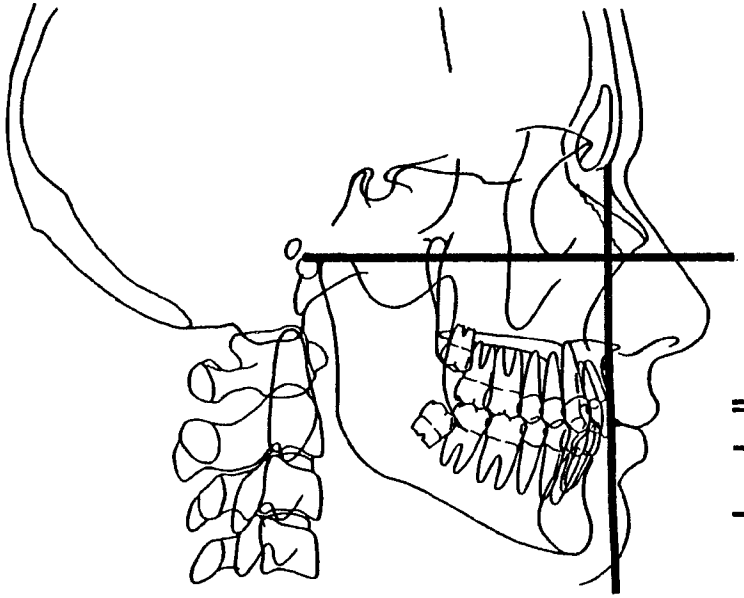
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
57	56	-.1	2.2	5.5	-11.6	NA	.95

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	4.9	—	4.9	—	5.0	—	—	—	—	—	—	—	—	NA	NA
INITIAL	5.0		4.9		5.2										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	5.5	6.0	5.2	4.2	4.6
	SD	2.6	2.8	3.0	3.0	3.8
	N	84	31	63	36	39
FEMALE	MEAN	5.6	6.0	5.7	5.8	4.4
	SD	2.3	3.1	3.2	3.0	3.8
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 178

MEASURE PDIS 9 TO NASION PERPENDICULAR (44)

NAME LABIAL SURFACE UPPER INCISOR TO NASION PERPENDICULAR USING MACHINE PORION

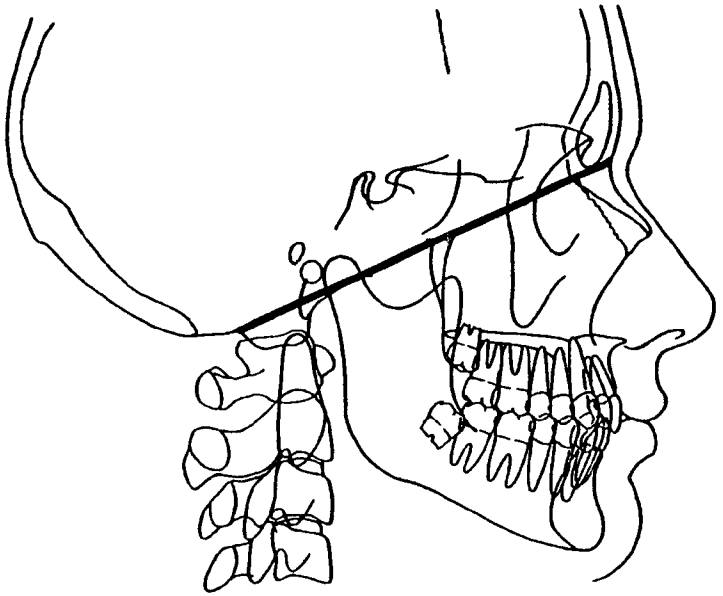
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
56	57	-.3	3.9	10.3	-10.9	NA	.96

	UNTREATED												TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	-.4	—	-.6	—	.2	—	—	—	—	—	—	—	—	NA	NA
INITIAL	-.1		-.2		.2										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	-.4	.5	0	0	-.5
	SD	4.3	4.5	4.5	4.1	4.2
	N	84	31	63	36	39
FEMALE	MEAN	.8	1.6	.3	1.4	.4
	SD	4.4	4.5	3.9	4.5	4.2
	N	39	24	29	27	15



CALCULATION 179

MEASURE SIMP 39-54

NAME BOLTON POINT TO NASION

INITIAL TO FINAL

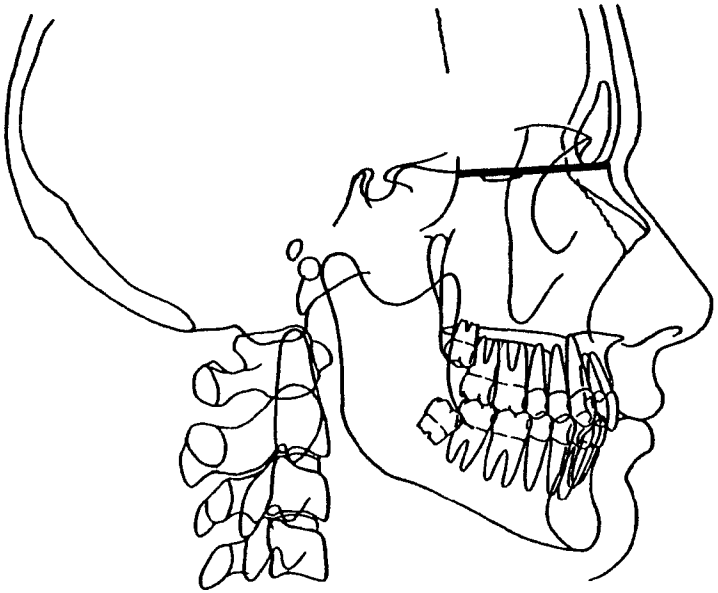
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
89	24	1.4	1.8	9.0	-2.7	1.1	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	132.8	***	135.3	***	127.1	***	***	***	—	—	*	**	—	**	***
INITIAL	131.4		134.0		125.6										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	133.8	134.5	133.7	135.7	135.6
	SD	4.5	4.7	4.4	3.9	4.2
	N	84	31	63	36	39
FEMALE	MEAN	126.2	125.9	124.3	127.0	128.0
	SD	5.1	4.8	2.9	4.3	4.6
	N	39	24	29	27	15



CALCULATION 180

MEASURE SIMP 47-54

NAME ETHMOID REGISTRATION POINT TO NASION

INITIAL TO FINAL

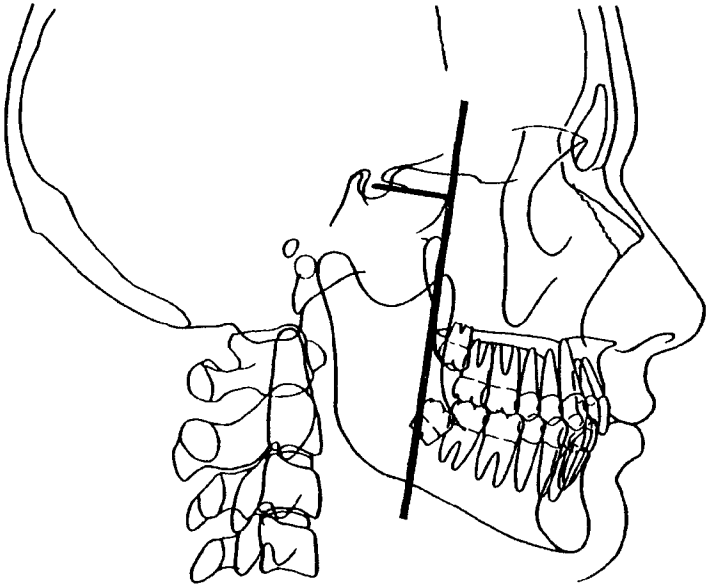
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
100	13	1.0	.9	3.0	-1.6	2.1	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	49.3	***	49.8	***	48.0	***	***	***	*	—	**	***	—	***	*
INITIAL	48.2		48.9		46.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	48.5	48.3	48.6	50.7	49.6
	SD	3.3	3.8	3.3	2.7	3.1
	N	84	31	63	36	39
FEMALE	MEAN	46.7	46.6	46.1	48.5	48.6
	SD	3.8	3.4	2.7	3.1	2.9
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 181

MEASURE PDIS 46 TO 60-47

NAME SELLA TO PM VERTICAL

INITIAL TO FINAL

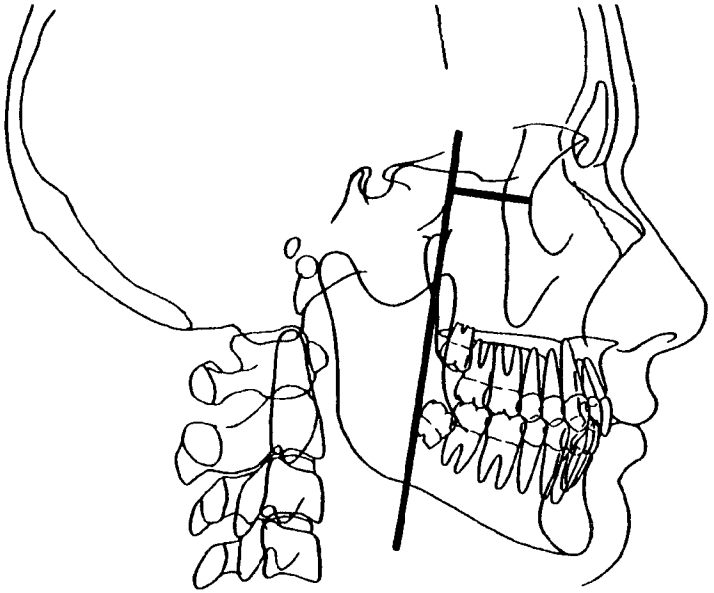
UNTREATED

GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
62	51	.1	.6	2.8	-1.6	.3	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	24.7	—	25.3	**	23.2	—	***	*	—	—	—	—	***	—	**
INITIAL	24.6		25.2		23.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	25.4	25.5	25.2	25.3	25.1
	SD	2.2	2.2	2.2	2.3	2.0
	N	84	31	63	36	39
FEMALE	MEAN	23.3	23.1	22.8	23.2	23.3
	SD	1.9	1.7	1.7	1.4	1.8
	N	39	24	29	27	15



CALCULATION 182

MEASURE PDIS 56 TO 47-60

NAME LATERAL ORBIT TO PM VERTICAL

INITIAL TO FINAL

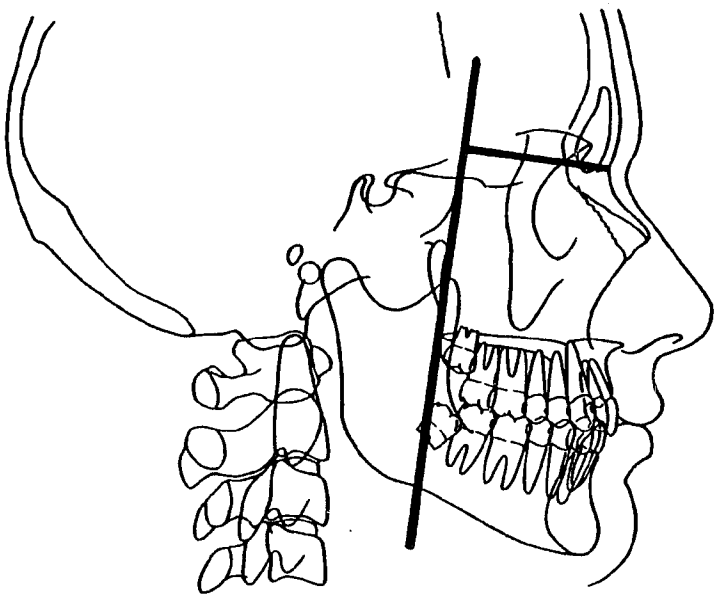
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
84	29	.5	.9	2.6	-1.6	2.0	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	26.7	***	27.0	***	26.2	**	*	*	—	—	—	—	*	**	—
INITIAL	26.2		26.4		25.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	26.2	25.8	26.5	28.2	27.1
	SD	2.6	2.5	2.2	2.6	3.1
	N	84	31	63	36	39
FEMALE	MEAN	25.6	25.2	25.3	27.2	27.2
	SD	2.7	2.8	2.9	2.3	1.9
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 183

MEASURE PDIS 54 TO 47-60

NAME NASION TO PM VERTICAL

INITIAL TO FINAL

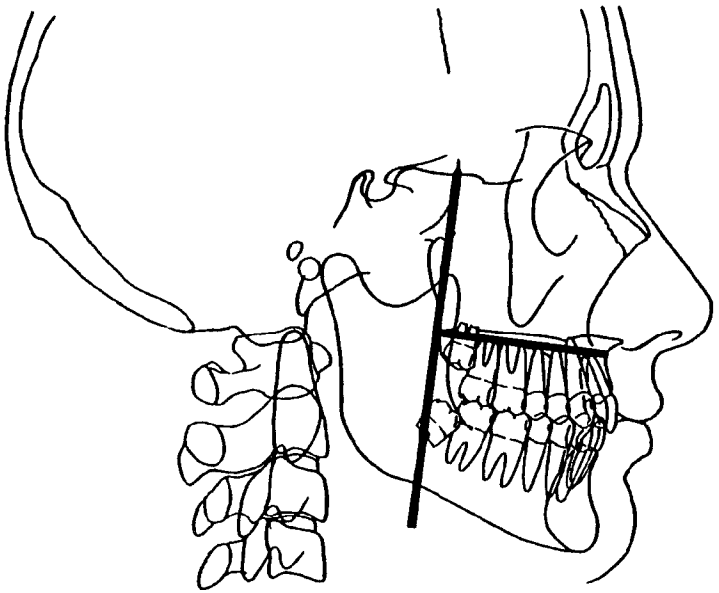
UNTREATED

GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
95	18	.9	1.0	3.1	-1.8	2.1	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	47.3	***	47.7	***	46.3	***	**	***	**	—	**	***	—	**	—
INITIAL	46.3		46.9		45.0										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	46.4	46.1	46.6	48.9	47.5
	SD	4.1	4.4	3.8	3.2	3.9
	N	84	31	63	36	39
FEMALE	MEAN	45.1	44.9	44.5	46.9	47.3
	SD	4.3	4.0	3.5	3.6	3.4
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 184

MEASURE PDIS 11 TO 47-60

NAME A POINT TO PM VERTICAL

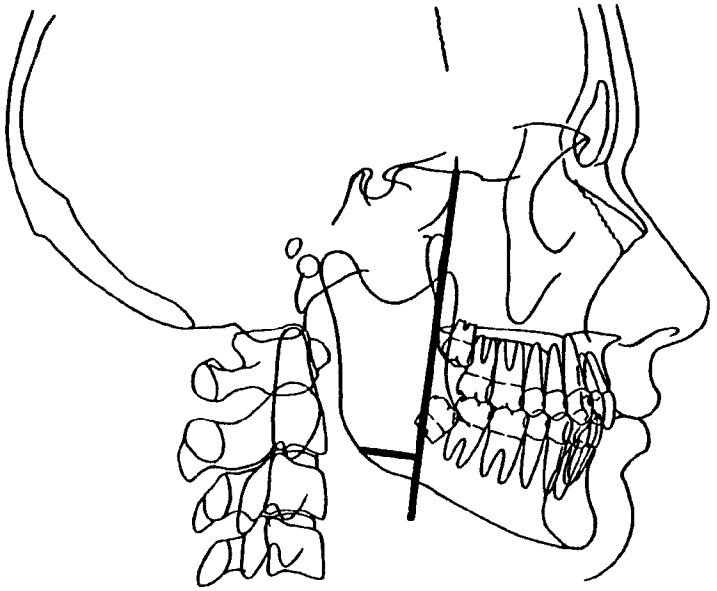
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
93	20	1.2	1.4	5.9	-2.5	2.1	.94

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	57.2	***	58.2	***	54.7	***	***	—	—	—	—	***	—	NA	NA
INITIAL	56.0		56.9		53.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	56.6	57.4	57.7	59.5	58.1
	SD	2.4	3.5	3.2	3.3	3.2
	N	84	31	63	36	39
FEMALE	MEAN	54.3	54.4	54.5	55.2	55.6
	SD	2.8	3.2	3.3	2.9	2.7
	N	39	24	29	27	15



CALCULATION 185

MEASURE PDIS 31 TO 60-47

NAME GONION TO PM VERTICAL

INITIAL TO FINAL

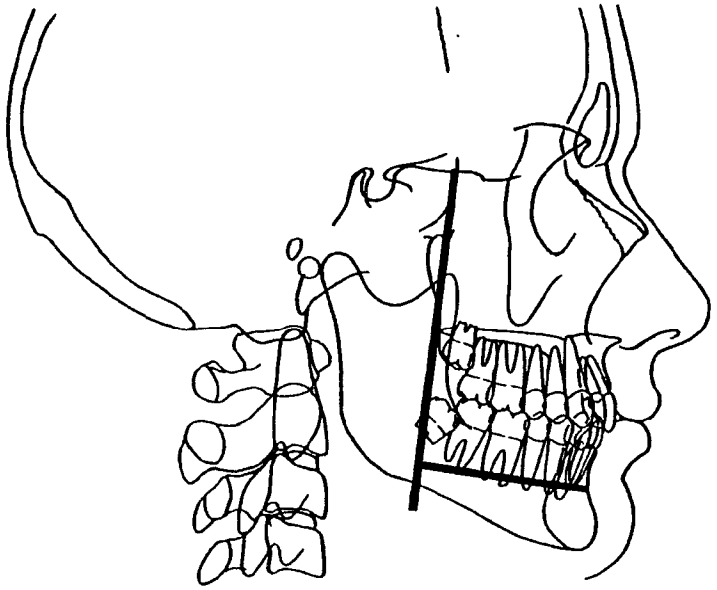
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
40	73	-.8	2.5	6.3	-9.0	-4.6	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	16.6	**	16.3	***	17.3	—	—	*	**	*	—	—	—	—	—
INITIAL	17.3		17.5		16.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	17.7	16.0	16.3	18.3	16.7
	SD	6.0	6.5	7.5	7.4	6.4
	N	84	31	63	36	39
FEMALE	MEAN	17.0	16.6	17.9	18.9	17.4
	SD	5.3	4.7	5.1	5.7	6.5
	N	39	24	29	27	15



CALCULATION 186

MEASURE PDIS 4 TO 47-60

NAME B POINT TO PM VERTICAL

INITIAL TO FINAL

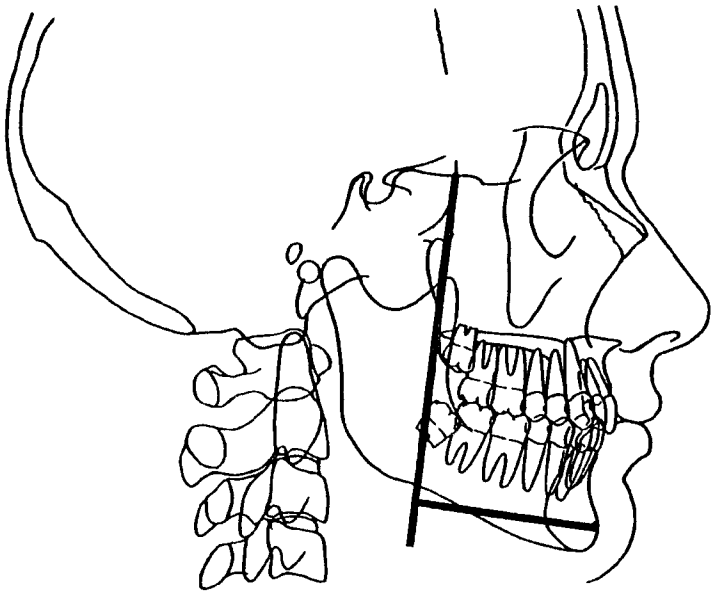
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
77	36	1.2	2.5	8.9	-5.3	2.2	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	58.1	***	59.5	***	54.8	—	***	—	*	*	—	—	—	—	***
INITIAL	56.9		57.8		54.6										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	57.9	59.4	59.5	59.2	59.3
	SD	5.7	6.8	6.4	6.1	5.4
	N	84	31	63	36	39
FEMALE	MEAN	54.8	55.6	53.8	55.1	54.3
	SD	5.1	4.5	4.8	5.2	5.7
	N	39	24	29	27	15



CALCULATION 187

MEASURE PDIS 3 TO 47-60

NAME POGONION TO PM VERTICAL

INITIAL TO FINAL

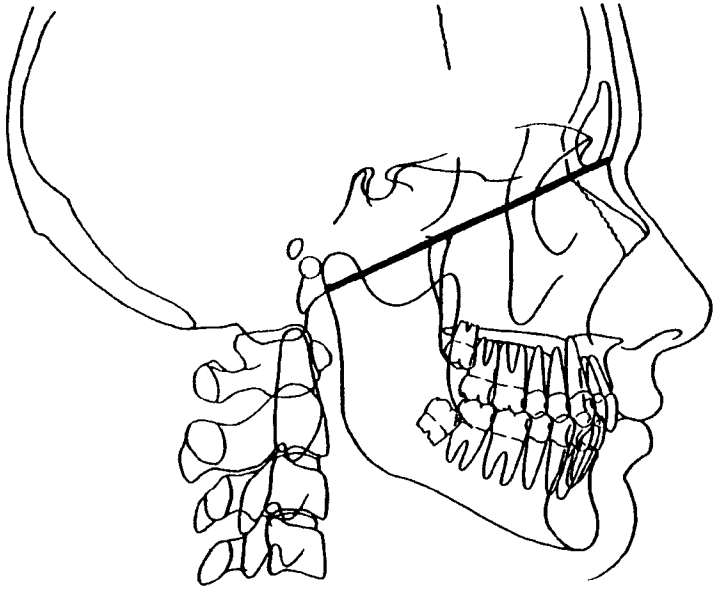
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
81	32	1.6	3.0	10.3	-6.7	2.6	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	63.3	***	65.1	***	59.1	—	***	—	*	*	*	—	—	*	***
INITIAL	61.7		63.0		58.6										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	63.1	65.3	65.0	64.5	65.0
	SD	7.2	8.2	8.1	7.4	6.7
	N	84	31	63	36	39
FEMALE	MEAN	58.4	59.5	57.6	59.3	58.3
	SD	6.3	5.1	5.7	6.4	7.4
	N	39	24	29	27	15



CALCULATION 188

MEASURE SIMP 41-54

NAME ARTICULARE POSTERIOR TO NASION

INITIAL TO FINAL

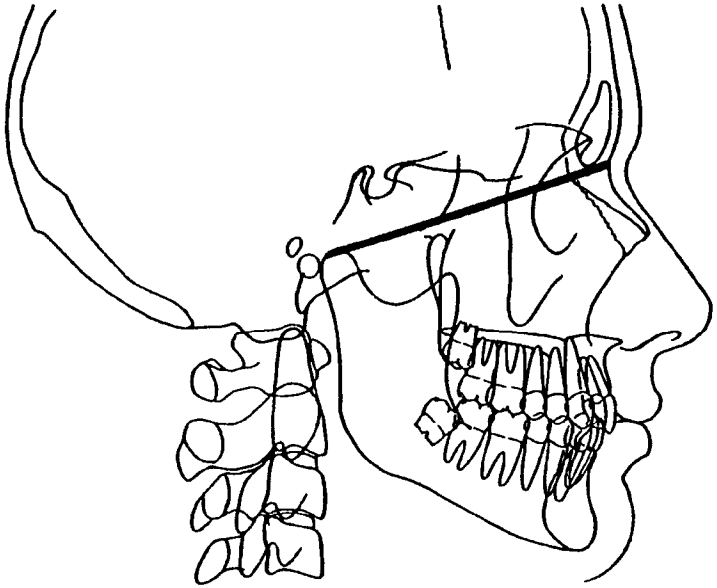
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
97	16	1.6	1.4	5.4	-1.5	1.6	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	102.1	***	104.3	***	96.9	***	***	***	*	—	—	***	—	***	***
INITIAL	100.5		102.7		95.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	102.5	103.2	103.4	104.4	105.0
	SD	4.1	4.3	4.3	4.2	3.6
	N	84	31	63	36	39
FEMALE	MEAN	95.6	94.9	93.2	97.6	97.9
	SD	4.1	4.2	2.4	3.2	3.5
	N	39	24	29	27	15



CALCULATION 189

MEASURE SIMP 43-54

NAME CONDYLION TO NASION

INITIAL TO FINAL

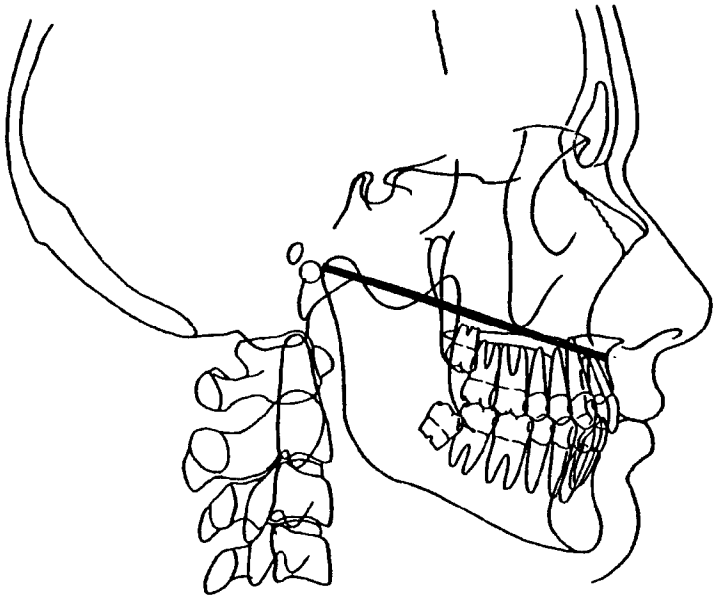
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
90	23	1.4	1.5	5.4	-2.0	1.4	.97

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	98.1	***	100.2	***	93.2	***	***	***	**	—	—	**	—	**	**
INITIAL	96.7		98.9		91.6										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	98.7	99.2	99.2	100.4	100.7
	SD	4.2	4.8	4.1	4.0	3.5
	N	84	31	63	36	39
FEMALE	MEAN	91.7	91.1	89.5	94.3	94.1
	SD	4.1	4.4	2.8	3.2	3.2
	N	39	24	29	27	15



CALCULATION 190

MEASURE SIMP 43-11

NAME CONDYLION TO A POINT

INITIAL TO FINAL

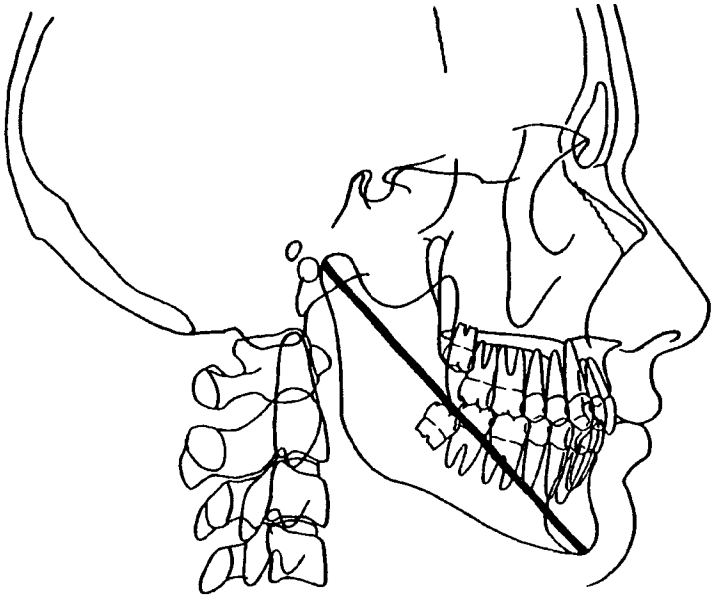
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
97	16	1.6	1.5	6.1	-.9	1.7	.95

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	96.6	***	98.5	***	92.0	***	***	***	**	*	—	***	—	***	—
INITIAL	95.0		97.0		90.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	97.0	97.5	97.5	100.1	98.8
	SD	4.0	4.7	4.6	5.0	5.0
	N	84	31	63	36	39
FEMALE	MEAN	90.8	90.5	90.1	94.1	93.0
	SD	4.3	5.1	4.3	3.6	3.7
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 191

MEASURE SIMP 43-2

NAME CONDYLION TO GNATHION

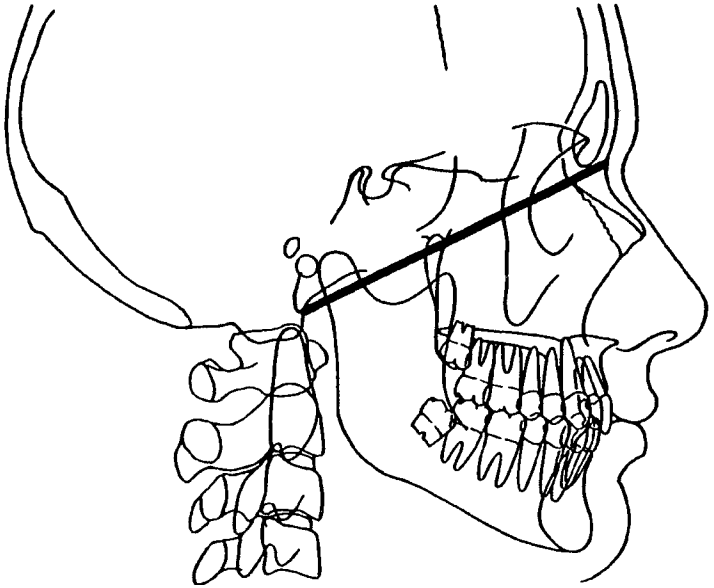
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
105	8	2.9	2.6	16.1	-1.2	2.4	.98

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	126.1	***	129.0	***	119.4	***	***	***	**	**	—	***	—	***	**
INITIAL	123.2		125.8		117.2										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	125.9	127.7	127.6	129.3	128.6
	SD	4.7	5.6	6.2	7.0	5.7
	N	84	31	63	36	39
FEMALE	MEAN	116.6	117.1	115.8	120.5	120.2
	SD	5.1	4.5	4.3	5.6	6.2
	N	39	24	29	27	15



CALCULATION 192

MEASURE SIMP 40-54

NAME BASION TO NASION

INITIAL TO FINAL

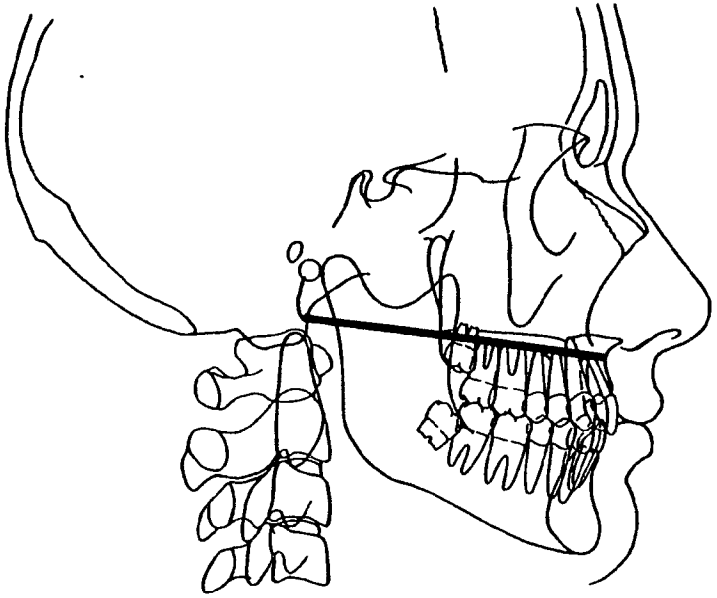
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
102	11	1.5	1.4	5.2	-2.0	1.4	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	112.8	***	114.9	***	108.0	***	***	***	—	—	*	***	—	***	***
INITIAL	111.3		113.3		106.6										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	113.1	114.3	114.2	114.8	115.2
	SD	4.6	4.7	4.7	4.0	3.9
	N	84	31	63	36	39
FEMALE	MEAN	106.6	106.8	106.3	107.7	108.6
	SD	3.5	2.9	2.2	3.2	4.4
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 193

MEASURE SIMP 40-11

NAME BASION TO A POINT

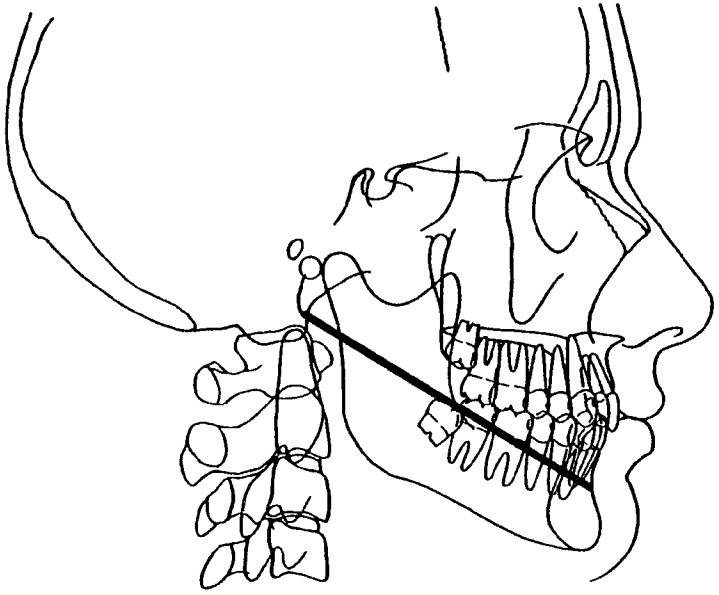
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
94	19	1.4	1.4	4.9	-1.9	1.4	.98

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	99.7	***	101.6	***	95.1	***	***	***	—	—	—	***	*	**	—
INITIAL	98.3		100.1		94.2										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	99.7	101.0	100.6	103.0	102.3
	SD	4.5	5.2	5.7	5.7	5.5
	N	84	31	63	36	39
FEMALE	MEAN	94.6	95.0	94.9	96.3	96.2
	SD	4.4	4.7	5.0	4.1	4.1
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 194

MEASURE SIMP 40-4

NAME BASION TO B POINT

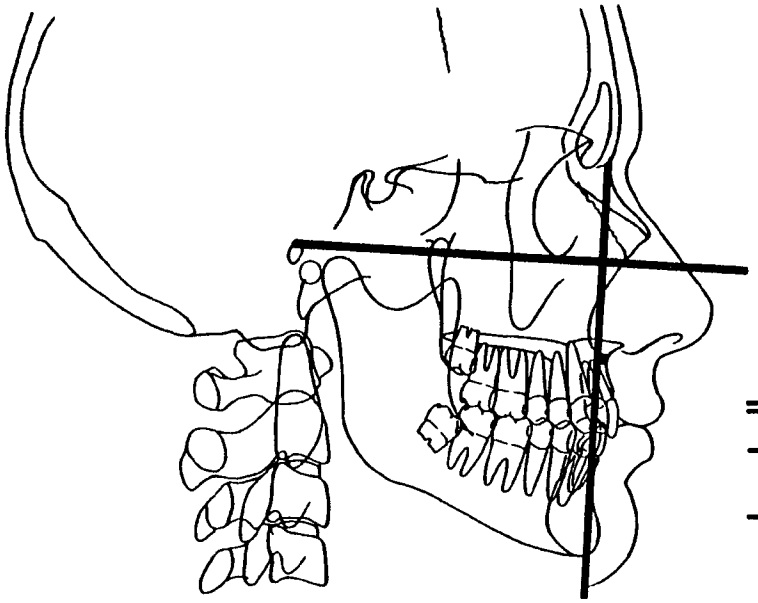
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
91	22	1.6	2.0	10.0	-2.1	1.5	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	106.0	***	108.2	***	100.8	*	***	**	—	—	—	*	**	—	—
INITIAL	104.4		106.2		100.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	105.9	107.5	107.2	108.6	108.5
	SD	4.6	5.4	5.8	5.6	5.0
	N	84	31	63	36	39
FEMALE	MEAN	100.2	100.8	99.0	102.0	101.4
	SD	4.9	4.9	4.3	4.6	4.9
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 195

MEASURE PDIS 11 TO 54-99

NAME A POINT TO NASION PERPENDICULAR BASED ON ANATOMIC PORION

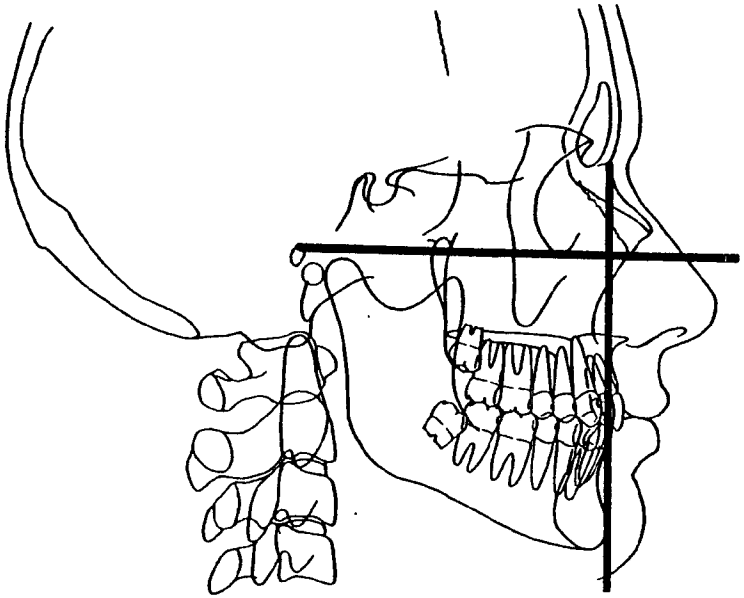
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
57	56	.2	2.9	7.2	-7.3	NA	.93

	UNTREATED												TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	2.7	—	2.7	—	2.7	—	—	—	—	—	—	—	—	NA	NA
INITIAL	2.6		2.6		2.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	3.0	3.8	3.4	3.8	2.5
	SD	3.6	4.5	4.4	5.4	5.9
	N	84	31	63	36	39
FEMALE	MEAN	3.1	4.0	5.1	5.2	1.7
	SD	4.0	4.1	4.8	4.3	4.4
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 196

MEASURE PDIS 3 TO 54-99

NAME POGONION TO NASION PERPENDICULAR BASED ON ANATOMIC PORION

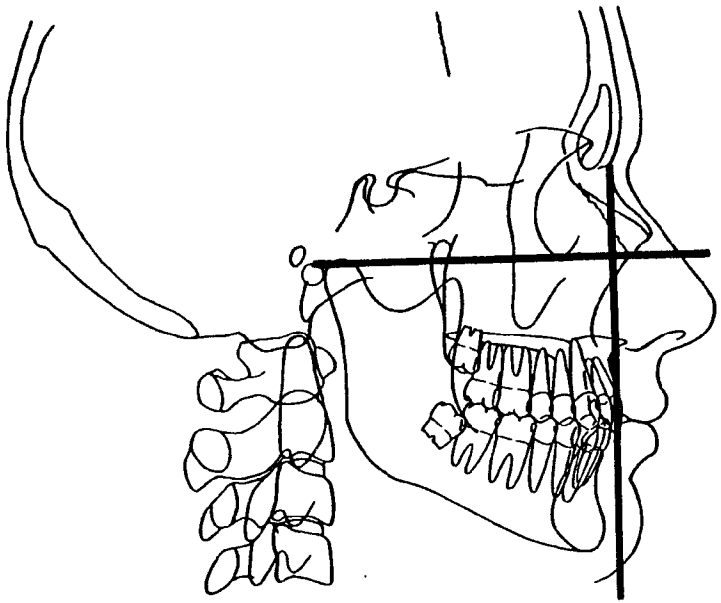
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
59	54	.3	5.2	13.6	-12.9	NA	.97

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	2.6	—	2.8	—	2.3	—	—	—	—	—	—	—	—	—	—
INITIAL	2.3		2.4		2.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	3.4	5.2	4.2	3.1	2.3
	SD	5.8	7.8	7.8	7.2	8.0
	N	84	31	63	36	39
FEMALE	MEAN	2.1	4.4	4.0	6.7	-.6
	SD	6.0	5.3	5.7	7.9	7.6
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 197

MEASURE PDIS 11 TO 54-96

NAME A POINT TO NASION PERPENDICULAR BASED ON MACHINE PORION

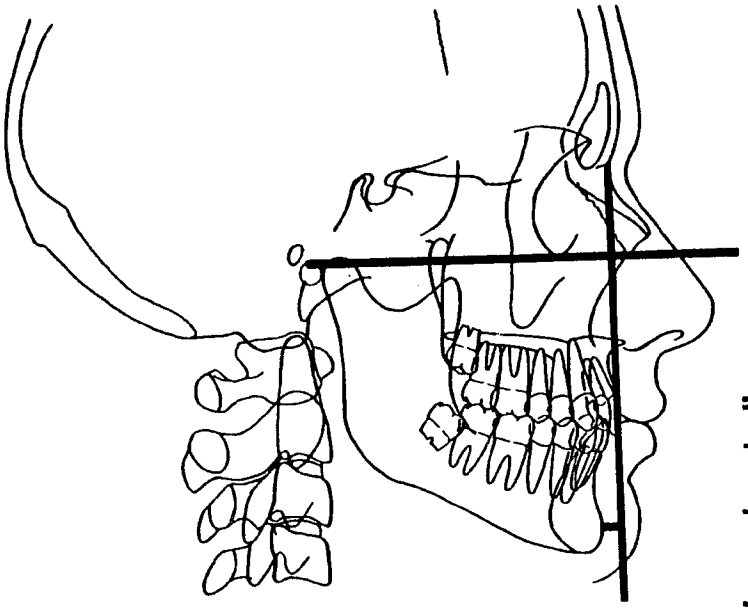
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
49	64	-.7	3.2	7.7	-10.1	NA	.96

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	-3.6	*	-3.8	*	-3.1	—	—	*	—	—	—	—	—	NA	NA
INITIAL	-2.8		-2.9		-2.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	-3.4	-2.3	-2.5	-2.2	-3.4
	SD	3.7	4.5	4.3	6.3	6.4
	N	84	31	63	36	39
FEMALE	MEAN	-1.8	-0.8	-1.2	-1.0	-3.3
	SD	4.3	5.0	5.1	4.4	4.3
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 198

MEASURE PDIS 3 TO 54-96

NAME POGONION TO NASION PERPENDICULAR BASED ON MACHINE PORION

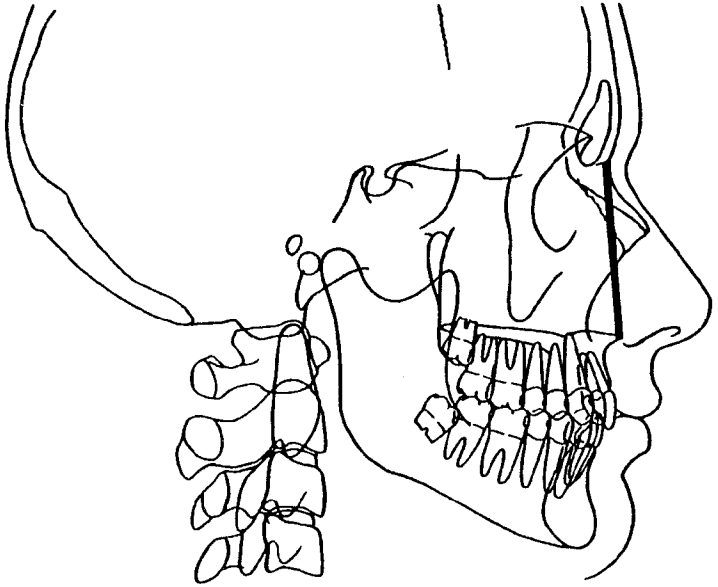
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
46	67	-1.5	6.2	14.7	-16.0	NA	.98

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	-9.2	**	-9.4	—	-8.7	—	—	*	—	—	—	*	—	—	—
INITIAL	-7.7		-7.8		-7.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	-8.4	-5.9	-6.6	-8.0	-8.8
	SD	6.3	7.5	7.0	8.8	9.5
	N	84	31	63	36	39
FEMALE	MEAN	-7.0	-4.5	-7.6	-4.5	-10.5
	SD	7.1	6.8	6.1	7.9	7.5
	N	39	24	29	27	15



CALCULATION 199
MEASURE SIMP 54-12
NAME NASION TO ANS

INITIAL TO FINAL

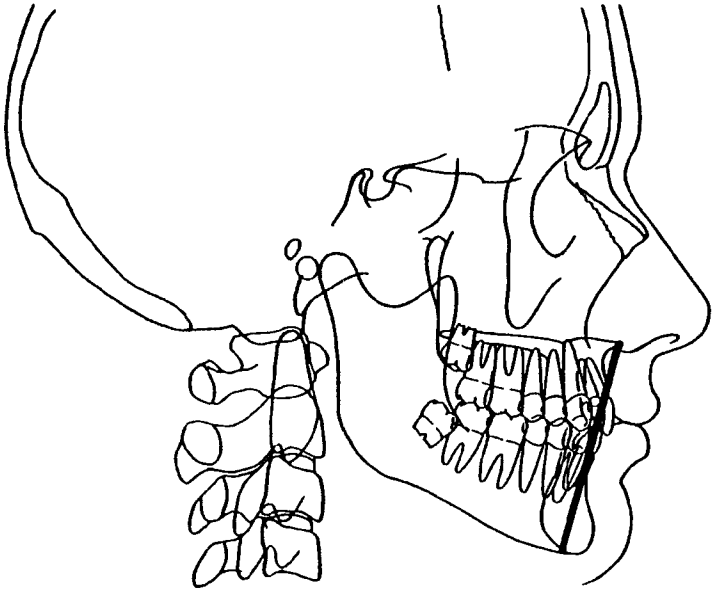
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
90	23	.9	1.2	5.8	-1.7	1.6	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	56.6	***	57.9	***	53.7	**	***	**	—	—	—	***	—	**	**
INITIAL	55.7		56.9		53.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	56.6	57.1	58.3	58.7	57.3
	SD	2.7	3.2	2.9	3.2	3.7
	N	84	31	63	36	39
FEMALE	MEAN	53.2	52.8	53.2	53.4	54.4
	SD	2.5	2.7	2.3	2.6	3.1
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 200
MEASURE SIMP 12-1
NAME ANS TO MENTON

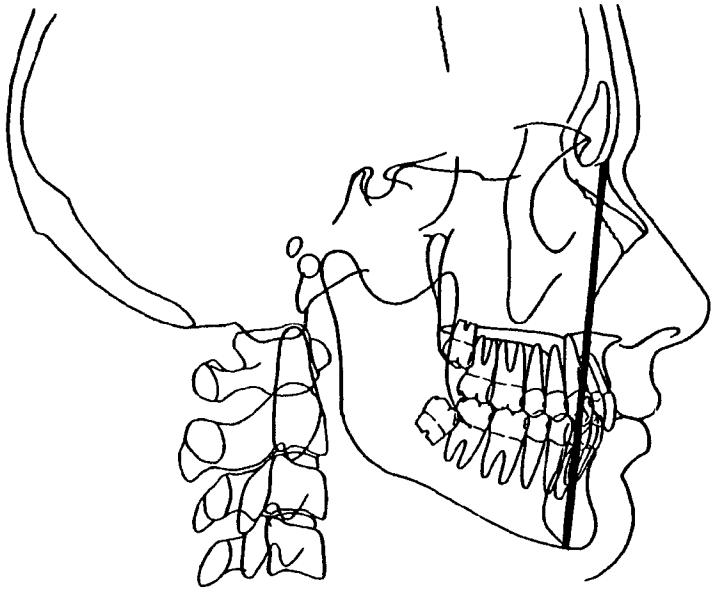
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
102	11	1.9	1.9	7.4	-2.6	2.8	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	71.7	***	73.1	***	68.5	***	***	***	***	*	*	***	—	*	**
INITIAL	69.8		71.3		66.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	71.5	72.2	71.8	71.7	72.9
	SD	5.2	5.5	5.8	7.5	6.6
	N	84	31	63	36	39
FEMALE	MEAN	66.5	66.5	66.4	66.5	69.8
	SD	3.6	3.5	3.2	5.4	4.9
	N	39	24	29	27	15



CALCULATION 201

MEASURE SIMP 54-1

NAME NASION-MENTON

INITIAL TO FINAL

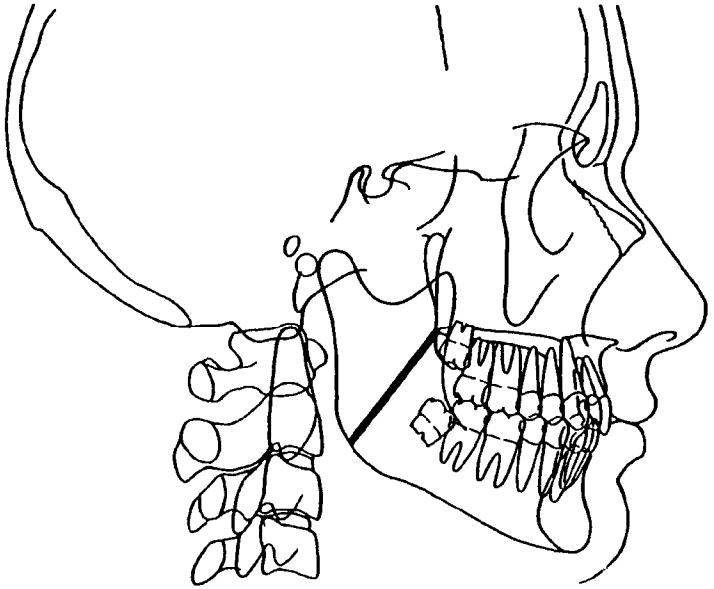
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
104	9	2.8	2.3	10.7	-.5	2.2	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	126.4	***	129.1	***	120.1	***	***	***	***	**	—	***	—	*	***
INITIAL	123.6		126.3		117.6										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	126.3	127.6	128.4	128.5	128.2
	SD	5.6	6.5	6.5	9.3	7.8
	N	84	31	63	36	39
FEMALE	MEAN	117.4	117.2	116.7	117.9	122.0
	SD	4.1	3.8	3.9	6.7	6.4
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 202

MEASURE SIMP 59-31

NAME PNS TO GONION

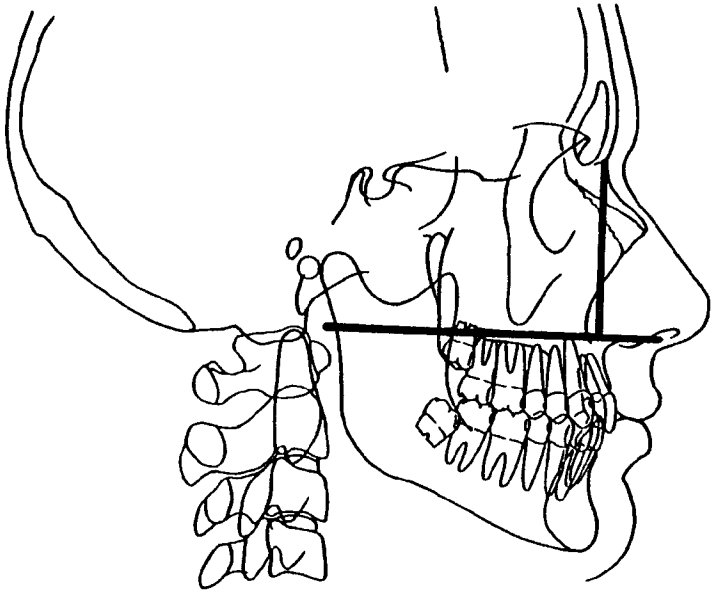
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
87	26	1.5	1.9	6.3	-2.8	3.2	.95

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	48.5	***	50.7	***	43.3	*	***	*	*	—	—	**	***	—	***
INITIAL	46.9		48.8		42.6										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	48.2	49.6	50.6	51.1	51.0
	SD	4.2	4.6	5.5	5.6	4.5
	N	84	31	63	36	39
FEMALE	MEAN	41.9	41.5	40.9	43.6	45.0
	SD	3.5	3.6	2.9	3.4	4.5
	N	39	24	29	27	15



CALCULATION 203

MEASURE PDIS 54 TO 59-12

NAME NASION TO PALATAL PLANE

INITIAL TO FINAL

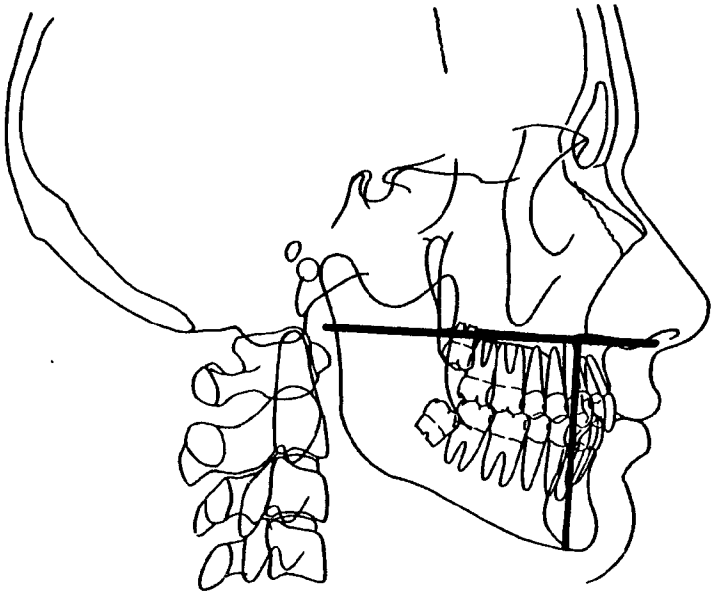
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
91	22	.9	1.0	5.0	-1.4	1.6	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	56.2	***	57.4	***	53.4	***	***	***	—	—	—	***	—	**	**
INITIAL	55.3		56.4		52.8										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	56.2	56.7	57.8	58.1	56.8
	SD	2.6	3.2	2.8	3.2	3.4
	N	84	31	63	36	39
FEMALE	MEAN	52.9	52.5	52.6	53.0	54.0
	SD	2.3	2.5	2.2	2.5	2.9
	N	39	24	29	27	15



CALCULATION 204

MEASURE PDIS 1 TO 12-59

NAME MENTON TO PALATAL PLANE

INITIAL TO FINAL

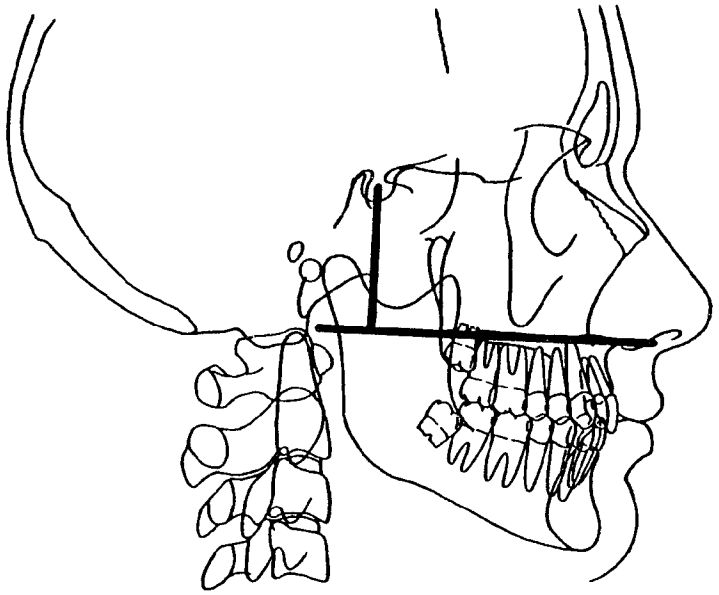
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
100	13	1.8	1.8	7.9	-2.2	2.7	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	69.5	***	71.1	***	65.8	***	***	***	***	**	*	***	—	*	**
INITIAL	67.7		69.2		64.0										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	69.4	70.3	70.1	69.9	70.6
	SD	4.6	5.2	5.5	7.2	6.1
	N	84	31	63	36	39
FEMALE	MEAN	63.7	63.8	63.2	64.3	67.1
	SD	3.5	3.0	3.4	5.2	4.8
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 205

MEASURE PDIS 46 TO 59-12

NAME SELLA TO PALATAL PLANE

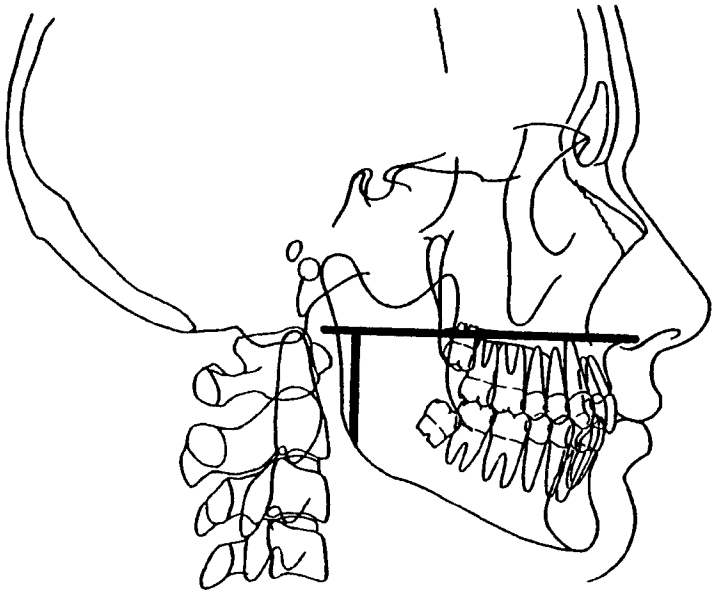
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
96	17	1.1	1.2	4.7	-1.7	2.5	.97

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	45.6	***	46.5	***	43.4	***	***	***	*	—	—	**	—	—	**
INITIAL	44.5		45.4		42.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	45.4	45.7	46.2	46.7	46.6
	SD	3.9	4.1	4.0	4.7	3.9
	N	84	31	63	36	39
FEMALE	MEAN	43.0	42.9	42.7	42.1	44.4
	SD	3.0	3.0	3.7	4.0	3.2
	N	39	24	29	27	15



CALCULATION 206

MEASURE PDIS 31 TO 12-59

NAME GONION TO PALATAL PLANE

INITIAL TO FINAL

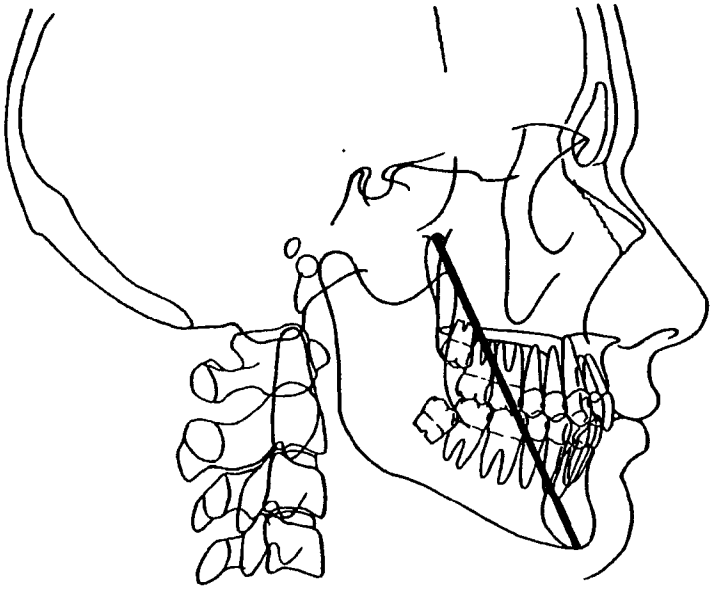
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
88	25	1.8	2.4	10.4	-3.6	4.9	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	39.5	***	42.0	***	33.6	—	***	—	—	—	—	**	***	—	**
INITIAL	37.7		39.6		33.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	38.7	40.9	42.0	42.0	42.2
	SD	4.8	4.2	4.8	5.3	5.2
	N	84	31	63	36	39
FEMALE	MEAN	31.9	31.4	30.0	33.8	35.8
	SD	4.9	4.9	4.8	3.8	5.2
	N	39	24	29	27	15



CALCULATION 207

MEASURE SIMP 62-2

NAME PTM SUPERIOR TO GNATHION

INITIAL TO FINAL

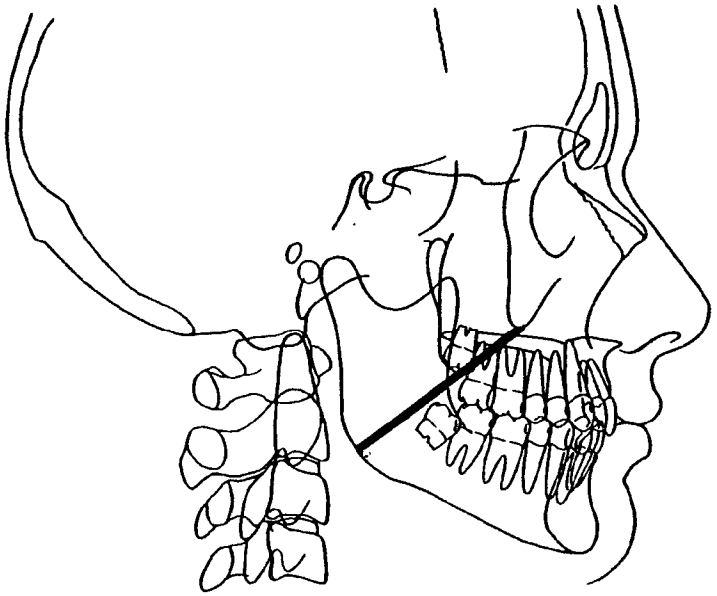
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
107	6	3.2	2.6	17.1	-.7	3.0	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	111.0	***	113.7	***	104.8	***	***	***	***	**	—	***	—	**	***
INITIAL	107.8		110.1		102.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	110.0	111.9	112.6	113.6	112.7
	SD	4.7	5.9	6.2	7.8	6.3
	N	84	31	63	36	39
FEMALE	MEAN	102.0	102.2	101.7	104.0	106.4
	SD	4.5	4.0	4.7	6.7	6.5
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 208

MEASURE SIMP 31-58

NAME GONION TO INFERIOR ZYGOMA

INITIAL TO FINAL

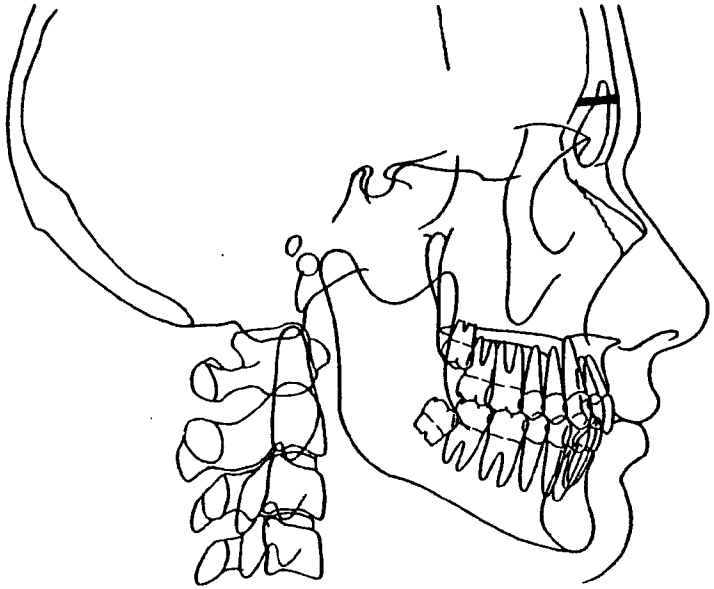
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
99	14	2.1	1.8	7.0	-1.9	3.2	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	67.9	***	70.0	***	63.0	***	***	***	**	—	—	***	***	—	***
INITIAL	65.7		67.6		61.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	67.5	68.7	69.8	70.4	71.1
	SD	4.5	4.7	5.9	5.8	4.5
	N	84	31	63	36	39
FEMALE	MEAN	60.9	60.7	60.1	63.6	64.7
	SD	4.1	4.4	3.4	3.2	5.2
	N	39	24	29	27	15



CALCULATION 209

MEASURE SIMP 48-49

NAME INTERNAL GLABELLA TO GLABELLA

INITIAL TO FINAL

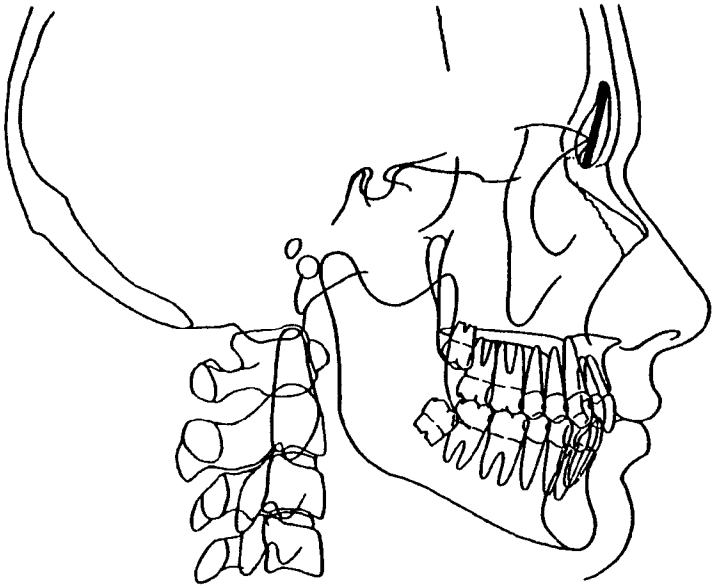
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
93	20	1.4	1.7	7.5	-2.0	9.2	.97

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	17.8	***	19.1	***	14.8	***	***	**	*	—	—	***	—	***	—
INITIAL	16.3		17.4		14.0										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	16.6	17.3	18.5	18.9	19.5
	SD	3.0	2.9	2.7	3.3	3.8
	N	84	31	63	36	39
FEMALE	MEAN	14.0	13.7	13.6	14.2	16.0
	SD	2.4	2.3	1.6	2.6	3.0
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 210

MEASURE SIMP 50-52

NAME FRONTAL SINUS SUPERIOR TO FRONTAL SINUS INFERIOR

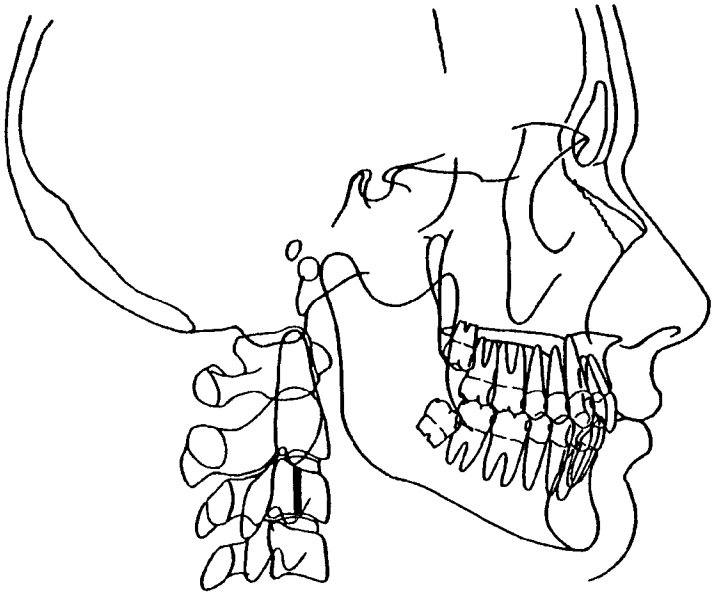
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
99	14	3.5	4.3	19.9	-5.6	30.8	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	31.3	***	32.4	***	28.9	***	—	***	*	—	—	***	**	**	—
INITIAL	27.8		28.2		26.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	28.4	30.4	32.3	29.2	33.8
	SD	9.9	9.9	8.8	11.1	10.9
	N	84	31	63	36	39
FEMALE	MEAN	26.9	27.2	29.5	30.8	28.0
	SD	6.8	7.6	6.2	7.1	8.7
	N	39	24	29	27	15



CALCULATION 211

MEASURE SIMP 63-65

NAME C3 HEIGHT

INITIAL TO FINAL

UNTREATED

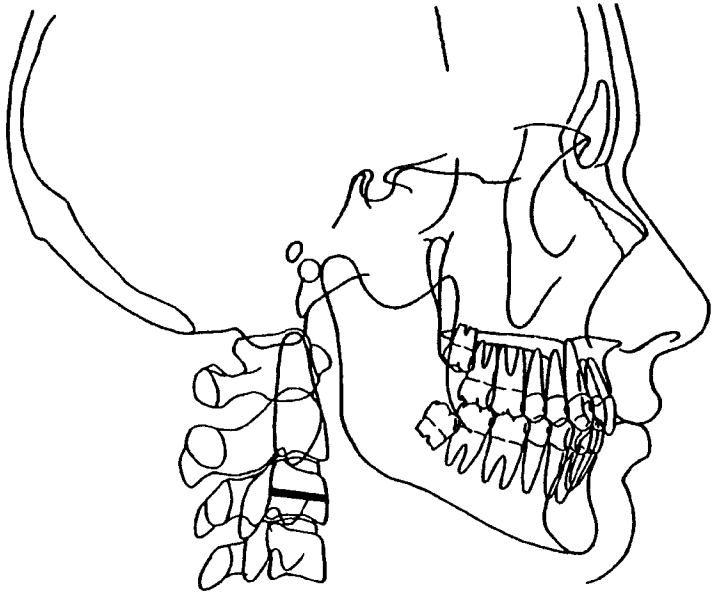
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
82	31	.6	1.0	5.4	-1.7	4.8	.95

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	14.2	***	14.8	***	12.8	**	***	—	—	—	—	*	—	—	***
INITIAL	13.6		14.1		12.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	14.3	14.8	14.9	14.8	14.8
	SD	1.3	1.4	1.5	1.7	1.2
	N	84	31	63	36	39
FEMALE	MEAN	12.3	12.4	12.5	12.8	12.9
	SD	.8	.8	.8	1.2	.9
	N	39	24	29	27	15



CALCULATION 212

MEASURE SIMP 64-66

NAME C3 WIDTH

INITIAL TO FINAL

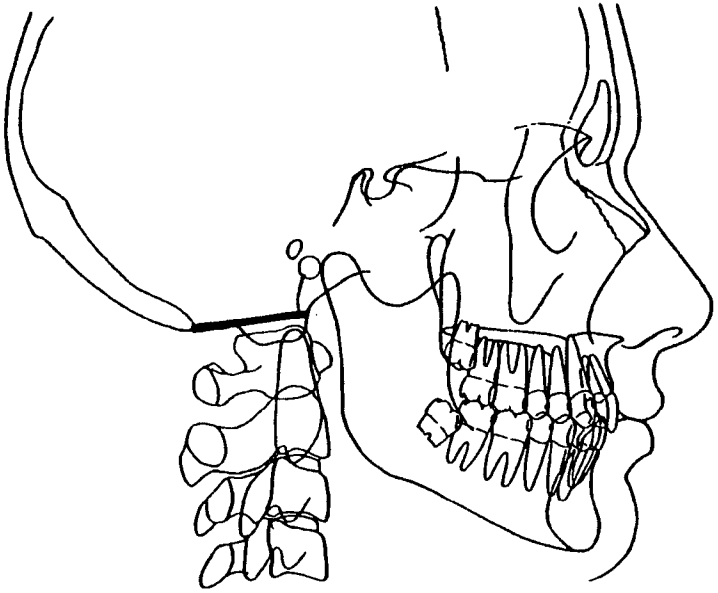
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
95	18	.7	.9	3.5	-2.2	4.5	.92

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	17.1	***	17.7	***	15.7	**	***	*	—	—	—	**	**	***	***
INITIAL	16.4		16.8		15.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	16.8	16.8	17.1	17.8	18.0
	SD	1.3	1.3	1.2	1.3	1.4
	N	84	31	63	36	39
FEMALE	MEAN	15.3	15.3	15.8	16.3	15.7
	SD	1.0	1.1	1.3	1.4	.8
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 213

MEASURE SIMP 38-40

NAME OPISTHION TO BASION

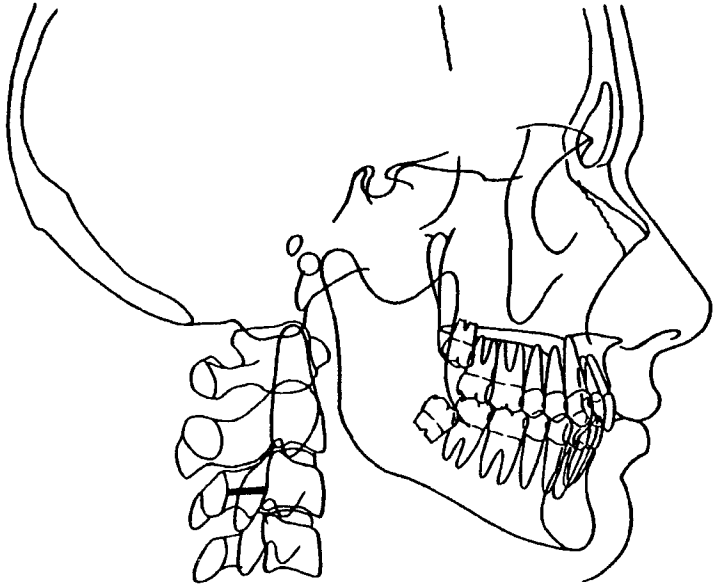
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
47	66	-.2	1.9	5.2	-4.3	-.3	.93

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	39.1	—	39.9	*	37.2	—	***	—	—	—	—	—	*	—	—
INITIAL	39.3		40.3		36.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	40.0	40.0	39.5	40.9	39.4
	SD	3.3	3.6	2.9	3.4	3.0
	N	84	31	63	36	39
FEMALE	MEAN	37.4	37.9	37.0	37.8	37.0
	SD	4.0	3.0	2.8	3.4	3.9
	N	39	24	29	27	15



CALCULATION 214

MEASURE SIMP 66-67

NAME WIDTH OF C3 VERTEBRAL CANAL

INITIAL TO FINAL

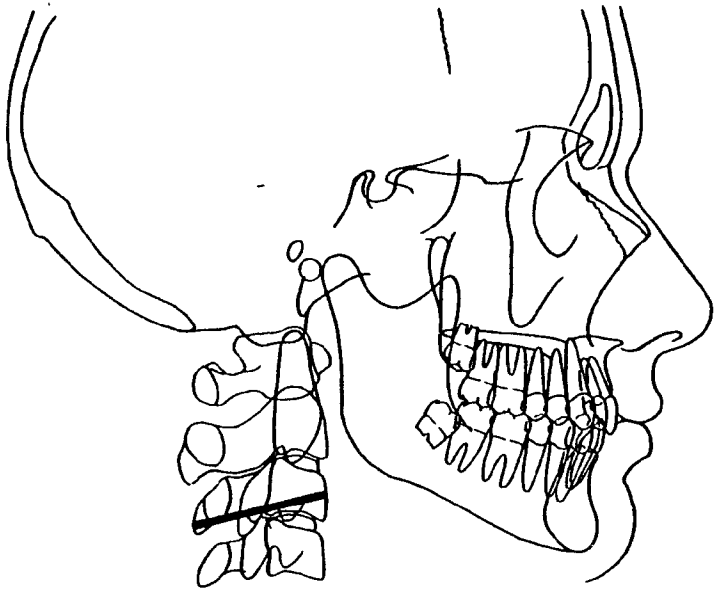
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
40	73	-.2	.8	1.8	-3.1	-1.3	.91

INITIAL TO FINAL

	UNTREATED												TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	16.6	***	16.8	***	16.3	—	*	—	*	—	—	—	—	—	—
INITIAL	16.9		17.1		16.5										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	17.1	17.8	17.0	16.4	16.9
	SD	1.8	1.9	1.5	1.5	1.7
	N	84	31	63	36	39
FEMALE	MEAN	16.6	16.9	16.1	15.6	16.5
	SD	1.6	1.3	1.3	1.3	1.5
	N	39	24	29	27	15



CALCULATION 215

MEASURE SIMP 64-68

NAME C3 TOTAL LENGTH

INITIAL TO FINAL

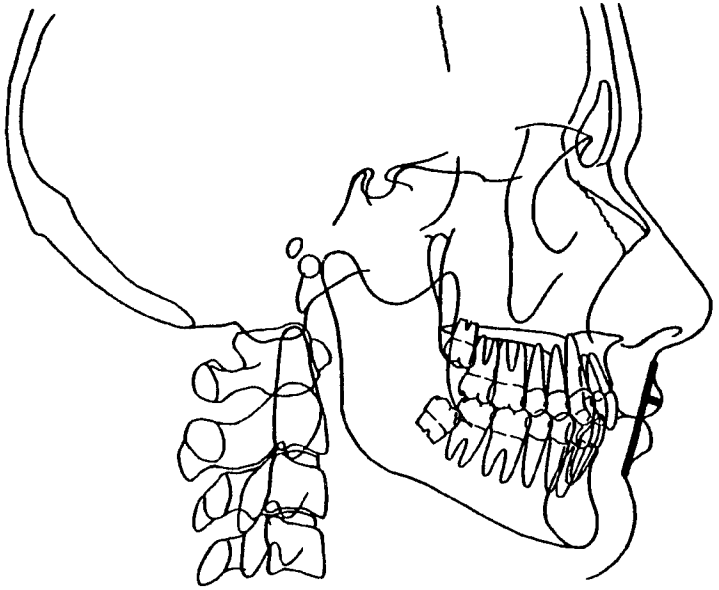
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
103	10	1.4	1.2	6.6	-1.3	2.9	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	49.3	***	50.8	***	45.8	***	***	***	**	**	—	**	—	***	—
INITIAL	47.9		49.2		44.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	49.2	49.8	49.8	51.1	51.1
	SD	2.8	3.2	2.6	3.2	2.8
	N	84	31	63	36	39
FEMALE	MEAN	45.1	45.2	44.8	45.4	46.0
	SD	1.9	1.7	1.7	1.8	2.6
	N	39	24	29	27	15



CALCULATION 216

MEASURE PDIS 81 TO 80-84

NAME UPPER LIP ANTERIOR TO SOFT TISSUE PLANE

INITIAL TO FINAL

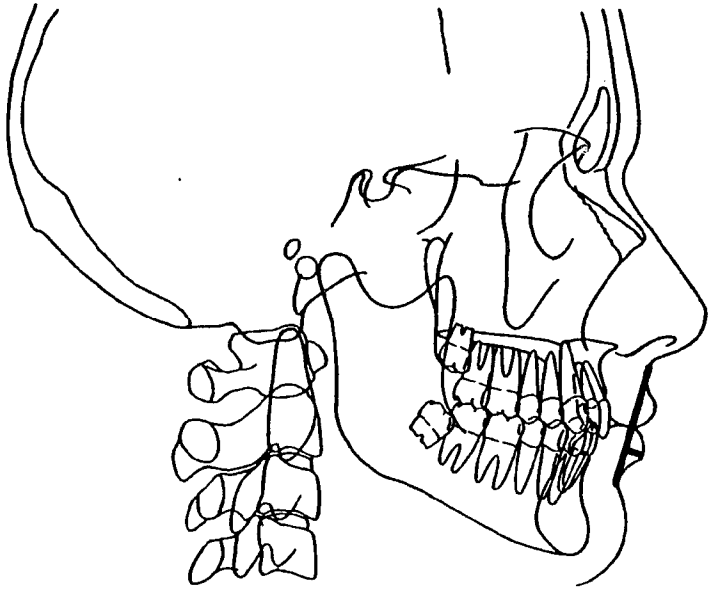
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
17	96	-1.2	1.3	1.8	-4.0	-21.5	.89

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	3.8	***	3.9	***	3.7	***	**	***	***	**	**	***	—	**	—
INITIAL	5.0		5.3		4.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	5.5	6.0	4.9	4.1	3.6
	SD	1.4	1.6	1.4	1.6	1.3
	N	84	31	63	36	39
FEMALE	MEAN	4.5	4.5	4.3	3.9	3.9
	SD	1.3	1.2	1.1	.9	.8
	N	39	24	29	27	15



CALCULATION 217

MEASURE PDIS 83 TO 80-84

NAME LOWER LIP ANTERIOR TO SOFT TISSUE PLANE

INITIAL TO FINAL

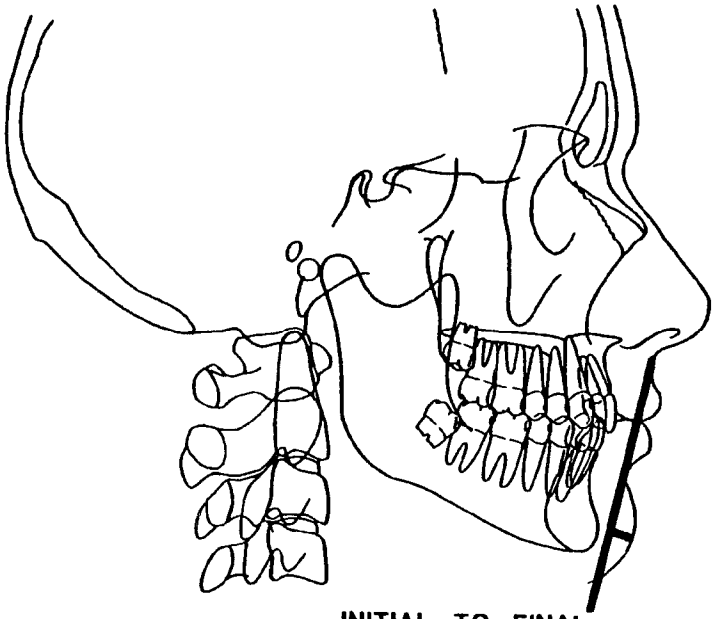
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
28	85	-1.0	1.5	2.3	-4.9	-15.2	.97

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	4.8	***	5.0	***	4.4	***	*	***	—	—	*	**	*	*	—
INITIAL	5.8		6.0		5.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	6.0	6.4	5.5	4.8	4.8
	SD	1.6	1.8	1.6	1.4	2.0
	N	84	31	63	36	39
FEMALE	MEAN	5.8	5.6	5.0	4.5	4.5
	SD	1.4	1.2	1.4	1.4	1.4
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 218

MEASURE PDIS 85 TO 80-84

NAME SOFT TISSUE POGONION TO SOFT TISSUE PLANE

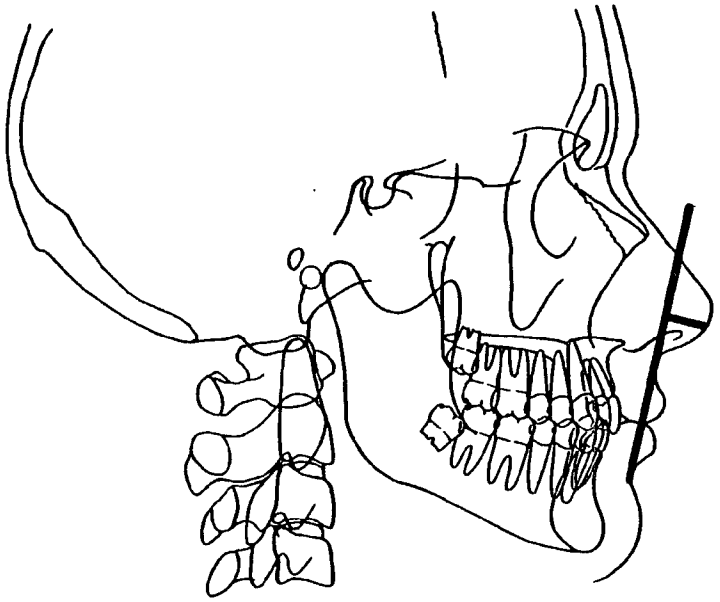
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
52	61	-.1	1.6	4.6	-4.0	.4	.97

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	6.9	—	7.6	—	5.2	*	***	***	**	—	—	—	—	*	***
INITIAL	6.9		7.5		5.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	7.0	7.6	7.9	7.7	7.8
	SD	2.3	2.5	2.8	2.7	2.9
	N	84	31	63	36	39
FEMALE	MEAN	5.7	5.6	5.3	4.8	6.0
	SD	1.8	1.5	1.5	2.2	2.4
	N	39	24	29	27	15



CALCULATION 219

MEASURE PDIS 78 TO 80-84

NAME NOSE POINT B TO SOFT TISSUE PLANE

INITIAL TO FINAL

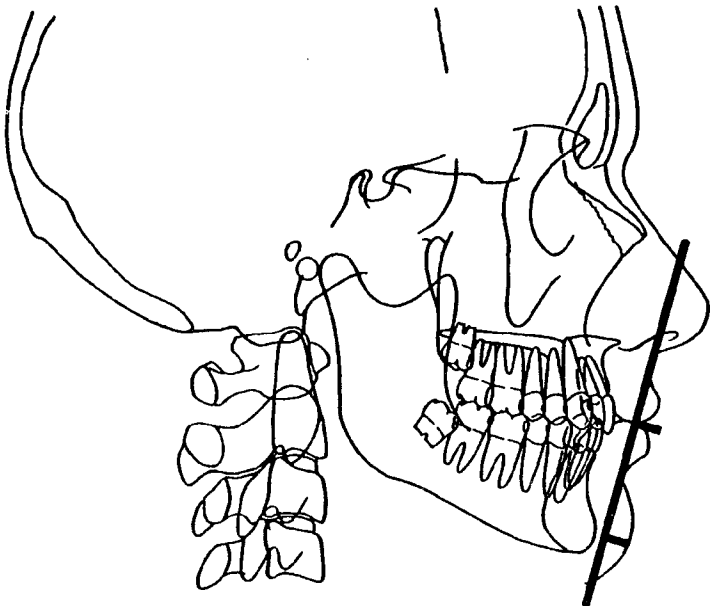
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
89	24	2.2	2.6	9.8	-3.3	22.0	.90

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	12.9	***	12.7	***	13.4	***	—	***	—	—	—	***	—	**	*
INITIAL	10.7		10.5		11.2										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	10.5	11.0	11.4	12.4	13.6
	SD	2.7	2.7	3.3	4.2	4.5
	N	84	31	63	36	39
FEMALE	MEAN	10.6	11.1	10.4	12.9	13.9
	SD	2.8	2.6	2.9	2.9	3.3
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 220

MEASURE SIMP 93-92

NAME SOFT TISSUE POGONION TO STOMION ALONG SOFT TISSUE PLANE

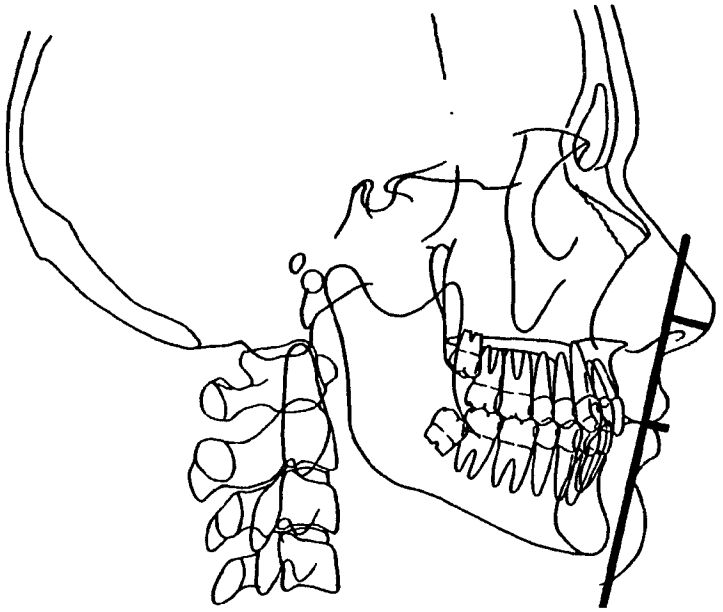
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
76	37	1.0	2.7	7.4	-6.1	3.4	.94

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	31.8	***	32.5	***	30.0	—	***	—	—	—	—	—	—	—	—
INITIAL	30.7		31.4		29.2										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	31.1	31.3	31.6	31.5	32.9
	SD	2.9	2.9	3.1	4.0	4.0
	N	84	31	63	36	39
FEMALE	MEAN	29.1	29.5	29.2	29.6	30.2
	SD	2.5	2.3	2.6	3.4	2.8
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 221

MEASURE SIMP 92-91

NAME NOSE POINT B TO STOMION ALONG SOFT TISSUE PLANE

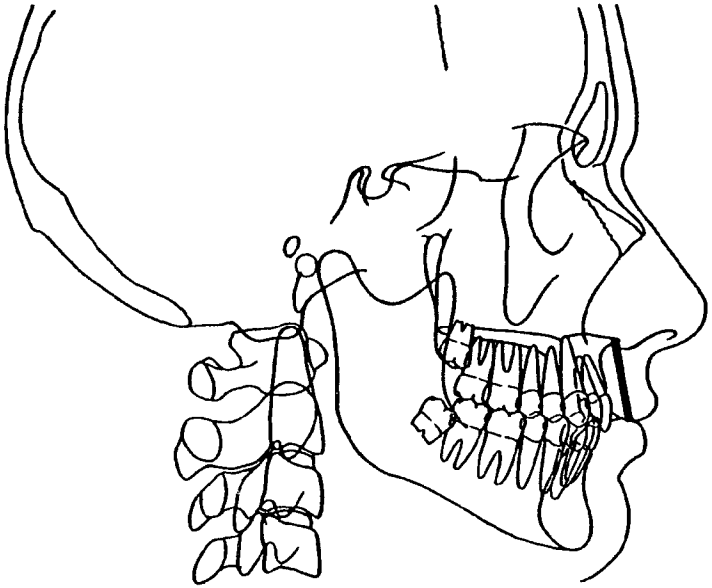
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
57	56	.1	2.3	6.0	-6.2	.1	.91

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	35.1	—	36.0	—	33.0	—	***	—	—	—	—	—	—	—	***
INITIAL	35.0		35.9		33.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	35.9	35.2	35.7	36.4	35.8
	SD	3.2	2.8	3.6	4.0	5.3
	N	84	31	63	36	39
FEMALE	MEAN	33.2	33.2	32.9	32.3	34.3
	SD	2.3	2.4	2.5	4.0	4.3
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 222

MEASURE SIMP 12-82

NAME ANS TO STOMION

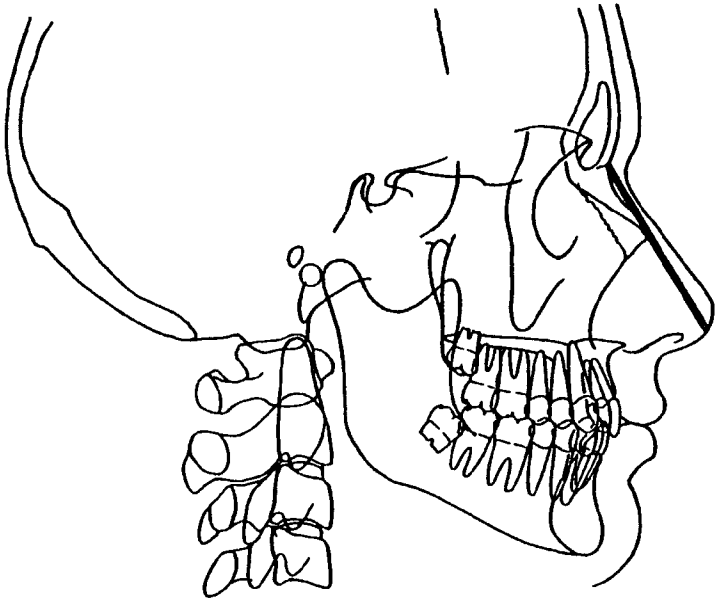
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
107	6	2.6	2.1	8.7	-1.4	9.6	.98

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	30.2	***	31.0	***	28.3	***	***	***	**	**	—	***	—	**	—
INITIAL	27.5		28.2		26.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	28.2	28.7	28.5	29.6	31.9
	SD	2.8	2.9	3.1	3.6	3.6
	N	84	31	63	36	39
FEMALE	MEAN	25.9	26.2	26.4	26.6	30.3
	SD	1.8	1.8	1.5	2.4	3.3
	N	39	24	29	27	15



CALCULATION 223

MEASURE SIMP 54-78

NAME NASION TO NOSE TIP B

INITIAL TO FINAL

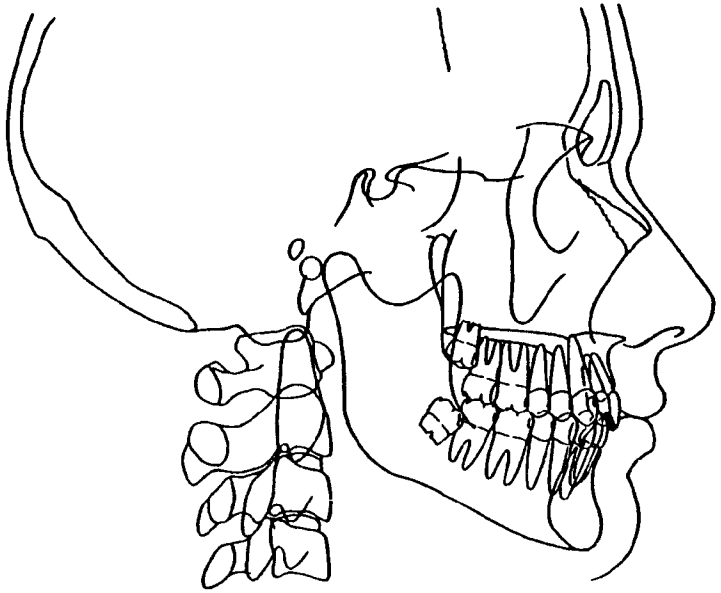
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
109	4	3.1	2.0	10.7	-.7	5.1	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	63.7	***	65.6	***	59.4	***	***	***	***	**	—	***	—	***	—
INITIAL	60.6		62.1		57.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	61.7	63.2	64.1	65.8	65.9
	SD	3.8	4.2	3.0	3.8	3.8
	N	84	31	63	36	39
FEMALE	MEAN	57.1	57.2	58.3	57.7	60.9
	SD	2.9	2.9	2.6	3.0	3.1
	N	39	24	29	27	15



CALCULATION 224

MEASURE SIMP 6-8

NAME UPPER INCISAL EDGE TO LOWER INCISAL EDGE

INITIAL TO FINAL

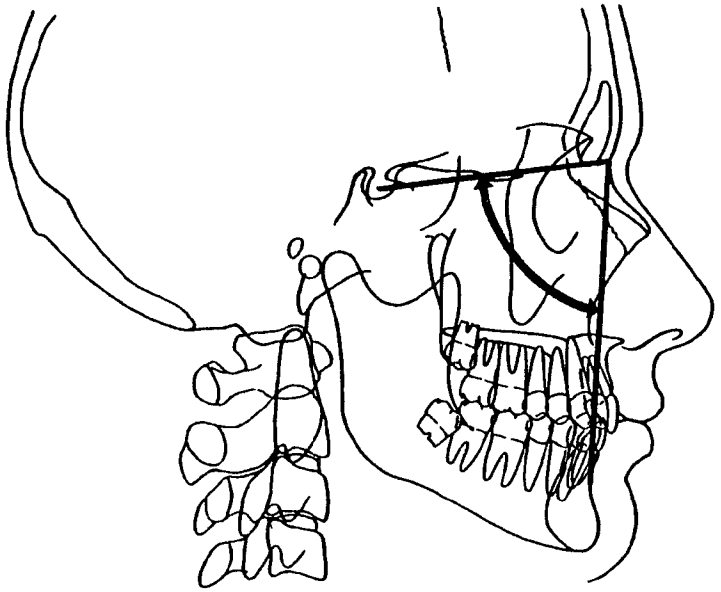
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
56	57	-.03	1.2	3.2	-2.9	0	.97

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	5.4	—	5.5	—	5.1	—	—	—	—	—	—	—	—	NA	NA
INITIAL	5.4		5.6		5.0										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	5.6	5.5	5.3	5.3	6.3
	SD	1.9	2.0	1.8	2.2	2.2
	N	84	31	63	36	39
FEMALE	MEAN	5.1	4.7	5.2	5.8	5.2
	SD	1.7	1.3	1.5	1.7	1.9
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 225

MEASURE 3PTA 46-54-4

NAME SELLA-NASION-B POINT

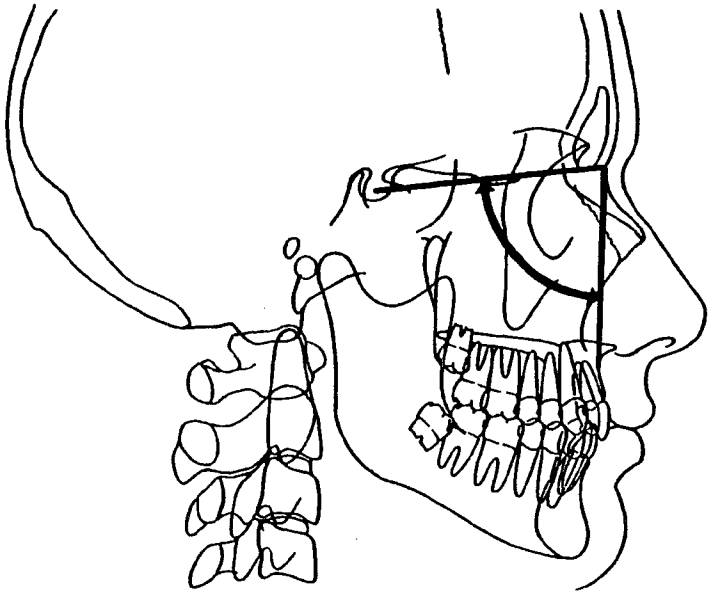
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
52	61	-.1	.9	3.7	-3.0	-.1	.97

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	78.7	—	79.0	*	77.8	***	—	—	—	—	—	—	***	—	***
INITIAL	78.7		78.8		78.5										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	78.8	78.7	79.0	79.7	78.9
	SD	3.2	3.0	3.0	3.7	3.8
	N	84	31	63	36	39
FEMALE	MEAN	78.6	78.9	78.1	78.3	78.4
	SD	3.1	2.9	3.1	2.7	3.0
	N	39	24	29	27	15



CALCULATION 226

MEASURE 3PTA 46-54-11

NAME SELLA-NASION-A POINT

INITIAL TO FINAL

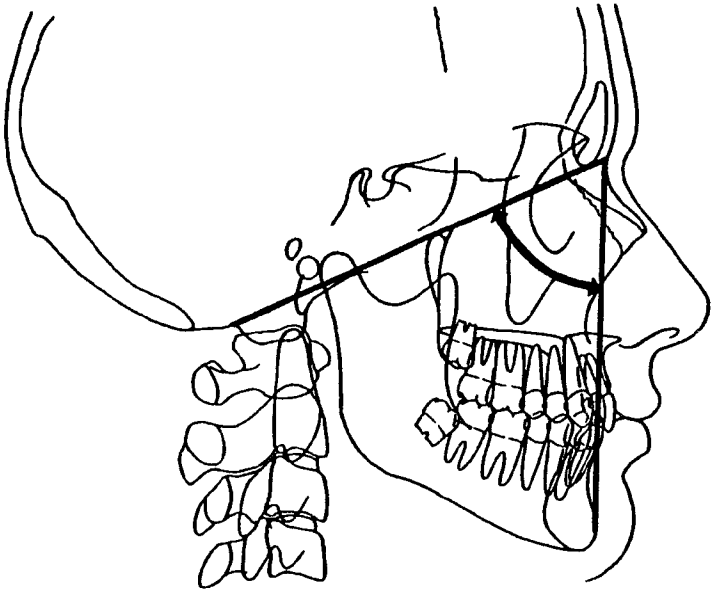
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
56	57	0	.8	2.3	-1.9	0	.94

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	81.6	—	81.9	—	80.9	—	—	—	—	—	—	*	**	NA	NA
INITIAL	81.5		81.7		81.2										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	81.5	81.5	81.7	83.4	81.9
	SD	3.0	3.2	3.0	4.7	4.6
	N	84	31	63	36	39
FEMALE	MEAN	81.7	81.7	82.2	81.4	82.1
	SD	3.3	3.8	3.7	3.6	3.3
	N	39	24	29	27	15



CALCULATION 227

MEASURE 3 PTA 39-54-3

NAME BOLTON POINT-NASION-POGONION

INITIAL TO FINAL

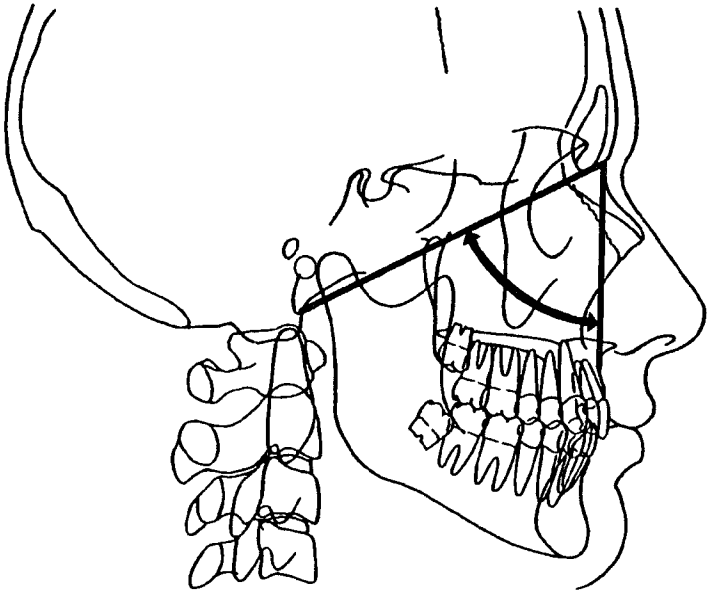
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
53	60	-.1	1.0	3.2	-2.8	-.1	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	63.6	—	63.9	—	63.1	**	—	**	**	**	—	—	***	—	—
INITIAL	63.7		63.7		63.6										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	63.7	64.2	63.6	64.3	64.3
	SD	2.8	2.5	2.8	3.0	3.1
	N	84	31	63	36	39
FEMALE	MEAN	63.2	63.9	63.3	64.7	62.6
	SD	2.9	2.3	2.7	3.3	2.5
	N	39	24	29	27	15



CALCULATION 228

MEASURE 3 PTA 40-54-11

NAME BASION - NASION - A POINT

INITIAL TO FINAL

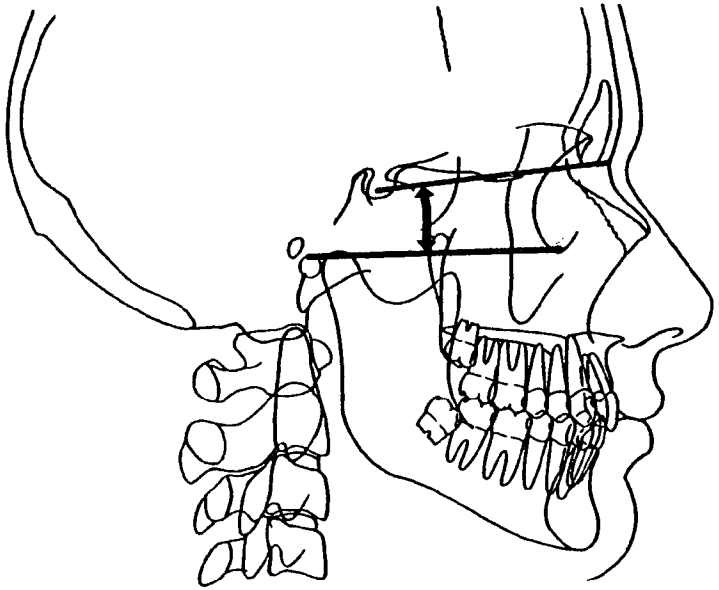
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
52	61	0	.8	1.9	-2.9	0	.97

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	61.5	—	61.6	—	61.3	—	—	—	—	—	—	—	**	—	*
INITIAL	61.5		61.5		61.6										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	61.3	61.6	61.1	62.9	62.1
	SD	2.8	3.3	3.2	4.8	4.4
	N	84	31	63	36	39
FEMALE	MEAN	62.0	62.2	62.5	62.6	61.8
	SD	3.0	3.6	3.9	3.0	2.8
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 229

MEASURE 4 PTA 46-54/44-57

NAME SELLA - NASION/FRANKFORT PLANE

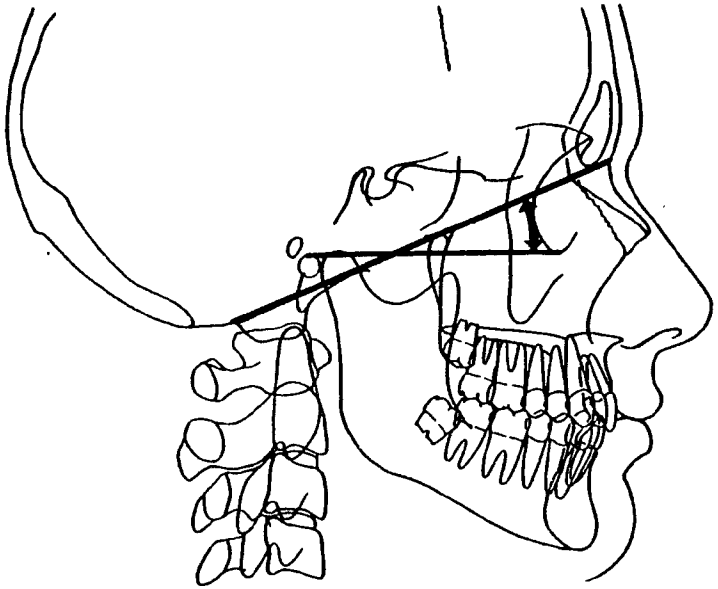
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
53	60	-.3	2.7	6.7	-6.2	NA	.97

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	5.6	—	5.2	—	6.4	—	*	—	—	—	—	*	**	—	—
INITIAL	5.9		5.7		6.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	5.4	6.6	6.1	5.3	5.5
	SD	3.9	3.1	3.2	2.7	3.9
	N	84	31	63	36	39
FEMALE	MEAN	6.7	7.5	6.6	7.8	5.4
	SD	3.9	4.1	4.1	3.9	3.3
	N	39	24	29	27	15



CALCULATION 230

MEASURE 4 PTA 39-54/44-57

NAME BOLTON POINT - NASION/FRANKFORT PLANE

INITIAL TO FINAL

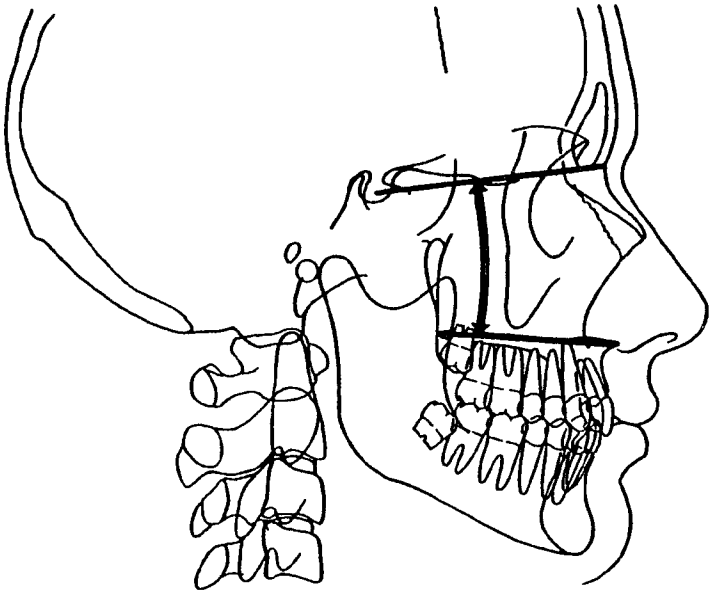
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
49	64	-.5	3.0	7.8	-8.7	-1.6	.97

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	22.0	—	21.7	*	22.5	—	—	—	—	—	—	—	***	—	—
INITIAL	22.5		22.5		22.5										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	22.2	22.9	23.2	22.0	21.6
	SD	3.1	2.7	2.5	3.0	3.7
	N	84	31	63	36	39
FEMALE	MEAN	23.2	23.7	22.7	23.0	22.2
	SD	2.8	3.1	2.8	2.6	3.2
	N	39	24	29	27	15



CALCULATION 231

MEASURE 4 PTA 46-54/59-12

NAME SELLA - NASION/PALATAL PLANE

INITIAL TO FINAL

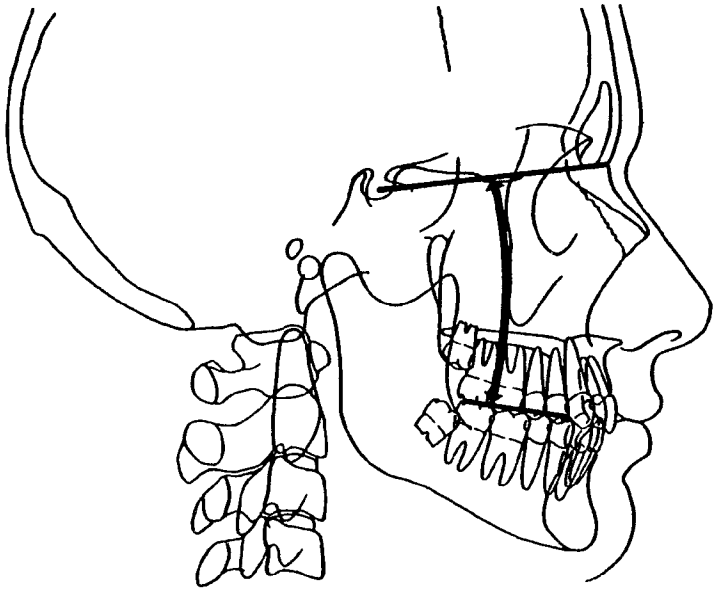
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
42	71	-.3	1.1	2.7	-3.6	-4.4	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	8.1	**	8.2	*	7.9	—	—	—	—	—	—	—	—	—	—
INITIAL	8.4		8.4		8.3										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	8.3	8.4	8.9	8.5	7.7
	SD	3.1	3.2	3.1	3.6	3.7
	N	84	31	63	36	39
FEMALE	MEAN	7.9	7.7	8.1	8.5	7.4
	SD	3.1	3.0	3.6	3.3	3.0
	N	39	24	29	27	15



CALCULATION 232

MEASURE 4 PTA 46-54/29-18

NAME SELLA - NASION/FUNCTIONAL OCCLUSAL PLANE

INITIAL TO FINAL

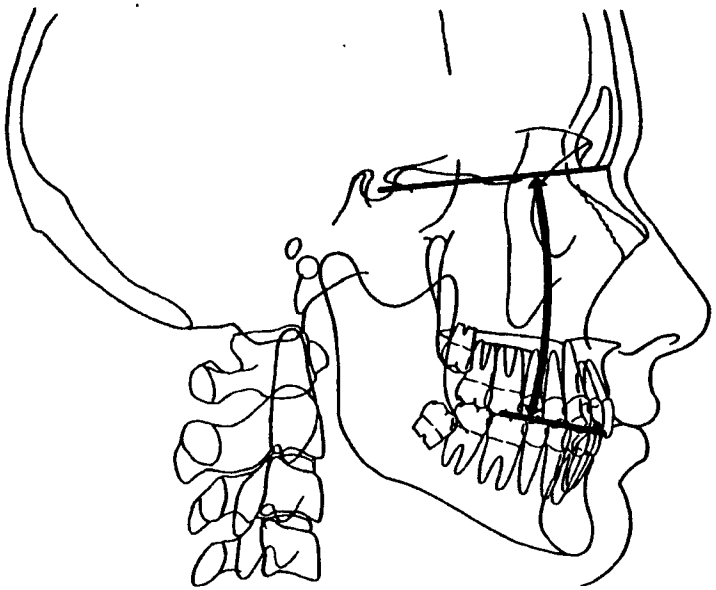
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
43	70	-.7	2.2	3.6	-8.1	-4.0	.91

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	14.7	***	13.7	***	17.2	—	***	—	—	—	—	—	—	NA	NA
INITIAL	15.5		14.5		17.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	14.7	14.0	13.9	13.4	13.1
	SD	4.3	3.7	4.0	3.9	4.1
	N	84	31	63	36	39
FEMALE	MEAN	17.8	17.3	17.8	16.1	17.0
	SD	4.0	4.3	3.9	3.2	3.9
	N	39	24	29	27	15



CALCULATION 233

MEASURE 4 PTA 46-54/24-7

NAME SELLA - NASION/DOWN'S OCCLUSAL PLANE

INITIAL TO FINAL

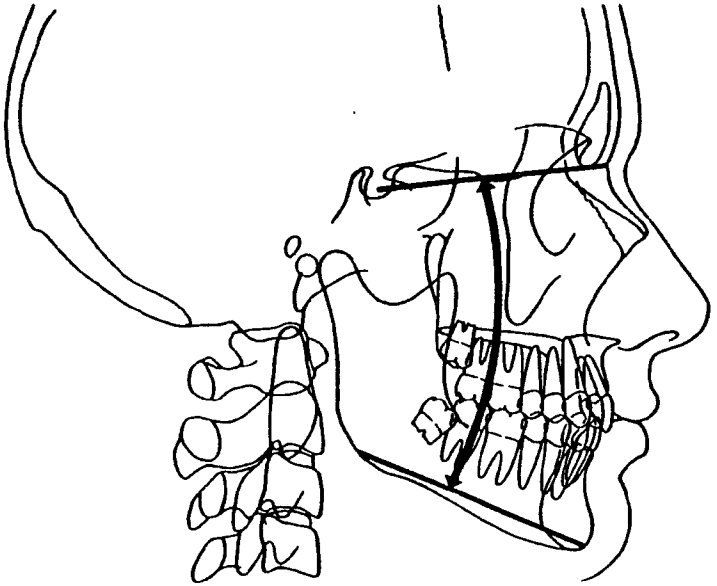
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
54	59	0	2.2	6.1	-7.1	.9	.88

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	13.9	—	13.1	—	15.7	—	**	—	—	—	—	—	**	NA	NA
INITIAL	13.9		13.4		15.0										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	13.7	13.2	13.2	13.1	12.6
	SD	4.5	4.2	5.0	4.5	5.8
	N	84	31	63	36	39
FEMALE	MEAN	14.8	14.5	16.5	15.7	15.5
	SD	4.5	4.1	5.1	4.8	5.2
	N	39	24	29	27	15



CALCULATION 234

MEASURE 4 PTA 46-54/31-2

NAME SELLA - NASION/GONION - GNATHION

INITIAL TO FINAL

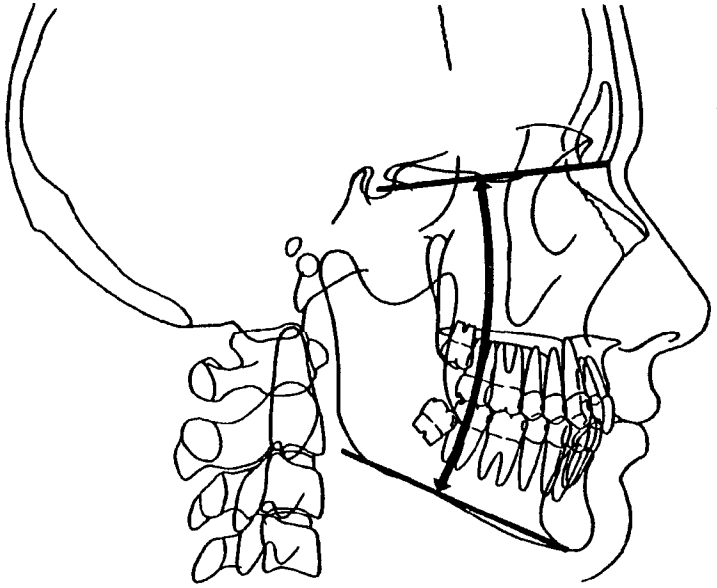
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
43	70	-.5	1.4	3.9	-5.3	-1.8	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	29.8	***	28.7	***	32.4	*	***	—	—	—	—	—	***	—	*
INITIAL	30.3		29.6		32.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	30.1	29.3	28.7	27.7	27.7
	SD	4.5	4.7	4.7	4.9	5.7
	N	84	31	63	36	39
FEMALE	MEAN	32.5	32.6	33.8	30.9	31.3
	SD	4.5	4.7	4.1	3.2	4.6
	N	39	24	29	27	15



CALCULATION 235

MEASURE 4 PTA 46-54/32-1

NAME SELLA - NASION/MANDIBULAR PLANE

INITIAL TO FINAL

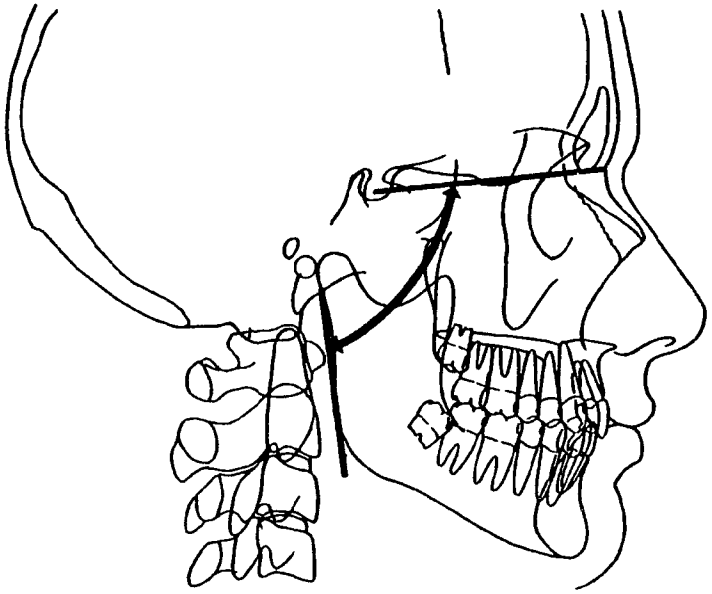
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
44	69	-.6	1.5	4.0	-5.2	-2.3	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	29.1	***	27.8	***	32.1	—	***	—	*	*	—	—	***	—	—
INITIAL	29.7		28.8		31.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	29.4	28.3	27.7	26.6	26.8
	SD	4.9	5.3	5.1	5.1	6.0
	N	84	31	63	36	39
FEMALE	MEAN	32.1	32.4	33.2	30.4	30.9
	SD	4.8	5.1	4.3	3.3	4.8
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 236

MEASURE 4 PTA 46-54/41-32

NAME SELLA - NASION/RAMAL PLANE

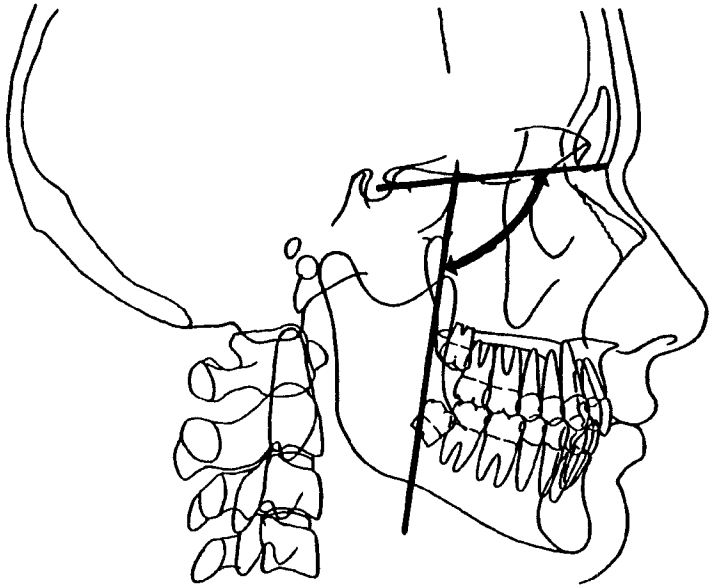
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
64	49	0	1.5	4.2	-4.6	.1	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	89.3	—	89.0	—	90.0	*	—	—	—	—	—	—	—	—	—
INITIAL	89.3		89.2		89.5										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	89.4	89.4	89.8	89.7	88.8
	SD	4.8	4.6	5.0	4.9	4.6
	N	84	31	63	36	39
FEMALE	MEAN	89.4	89.7	92.7	90.0	89.0
	SD	5.7	5.9	7.2	4.7	4.3
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 237

MEASURE 4 PTA 46-54/47-60

NAME SELLA - NASION/PM VERTICAL

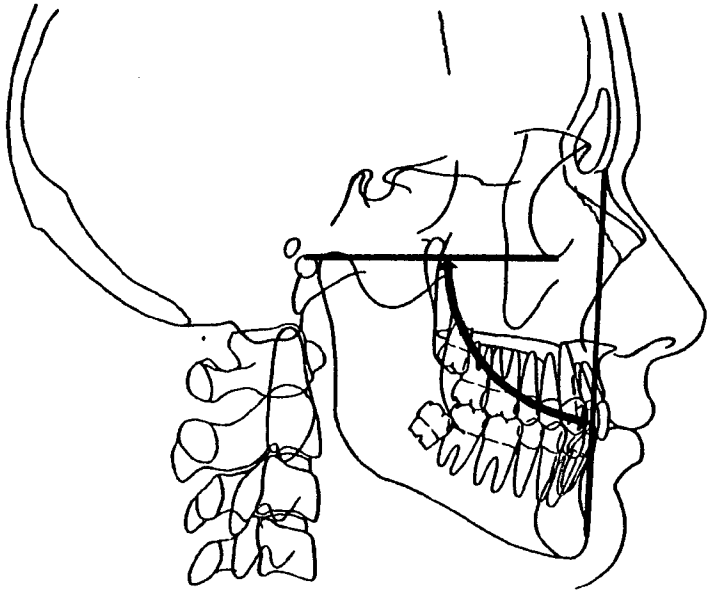
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
62	51	.1	1.4	5.0	-3.2	.1	.98

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	107.4	—	107.5	—	107.1	—	—	**	**	—	—	—	—	—	—
INITIAL	107.3		107.3		107.2										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	107.7	108.7	108.2	106.0	107.6
	SD	5.2	4.8	4.2	5.0	5.3
	N	84	31	63	36	39
FEMALE	MEAN	107.2	107.6	107.5	106.6	105.7
	SD	4.2	3.8	3.9	4.4	5.0
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 238

MEASURE 4 PTA 57-44/54-3

NAME FRANKFORT PLANE/NASION-POGONION

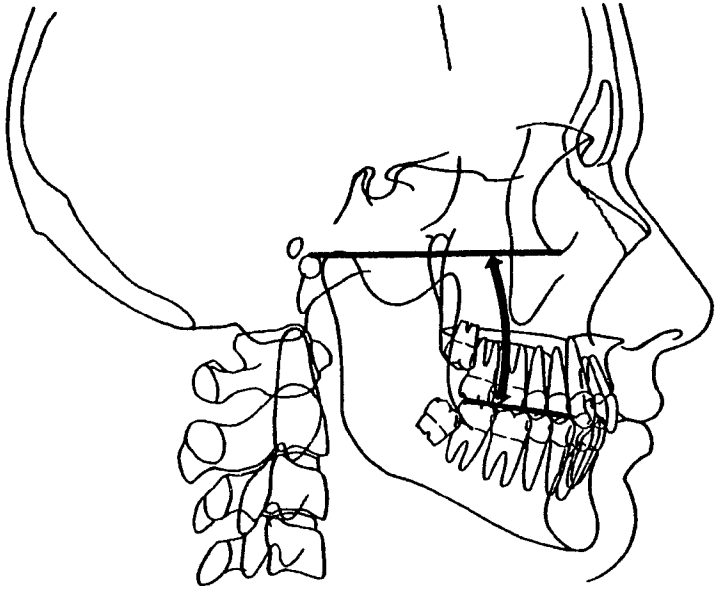
INITIAL TO FINAL

UNTREATED							
GAIN	NC GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
48	65	-.6	3.0	7.2	-7.4	-.7	.98

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	85.6	*	85.6	—	85.6	—	—	*	—	—	—	—	—	—	—
INITIAL	86.2		86.2		86.2										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	85.9	87.2	86.8	86.3	85.9
	SD	3.0	3.6	3.3	4.0	4.6
	N	84	31	63	36	39
FEMALE	MEAN	86.4	87.6	86.0	87.7	84.7
	SD	3.6	3.6	3.2	4.0	3.7
	N	39	24	29	27	15



CALCULATION 239

MEASURE 4 PTA 44-57/29-18

NAME FRANKFORT PLANE/FUNCTIONAL OCCLUSAL PLANE

INITIAL TO FINAL

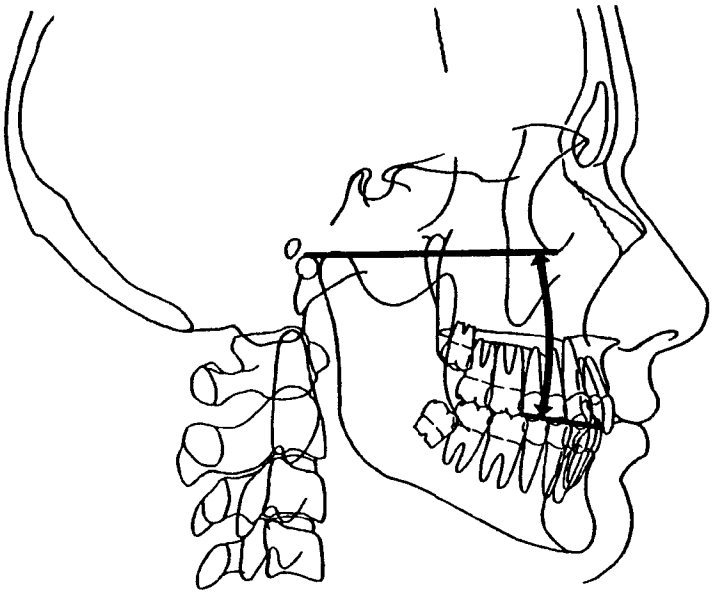
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
51	62	-.1	3.6	7.9	-8.4	NA	.96

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	9.6	—	8.9	—	11.0	—	***	—	—	—	—	—	—	NA	NA
INITIAL	9.6		8.9		11.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	9.4	7.6	7.9	8.6	8.0
	SD	4.2	4.2	3.8	4.2	4.7
	N	84	31	63	36	39
FEMALE	MEAN	11.2	9.8	11.3	8.4	12.2
	SD	4.6	5.0	4.3	4.9	3.9
	N	39	24	29	27	15



CALCULATION 240

MEASURE 4 PTA 44-57/24-7

NAME FRANKFORT PLANE/DOWNS OCCLUSAL PLANE

INITIAL TO FINAL

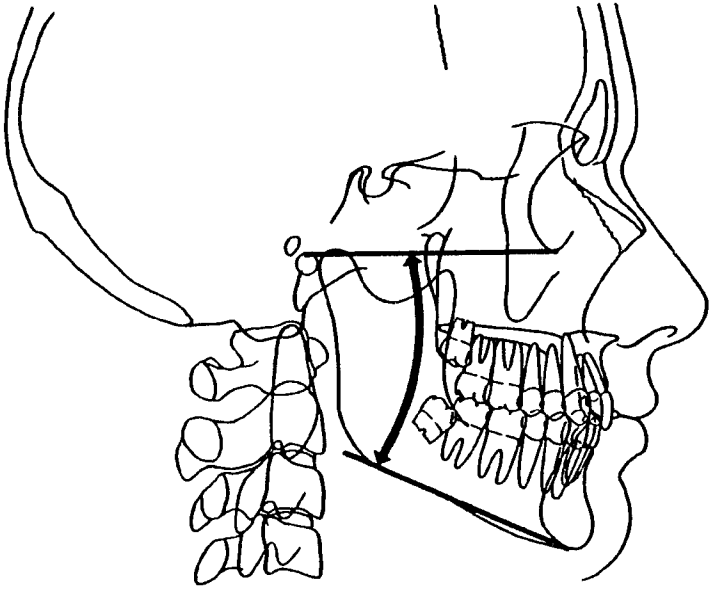
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
61	52	.6	3.1	7.3	-6.7	NA	.93

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	8.9	*	8.5	—	9.8	—	—	*	—	—	—	—	—	NA	NA
INITIAL	8.3		8.0		9.0										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	8.3	7.0	7.4	8.4	7.7
	SD	4.1	3.9	3.8	4.5	5.2
	N	84	31	63	36	39
FEMALE	MEAN	8.4	7.4	9.9	8.4	10.7
	SD	3.9	3.5	3.0	5.1	5.2
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 241

MEASURE 4 PTA 44-57/32-1

NAME FRANKFORT PLANE/MANDIBULAR PLANE

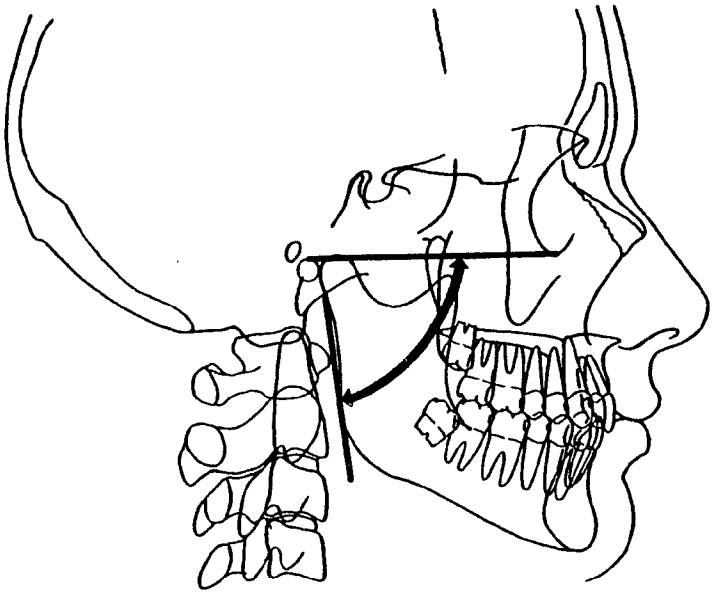
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
57	56	0	3.2	6.7	-7.1	.7	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	23.9	—	23.0	—	25.9	—	**	*	—	—	—	—	—	—	—
INITIAL	23.8		23.1		25.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	24.0	21.8	21.6	21.8	21.7
	SD	4.9	5.7	5.5	6.5	6.6
	N	84	31	63	36	39
FEMALE	MEAN	25.5	24.9	26.6	22.6	26.0
	SD	5.8	6.1	5.2	5.4	4.7
	N	39	24	29	27	15



CALCULATION 242

MEASURE 4 PTA 44-57/41-32

NAME FRANKFORT PLANE/RAMAL PLANE

INITIAL TO FINAL

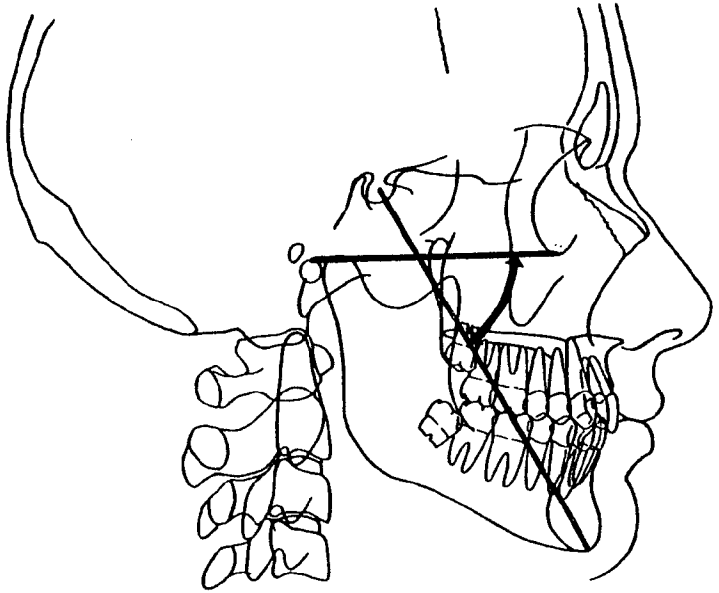
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
67	46	.7	3.4	7.9	-7.8	.9	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	84.1	*	84.2	—	83.8	—	—	—	—	—	—	—	—	—	—
INITIAL	83.4		83.5		83.2										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	84.0	82.8	83.7	85.0	83.7
	SD	4.2	5.3	5.3	5.8	5.5
	N	84	31	63	36	39
FEMALE	MEAN	82.8	82.2	86.2	82.2	84.1
	SD	5.2	6.0	6.2	5.6	5.3
	N	39	24	29	27	15



CALCULATION 243

MEASURE 4 PTA 44-57/46-2

NAME FRANKFORT PLANE/SELLA-GNATHION

INITIAL TO FINAL

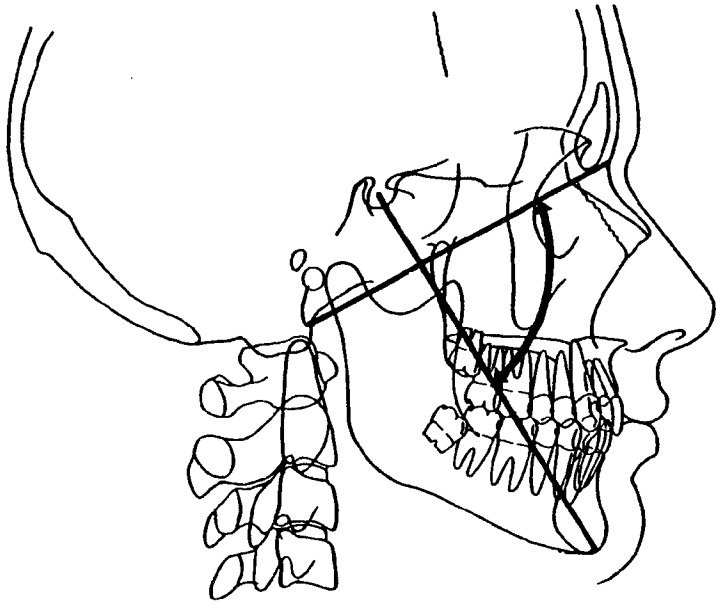
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
68	45	.8	3.0	8.0	-7.1	1.4	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	61.9	**	62.1	**	61.4	—	—	*	—	—	—	*	—	—	—
INITIAL	61.1		61.2		60.8										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	61.6	60.5	61.1	61.2	61.7
	SD	3.3	3.7	3.5	4.7	5.3
	N	84	31	63	36	39
FEMALE	MEAN	60.6	59.5	61.2	58.5	62.5
	SD	4.4	4.2	4.1	5.0	4.1
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 244

MEASURE 4 PTA 40-54/46-2

NAME BASION-NASION/SELLA-GNATHION

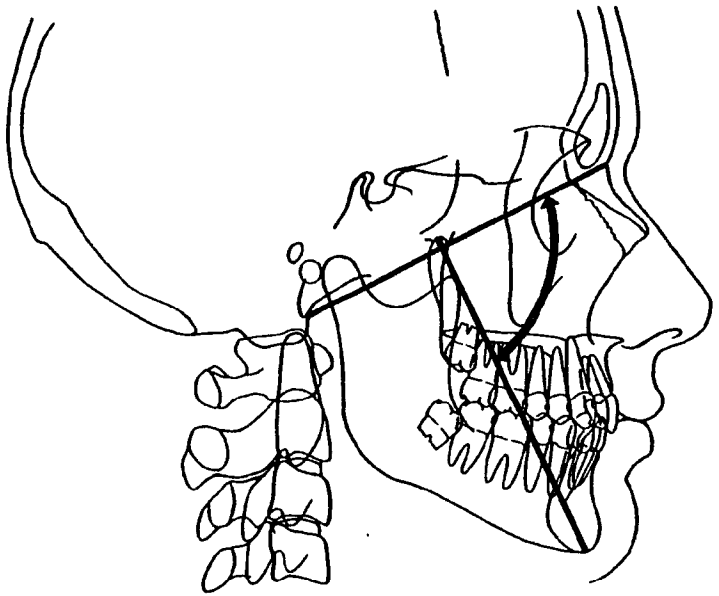
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
64	49	.2	1.0	2.5	-2.3	.2	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	87.1	—	87.1	—	87.1	**	—	—	—	—	—	—	**	—	—
INITIAL	87.0		87.1		86.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	87.3	87.0	87.8	86.4	86.6
	SD	3.4	3.3	3.6	4.1	4.2
	N	84	31	63	36	39
FEMALE	MEAN	86.9	86.5	87.4	85.0	87.7
	SD	3.4	3.2	3.2	3.8	3.3
	N	39	24	29	27	15



CALCULATION 245

MEASURE 4 PTA 40-54/62-2

NAME BASION-NASION/PTM SUPERIOR-GNATHION

INITIAL TO FINAL

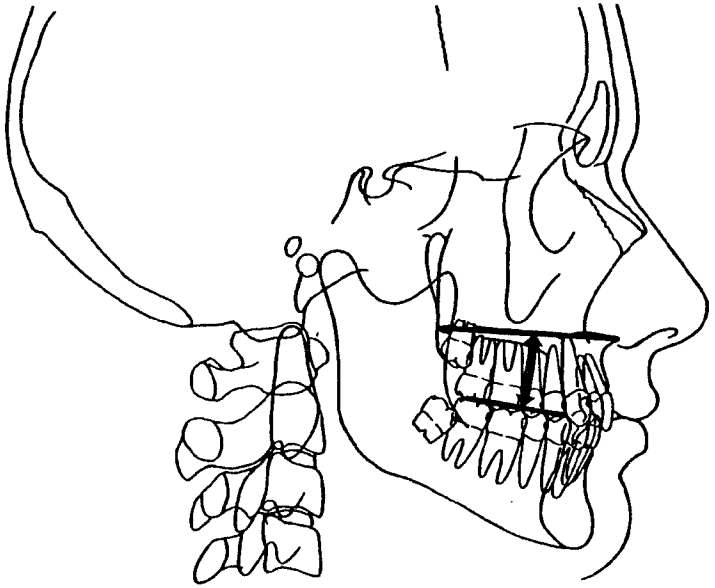
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
77	36	.4	1.2	3.2	-2.5	.4	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	92.2	***	92.0	—	92.6	***	—	—	—	—	—	*	**	—	—
INITIAL	91.8		91.9		91.8										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	92.1	92.1	92.5	91.2	91.3
	SD	4.0	3.9	4.1	4.5	4.8
	N	84	31	63	36	39
FEMALE	MEAN	92.1	91.8	92.8	90.5	93.2
	SD	3.3	3.3	3.1	4.1	3.5
	N	39	24	29	27	15



CALCULATION 246

MEASURE 4 PTA 59-12/29-18

NAME PALATAL PLANE/FUNCTIONAL OCCLUSAL PLANE

INITIAL TO FINAL

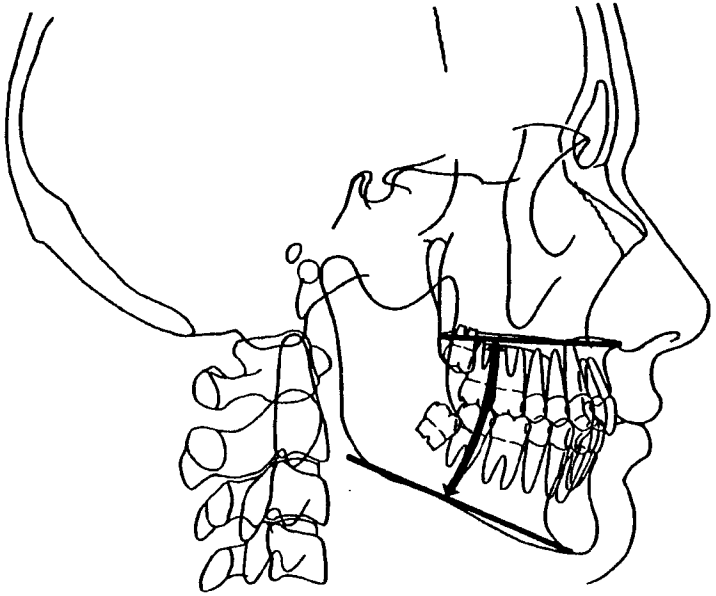
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
51	62	-.4	2.3	4.2	-9.0	NA	.95

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	6.9	—	5.8	*	9.3	—	***	—	—	—	—	—	—	NA	NA
INITIAL	7.2		6.3		9.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	6.6	5.7	5.2	5.3	5.5
	SD	4.3	3.4	3.6	2.9	3.9
	N	84	31	63	36	39
FEMALE	MEAN	9.9	9.6	9.8	7.6	9.5
	SD	3.8	3.7	3.3	4.0	3.7
	N	39	24	29	27	15



CALCULATION 247

MEASURE 4 PTA 59-12/32-1

NAME PALATAL PLANE/MANDIBULAR PLANE

INITIAL TO FINAL

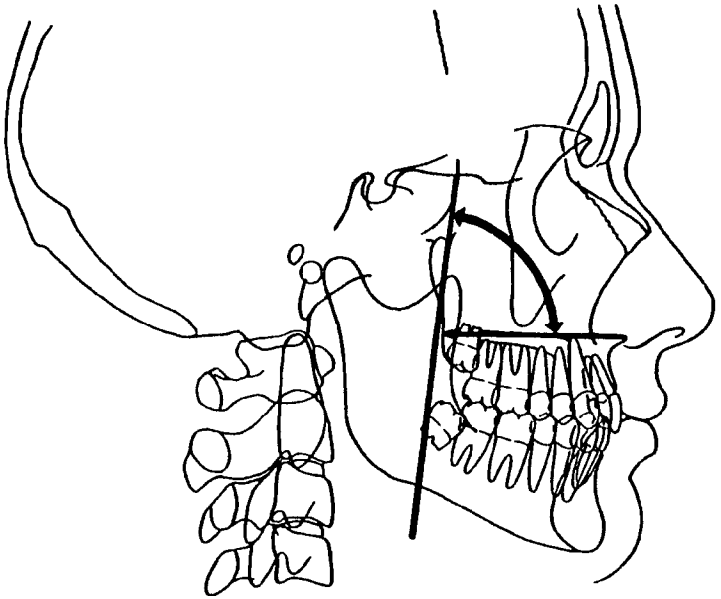
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
47	66	-.3	1.7	3.4	-5.0	-1.7	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	21.0	*	19.6	***	24.2	***	***	—	*	—	*	—	***	—	—
INITIAL	21.3		20.4		23.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	21.2	20.0	18.8	18.1	19.2
	SD	5.5	5.1	5.7	6.0	6.1
	N	84	31	63	36	39
FEMALE	MEAN	24.2	24.7	25.1	21.9	23.4
	SD	5.2	5.5	4.5	4.3	5.5
	N	39	24	29	27	15



CALCULATION 248

MEASURE 4PTA 60-47/59-12

NAME PM VERTICAL / PALATAL PLANE

INITIAL TO FINAL

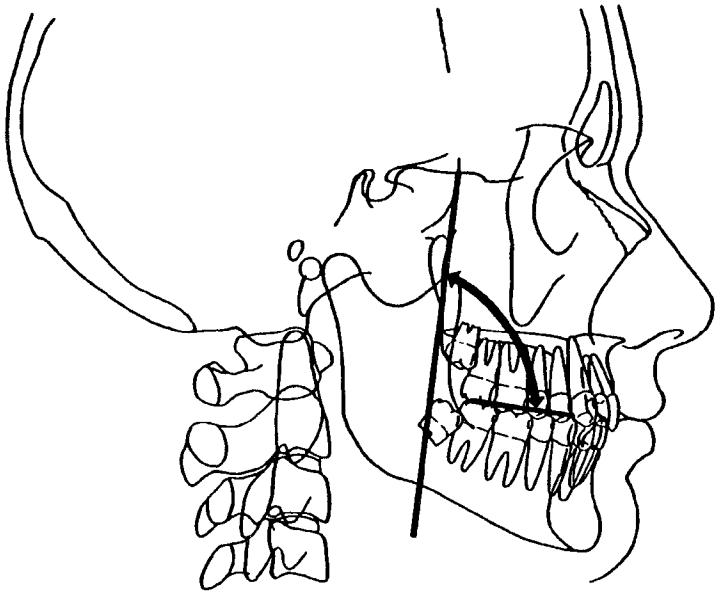
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
46	67	-.4	1.7	4.3	-5.5	-.5	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	80.7	*	80.7	*	80.7	—	—	—	—	—	—	—	—	—	—
INITIAL	81.1		81.1		81.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	80.6	79.7	80.7	82.5	80.1
	SD	5.8	5.8	5.4	5.7	5.6
	N	84	31	63	36	39
FEMALE	MEAN	80.6	80.1	80.6	82.0	81.7
	SD	4.8	4.8	5.6	5.1	5.2
	N	39	24	29	27	15



CALCULATION 249

MEASURE 4PTA 60-47/29-18

NAME PM VERTICAL / FUNCTIONAL OCCLUSAL PLANE

INITIAL TO FINAL

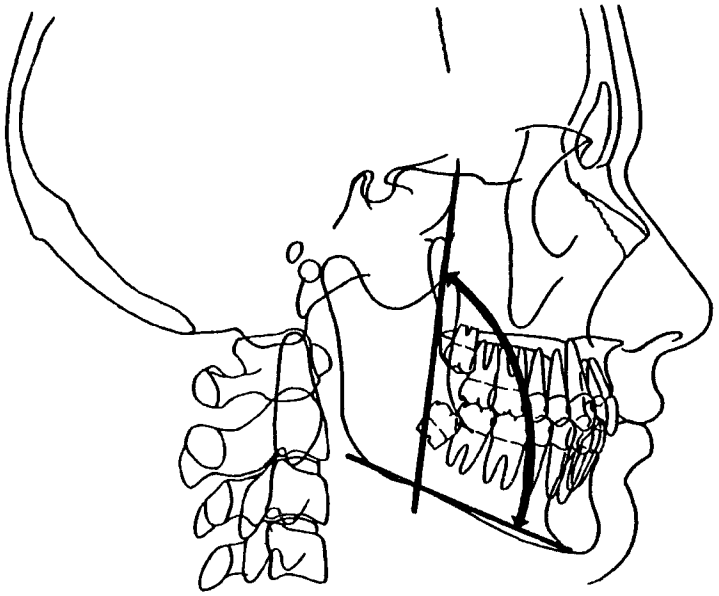
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
44	69	-.8	2.8	5.2	-10.2	-.9	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	87.3	**	86.2	***	90.0	—	***	—	*	**	—	—	—	NA	NA
INITIAL	88.2		87.2		90.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	87.0	85.3	85.7	87.3	85.5
	SD	6.3	6.8	6.2	5.9	6.0
	N	84	31	63	36	39
FEMALE	MEAN	90.5	89.7	90.4	89.6	91.3
	SD	5.6	5.6	5.2	6.3	5.6
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 250

MEASURE 4PTA 60-47/32-1

NAME PM VERTICAL / MANDIBULAR PLANE

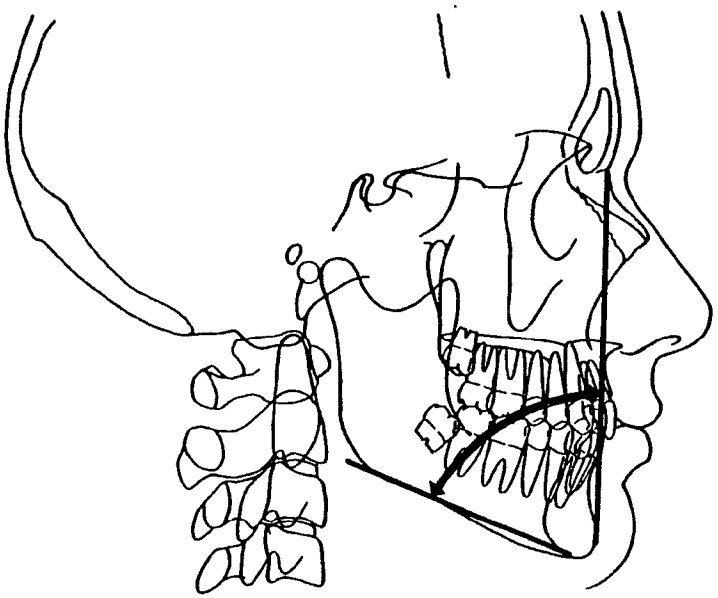
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
39	74	-.7	2.2	4.4	-6.4	-.7	.99

	UNTREATED												TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	101.7	***	100.2	***	104.9	—	***	*	**	**	**	—	*	—	*
INITIAL	102.4		101.5		104.5										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	101.7	99.6	99.5	100.6	99.2
	SD	6.7	7.1	6.5	6.1	6.7
	N	84	31	63	36	39
FEMALE	MEAN	104.9	104.8	105.7	103.8	105.1
	SD	5.0	4.8	4.1	5.5	6.3
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 251

MEASURE 4PTA 3-54/1-32

NAME POGONION-NASION / MANDIBULAR PLANE

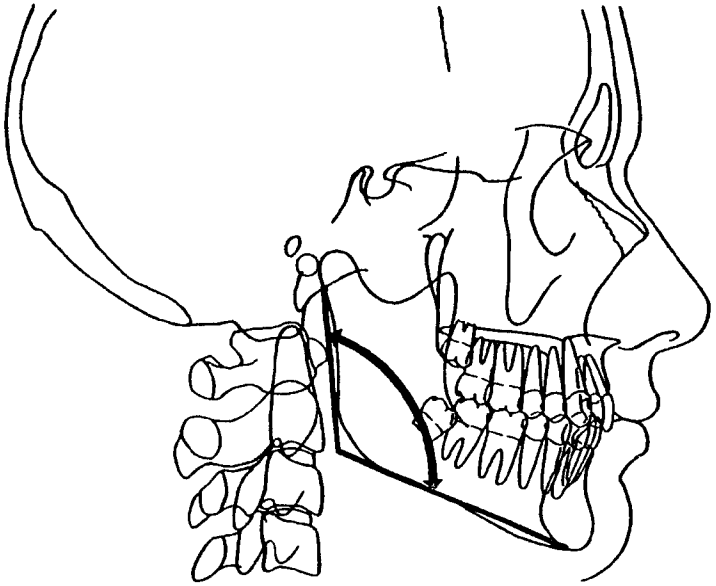
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
80	33	.6	1.0	4.6	-1.4	.8	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	70.6	***	71.4	***	68.5	—	***	—	—	—	*	—	*	—	—
INITIAL	70.0		70.7		68.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	70.0	71.0	71.6	71.9	72.4
	SD	4.3	4.6	5.1	4.3	4.4
	N	84	31	63	36	39
FEMALE	MEAN	68.1	67.5	67.4	69.7	69.3
	SD	3.7	3.6	2.9	2.8	3.9
	N	39	24	29	27	15



CALCULATION 252

MEASURE 3PTA 41-32-1

NAME ARTICULARE POSTERIOR-GONIAL INTERSECTION-MENTON

INITIAL TO FINAL

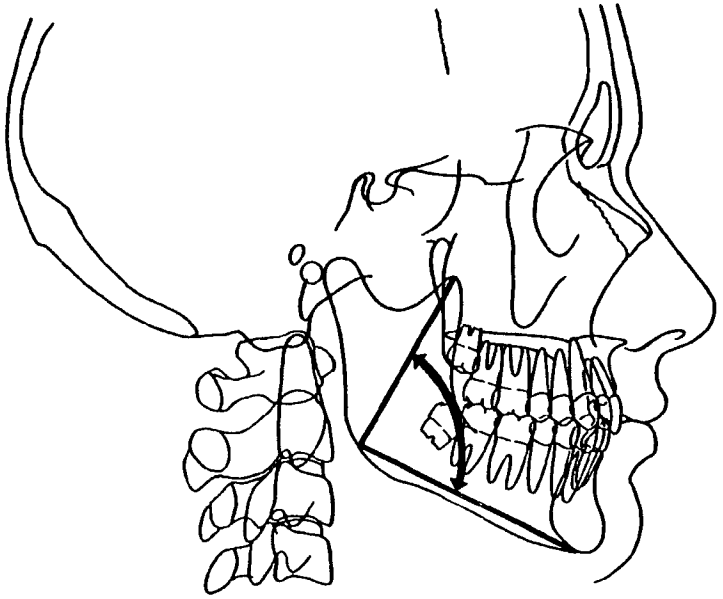
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
34	79	-.7	1.6	3.4	-5.6	-.6	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	119.8	***	118.8	***	122.1	—	***	—	—	—	*	—	**	—	—
INITIAL	120.4		119.6		122.2										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	120.1	119.0	117.9	116.8	118.0
	SD	6.0	7.5	8.1	6.6	5.5
	N	84	31	63	36	39
FEMALE	MEAN	122.7	122.7	120.4	120.4	121.9
	SD	6.1	6.7	6.6	4.7	5.9
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 253

MEASURE 3PTA 61-31-1

NAME CORONOID PROCESS-GONION-MENTON

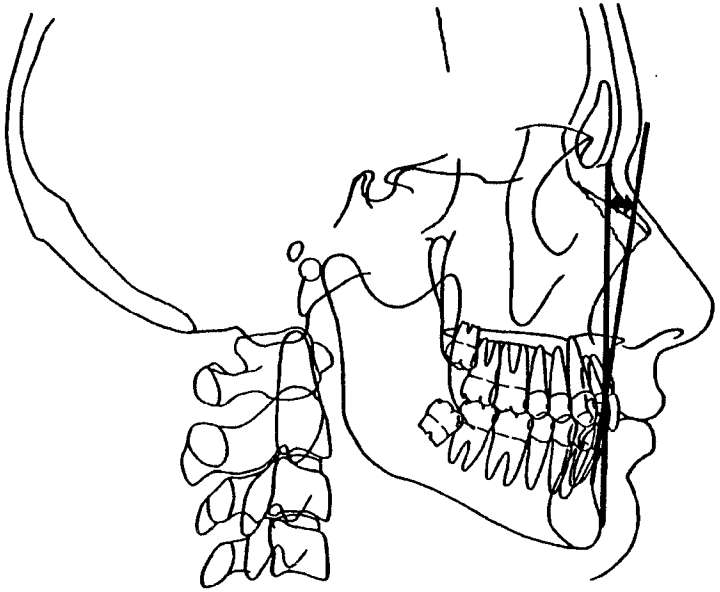
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
53	60	.1	1.9	5.0	-5.6	.1	.98

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	84.2	—	84.1	—	84.4	—	—	—	—	—	—	*	**	—	—
INITIAL	84.1		83.8		84.8										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	83.7	84.0	83.5	83.5	82.6
	SD	4.4	5.7	6.6	5.6	4.2
	N	84	31	63	36	39
FEMALE	MEAN	84.9	85.2	85.5	82.9	83.6
	SD	4.7	5.2	5.4	3.9	4.4
	N	39	24	29	27	15



CALCULATION 254

MEASURE 4PTA 3-54/4-11

NAME NASION-POGONION / A POINT - B POINT

INITIAL TO FINAL

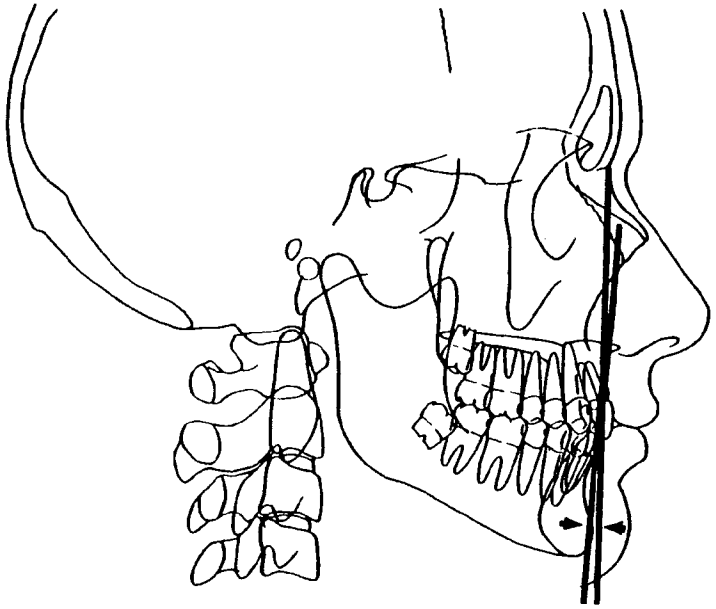
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
56	57	.1	1.4	4.1	-4.6	NA	.94

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	6.7	—	6.6	—	6.8	***	—	*	**	—	—	—	—	NA	NA
INITIAL	6.6		6.8		6.0										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	6.4	6.6	6.5	8.7	6.9
	SD	3.2	3.5	3.5	4.6	4.9
	N	84	31	63	36	39
FEMALE	MEAN	6.5	6.2	8.3	7.3	7.3
	SD	3.6	4.3	4.8	5.3	2.7
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 255

MEASURE 3PTA 54-11-3

NAME NASION - A POINT - POGONION

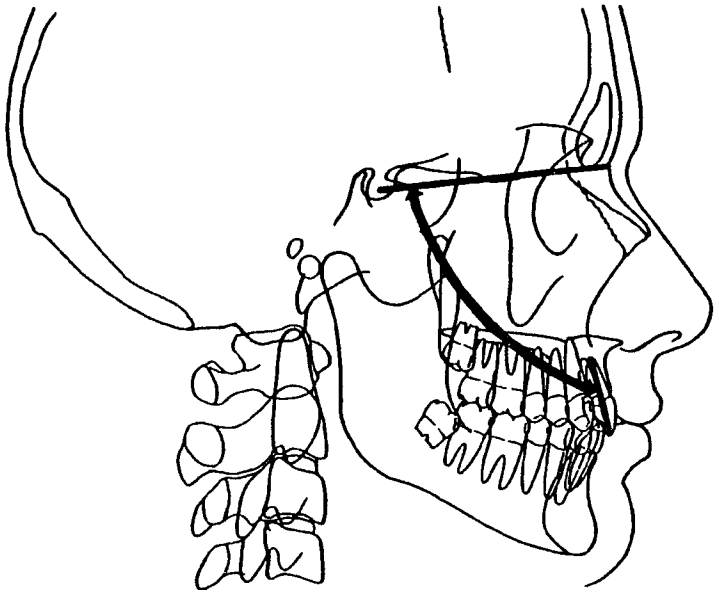
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
61	52	-.1	1.7	7.1	-6.5	-.1	.92

	UNTREATED												TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+		T P	T UNTX	T P	T UNTX
FINAL	174.7	—	174.8	—	174.3	—	—	**	***	—	—		—	—	NA	NA
INITIAL	174.8		174.8		174.7											

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	175.2	175.1	175.2	173.9	174.3
	SD	3.4	3.4	3.5	5.6	5.2
	N	84	31	63	36	39
FEMALE	MEAN	174.2	174.5	172.3	173.4	174.0
	SD	4.3	4.3	5.8	4.5	3.2
	N	39	24	29	27	15



CALCULATION 256

MEASURE 4PTA 54-46/13-8

NAME SELLA - NASION / UPPER INCISOR AXIS

INITIAL TO FINAL

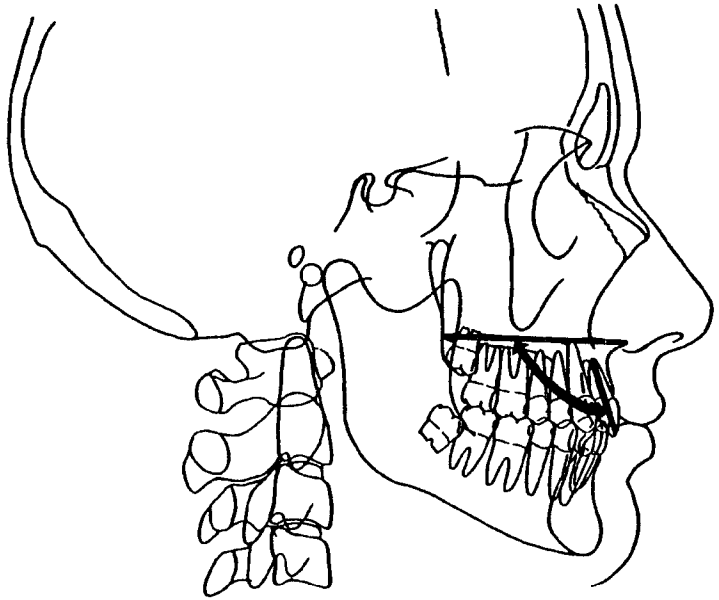
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
37	76	-1.6	3.9	11.4	-13.6	-1.5	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	100.0	***	99.9	***	100.2	*	—	***	***	**	—	—	—	NA	NA
INITIAL	101.6		101.6		101.5										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	101.8	100.9	101.3	99.7	98.4
	SD	7.4	7.7	7.7	7.3	9.4
	N	84	31	63	36	39
FEMALE	MEAN	101.7	102.7	99.0	98.8	100.1
	SD	8.3	7.8	10.4	9.2	7.1
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 257

MEASURE 4PTA 12-59/13-8

NAME PALATAL PLANE / UPPER INCISOR AXIS

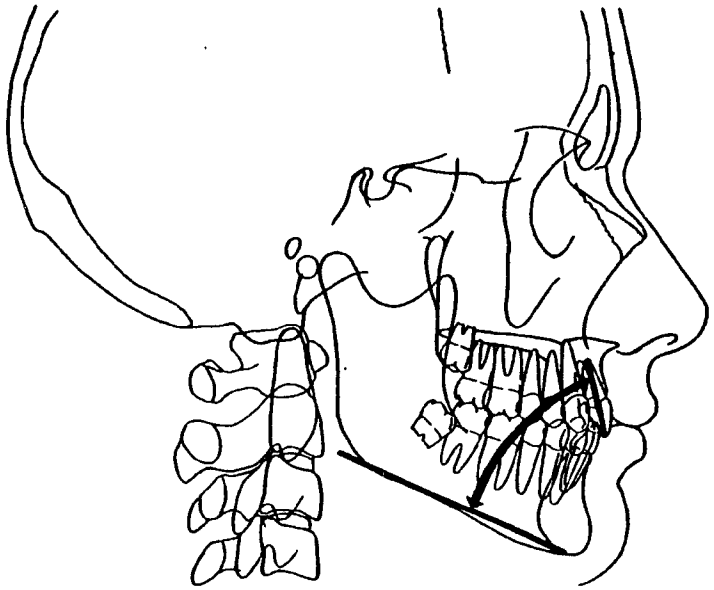
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
33	80	-1.9	4.0	10.6	-13.6	-1.7	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	108.0	***	108.0	***	108.1	**	—	***	***	**	*	—	—	NA	NA
INITIAL	109.9		110.0		109.8										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	110.1	109.3	110.2	108.3	106.0
	SD	7.6	7.6	7.1	7.2	9.0
	N	84	31	63	36	39
FEMALE	MEAN	109.5	110.4	107.1	107.3	107.5
	SD	7.9	7.1	8.7	8.7	6.9
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 258

MEASURE 4PTA 1-32/8-13

NAME MANDIBULAR PLANE / UPPER INCISOR AXIS

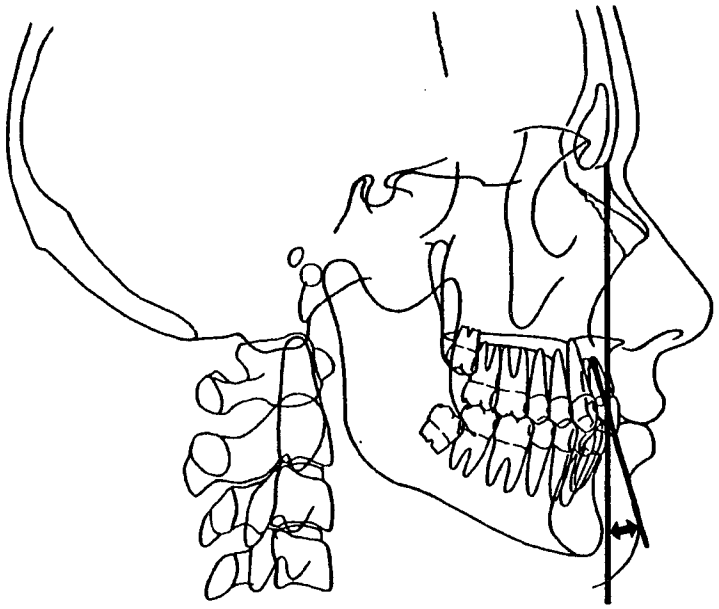
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
79	34	2.2	3.8	14.1	-7.5	4.7	.99

	UNTREATED												TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+		T P	T UNTX	T P	T UNTX
FINAL	51.0	***	52.4	***	47.7	—	**	***	**	*	—		—	**	NA	NA
INITIAL	48.8		49.6		46.8											

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	48.8	50.7	51.0	53.7	54.8
	SD	7.8	8.0	8.4	9.0	9.5
	N	84	31	63	36	39
FEMALE	MEAN	46.2	44.9	47.8	50.8	49.1
	SD	8.4	8.6	11.0	8.0	7.3
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 259

MEASURE 4PTA 54-11/13-8

NAME NASION-A POINT / UPPER INCISOR AXIS

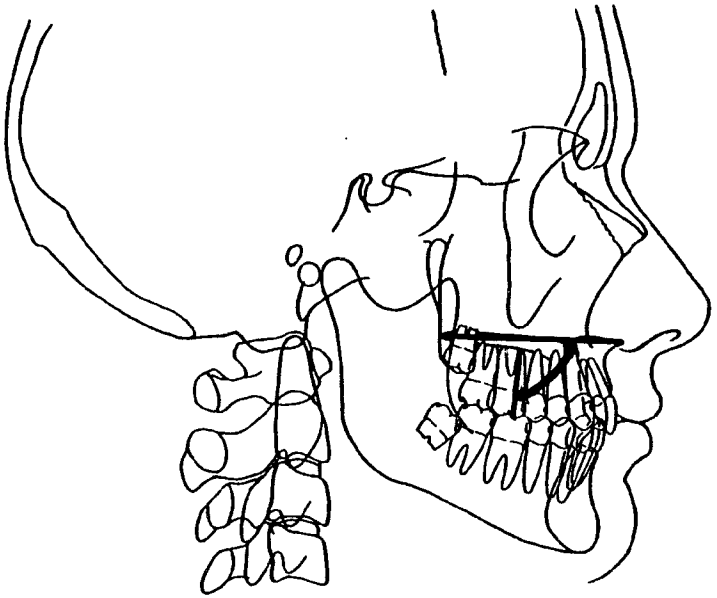
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
39	74	-1.5	4.0	11.0	-14.3	-2.0	.99

	UNTREATED												TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	18.7	***	18.3	***	19.6	—	—	***	**	—	—	—	—	NA	NA
INITIAL	20.2		20.0		20.6										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	20.3	19.5	19.6	16.6	17.2
	SD	6.7	6.8	7.7	8.1	9.4
	N	84	31	63	36	39
FEMALE	MEAN	20.4	21.3	17.8	17.9	18.0
	SD	7.4	7.8	9.4	9.8	7.5
	N	39	24	29	27	15



CALCULATION 260

MEASURE 4PTA 59-12/27-23

NAME PALATAL PLANE / UPPER MOLAR AXIS

INITIAL TO FINAL

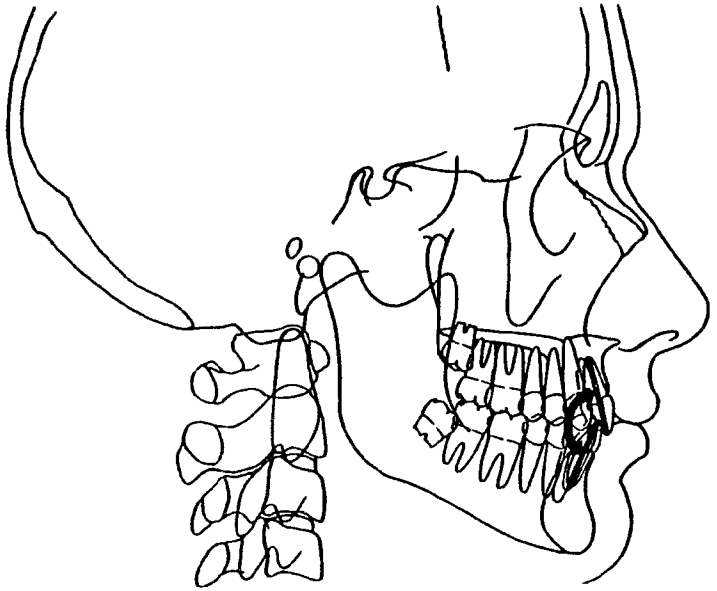
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
43	70	-.8	4.6	18.5	-10.6	-.7	.94

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	94.0	—	93.0	**	96.3	—	**	—	—	—	—	—	—	NA	NA
INITIAL	94.8		94.4		95.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	94.9	93.8	92.7	93.0	94.0
	SD	6.2	4.6	4.8	5.6	7.0
	N	84	31	63	36	39
FEMALE	MEAN	97.3	96.6	96.1	93.1	98.3
	SD	6.0	6.3	5.4	5.8	6.6
	N	39	24	29	27	15



CALCULATION 261

MEASURE 4PTA 8-13/6-16

NAME UPPER INCISOR AXIS / LOWER INCISOR AXIS

INITIAL TO FINAL

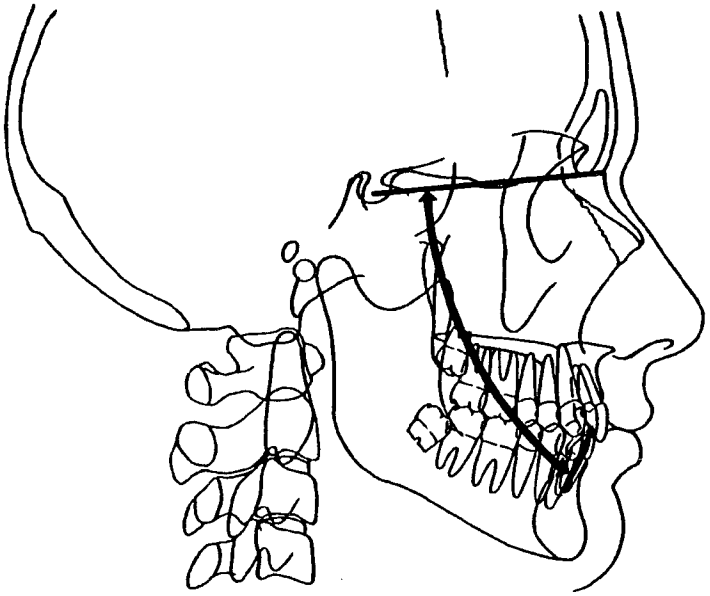
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
67	46	1.7	5.6	21.9	-9.2	1.4	.99

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	134.3	***	135.3	***	131.9	—	—	—	**	—	—	—	*	NA	NA
INITIAL	132.6		132.9		131.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	133.0	133.9	134.5	133.8	137.6
	SD	10.3	9.8	9.0	8.8	11.3
	N	84	31	63	36	39
FEMALE	MEAN	130.6	129.3	131.5	136.0	131.6
	SD	10.6	10.5	12.6	10.0	10.2
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 262

MEASURE 4PTA 54-46/6-16

NAME SELLA-NASION / LOWER INCISOR AXIS

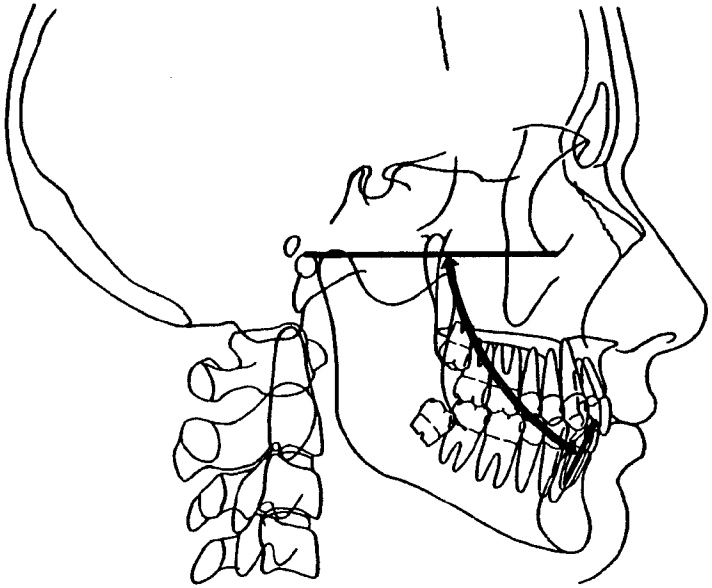
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
58	55	.1	3.5	9.8	-8.5	.4	.97

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	54.3	—	55.2	—	52.2	*	*	—	—	—	—	—	**	NA	NA
INITIAL	54.1		54.5		53.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	54.8	54.8	55.8	53.6	56.0
	SD	7.5	6.0	6.9	6.3	7.5
	N	84	31	63	36	39
FEMALE	MEAN	52.3	52.0	50.5	54.8	51.7
	SD	7.1	6.5	7.3	8.0	7.0
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 263

MEASURE 4PTA 57-44/6-16

NAME FRANKFORT PLANE / LOWER INCISOR AXIS

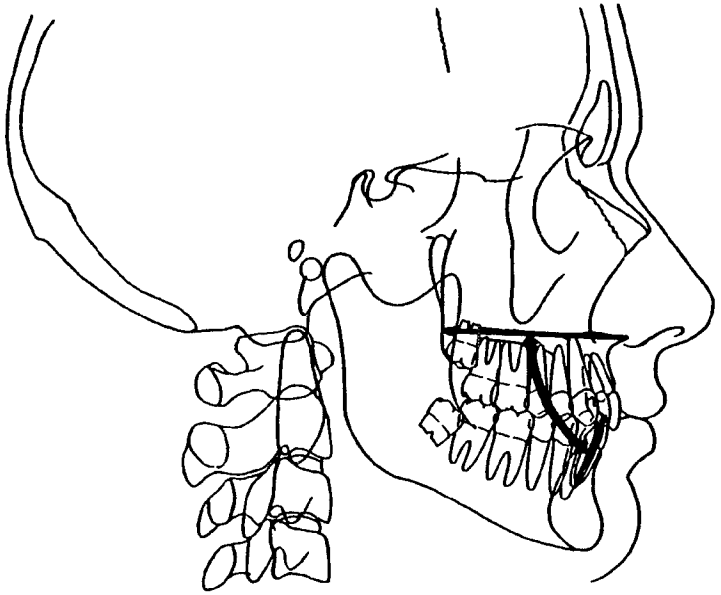
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
53	60	-.5	4.6	11.6	-11.6	-.7	.97

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	59.5	—	60.0	—	58.3	—	—	*	—	—	—	—	—	NA	NA
INITIAL	60.0		60.1		59.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	60.2	61.4	61.9	58.3	61.1
	SD	7.0	6.3	6.3	5.7	6.9
	N	84	31	63	36	39
FEMALE	MEAN	58.9	59.5	57.1	62.6	56.5
	SD	7.1	7.3	7.7	9.1	7.5
	N	39	24	29	27	15



CALCULATION 264

MEASURE 4PTA 12-59/6-16

NAME PALATAL PLANE / LOWER INCISOR AXIS

INITIAL TO FINAL

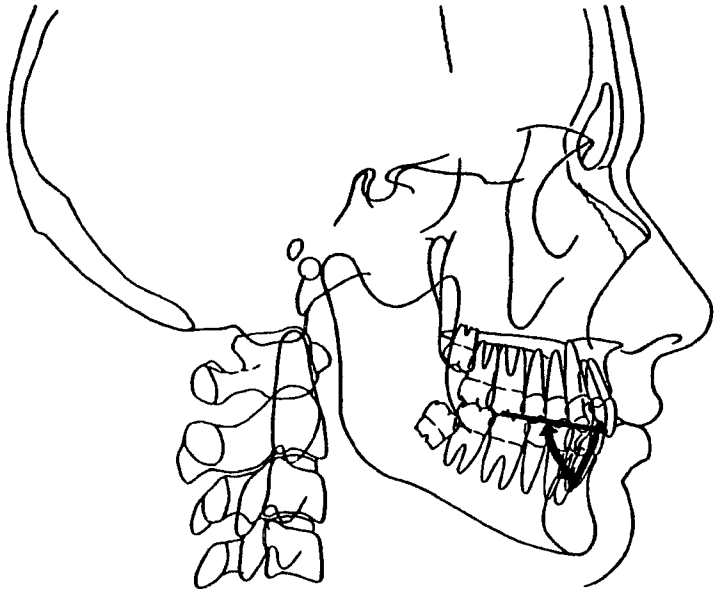
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
54	59	-.2	3.7	9.2	-9.1	-.2	.96

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	62.4	—	63.4	—	60.0	***	*	—	—	—	—	—	**	NA	NA
INITIAL	62.5		62.9		61.7										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	63.1	63.2	64.7	62.1	63.7
	SD	6.7	5.6	5.9	6.1	7.2
	N	84	31	63	36	39
FEMALE	MEAN	60.2	59.7	58.6	63.4	59.1
	SD	6.4	6.6	7.4	7.8	6.4
	N	39	24	29	27	15



CALCULATION 265

MEASURE 4PTA 7-24/6-16

NAME DOWNS OCCLUSAL PLANE / LOWER INCISOR AXIS

INITIAL TO FINAL

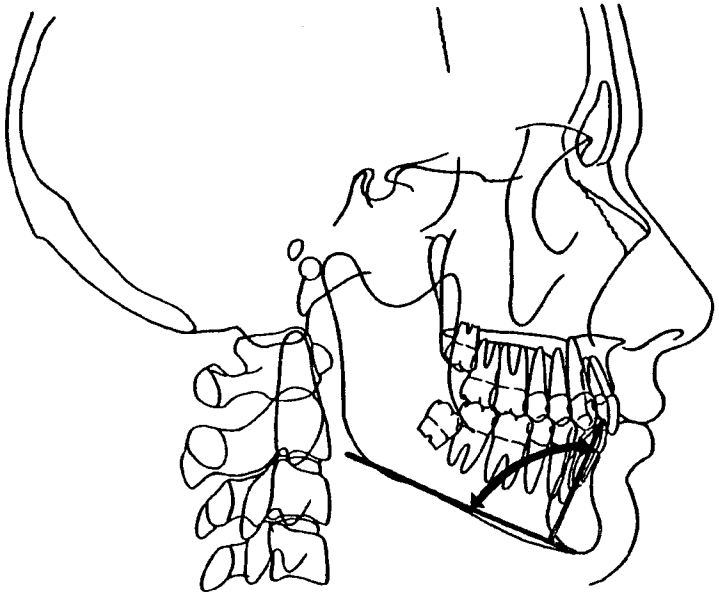
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
56	57	.1	4.0	11.3	-8.7	.2	.94

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	68.2	—	68.3	—	67.8	—	—	—	—	—	—	—	—	NA	NA
INITIAL	68.1		67.9		68.4										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	68.5	68.0	69.0	66.6	68.6
	SD	6.0	6.4	5.9	5.5	6.6
	N	84	31	63	36	39
FEMALE	MEAN	67.1	66.5	67.0	70.5	67.2
	SD	5.9	6.1	7.0	7.2	7.0
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 266

MEASURE 4PTA 1-32/16-6

NAME MANDIBULAR PLANE / LOWER INCISOR AXIS

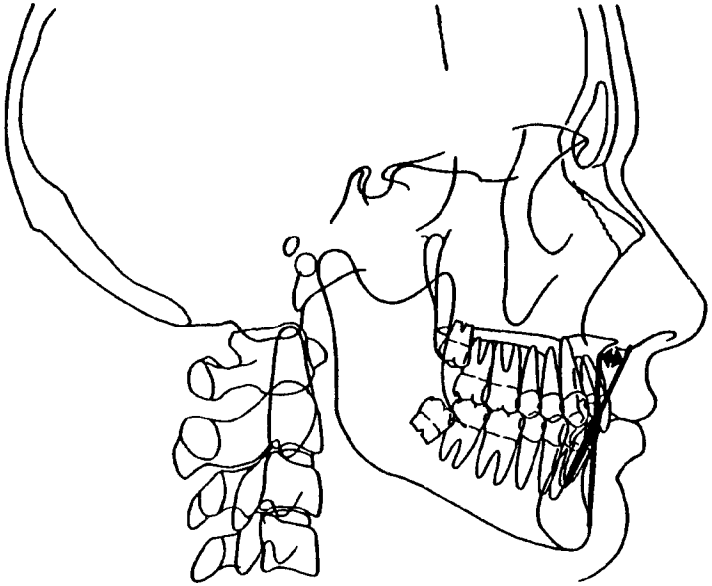
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
64	49	.5	3.1	8.7	-7.9	.5	.96

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	r UNTX
FINAL	96.7	—	97.0	—	95.7	—	—	—	—	—	—	—	—	NA	NA
INITIAL	96.2		96.7		94.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	95.8	96.9	96.5	99.9	97.2
	SD	6.7	6.6	7.2	5.9	7.4
	N	84	31	63	36	39
FEMALE	MEAN	95.6	95.6	96.3	94.8	97.5
	SD	6.8	6.6	6.1	7.1	6.8
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 267

MEASURE 4PTA 3-11/16-6

NAME A POINT-POGONION / LOWER INCISOR AXIS

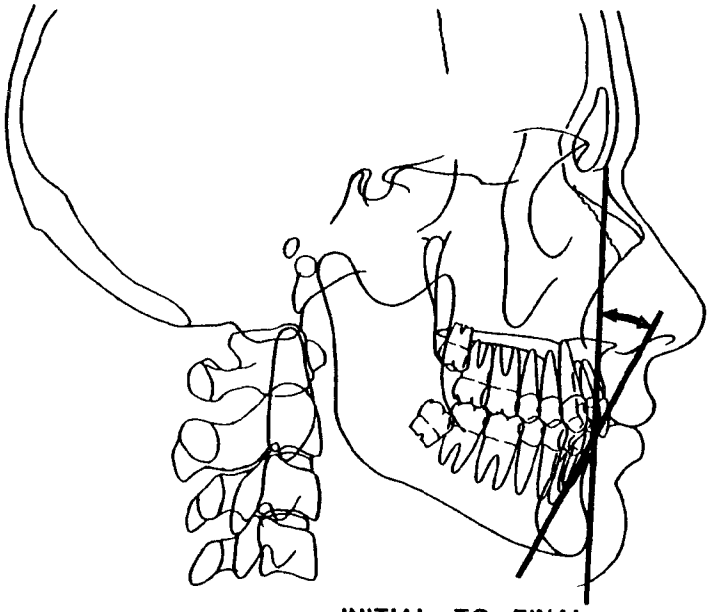
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
60	53	-.1	2.9	7.6	-9.1	.2	.92

	UNTREATED												TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+		T P	T UNTX	T P	T UNTX
FINAL	24.6	—	24.3	—	25.4	—	—	—	—	—	—		—	—	NA	NA
INITIAL	24.7		24.6		24.9											

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	24.4	24.7	23.7	25.5	23.3
	SD	4.8	3.9	4.4	3.8	5.1
	N	84	31	63	36	39
FEMALE	MEAN	25.1	26.2	25.3	23.2	25.7
	SD	4.5	4.9	4.8	4.5	4.4
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 268

MEASURE 4PTA 4-54/16-6

NAME NASION-POGONION / LOWER INCISOR AXIS

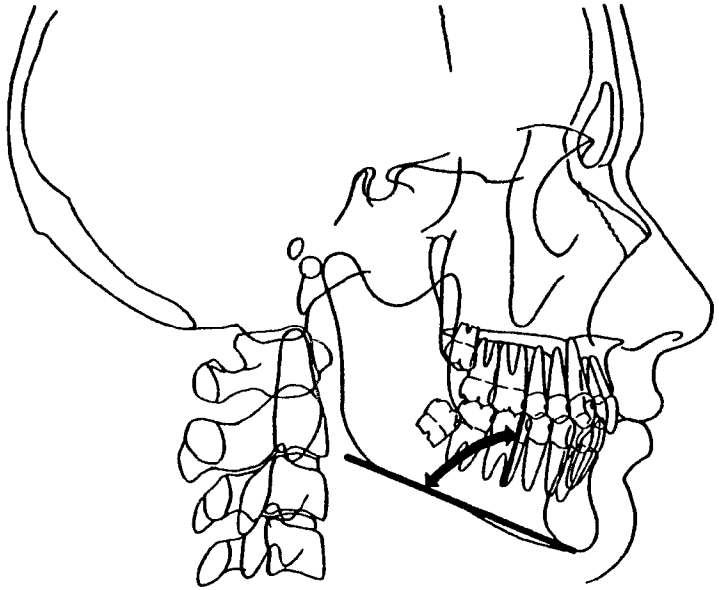
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
59	54	-.2	3.2	7.2	-8.4	-.4	.97

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	24.4	—	23.8	—	25.7	—	—	—	—	—	—	—	—	NA	NA
INITIAL	24.6		24.4		25.1										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	24.0	23.9	23.2	26.2	23.0
	SD	6.3	5.4	5.8	5.5	6.8
	N	84	31	63	36	39
FEMALE	MEAN	26.3	26.9	27.6	23.5	26.7
	SD	6.2	6.1	6.7	7.0	6.0
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 269

MEASURE 4PTA 32-1/25-20

NAME MANDIBULAR PLANE / LOWER MOLAR AXIS

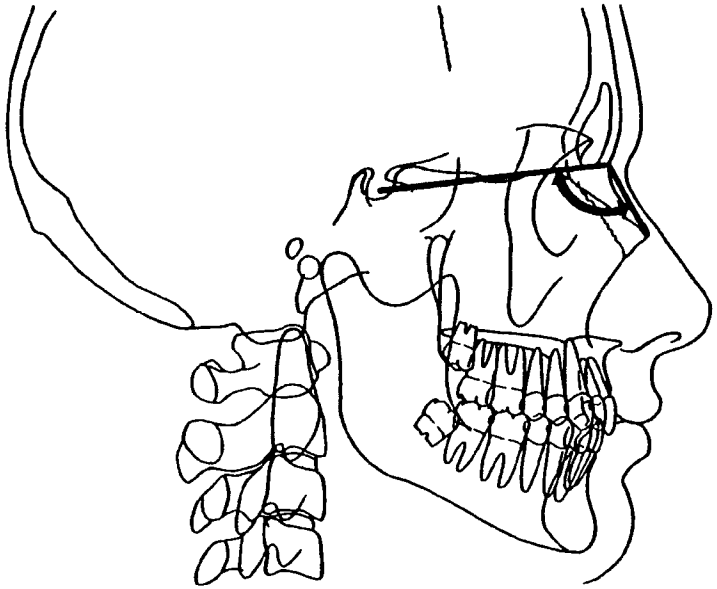
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
62	51	.4	4.5	14.6	-13.2	.7	.80

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	85.3	—	85.0	*	85.8	—	*	—	—	—	—	—	*	NA	NA
INITIAL	84.8		84.0		86.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	83.2	83.8	83.9	85.8	85.6
	SD	6.0	6.7	7.1	6.3	6.6
	N	84	31	63	36	39
FEMALE	MEAN	86.1	84.6	86.0	85.7	88.0
	SD	5.5	5.0	5.2	4.4	6.6
	N	39	24	29	27	15



CALCULATION 270

MEASURE 3PTA 46-54-55

NAME SELLA-NASION-NASAL TIP

INITIAL TO FINAL

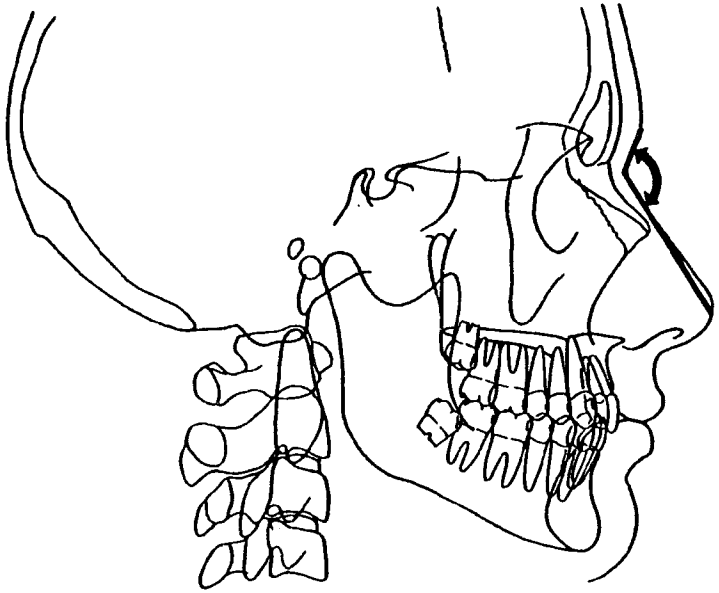
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
70	43	.2	2.3	4.6	-12.0	.2	.98

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	115.5	—	116.9	*	112.2	—	***	—	—	—	—	—	—	*	**
INITIAL	115.3		116.4		112.8										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	115.9	116.6	115.9	117.6	117.8
	SD	6.3	7.4	6.3	7.5	7.0
	N	84	31	63	36	39
FEMALE	MEAN	112.8	113.5	113.4	111.8	112.7
	SD	4.9	4.8	5.7	4.7	4.9
	N	39	24	29	27	15



CALCULATION 271

MEASURE 3PTA 75-76-77

NAME SOFT TISSUE: GLABELLA-NASION-NOSE POINT A

INITIAL TO FINAL

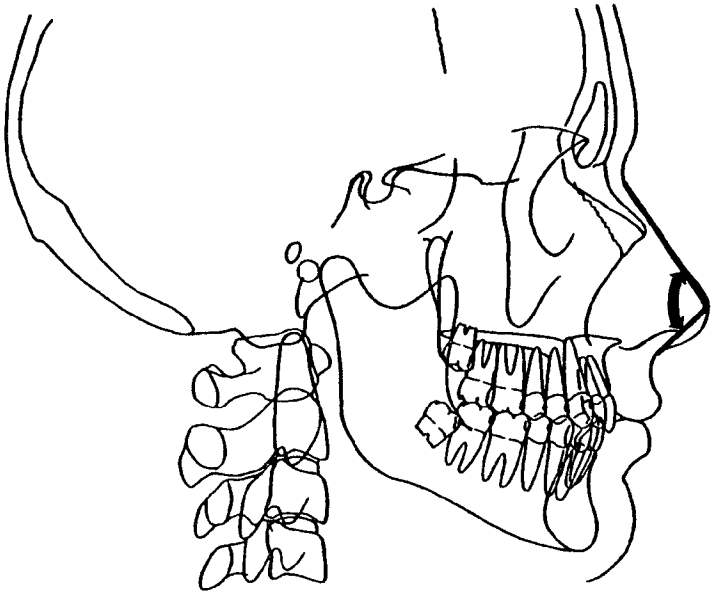
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
66	47	1.7	8.1	23.6	-26.7	1.5	.97

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	129.6	*	129.9	—	133.7	***	—	**	—	—	—	—	—	*	—
INITIAL	129.3		129.4		129.2										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	129.6	130.2	128.3	129.0	130.7
	SD	8.0	7.4	6.7	10.1	8.8
	N	84	31	63	36	39
FEMALE	MEAN	128.4	128.8	127.9	131.9	135.0
	SD	3.7	5.3	4.8	6.2	8.7
	N	39	24	29	27	15



CALCULATION 272

MEASURE 3PTA 76-77-79

NAME SOFT TISSUE: NASION-NOSE POINT A-SUBNASALE

INITIAL TO FINAL

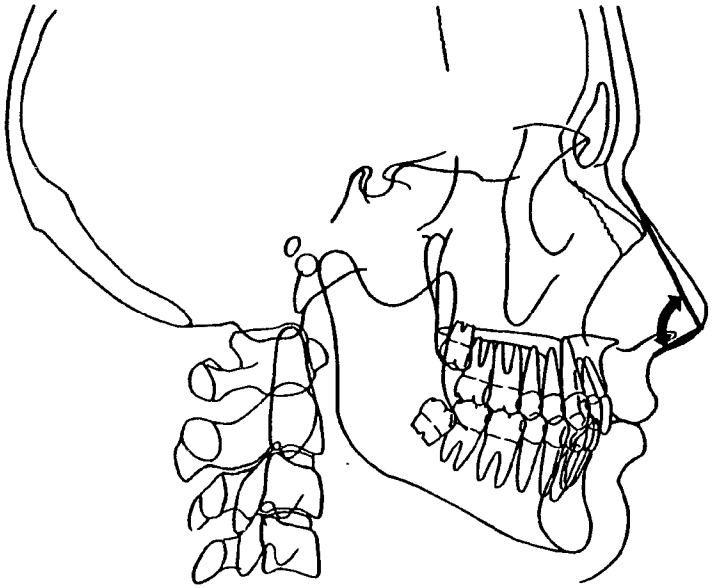
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
17	96	-4.7	4.2	5.0	-16.3	-4.8	.93

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	91.8	***	91.2	***	93.3	***	**	***	**	—	—	***	—	***	—
INITIAL	96.5		95.9		97.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	97.8	95.2	94.2	90.4	90.6
	SD	4.7	4.7	4.2	5.2	4.4
	N	84	31	63	36	39
FEMALE	MEAN	99.1	97.3	95.4	94.2	94.2
	SD	4.2	5.2	5.3	4.8	5.3
	N	39	24	29	27	15



CALCULATION 273

MEASURE 3PTA 76-78-79

NAME SOFT TISSUE: NASION-NOSE POINT B-SUBNASALE

INITIAL TO FINAL

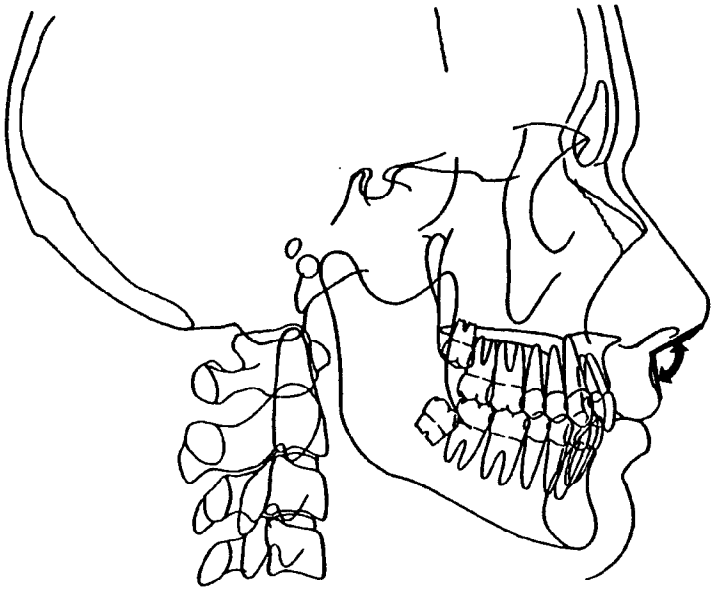
UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
15	98	-5.0	4.2	5.6	-15.3	-5.4	.86

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	85.5	***	84.5	***	87.7	***	**	***	***	*	—	***	—	**	—
INITIAL	90.5		89.8		91.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	91.6	88.9	87.7	84.2	83.3
	SD	5.3	5.4	4.8	5.9	5.0
	N	84	31	63	36	39
FEMALE	MEAN	93.0	91.7	90.1	88.6	88.5
	SD	4.6	5.9	5.9	4.8	6.1
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 274

MEASURE 3PTA 78-79-81

NAME SOFT TISSUE: NOSE POINT B-SUBNASALE-UPPER LIP ANTERIOR

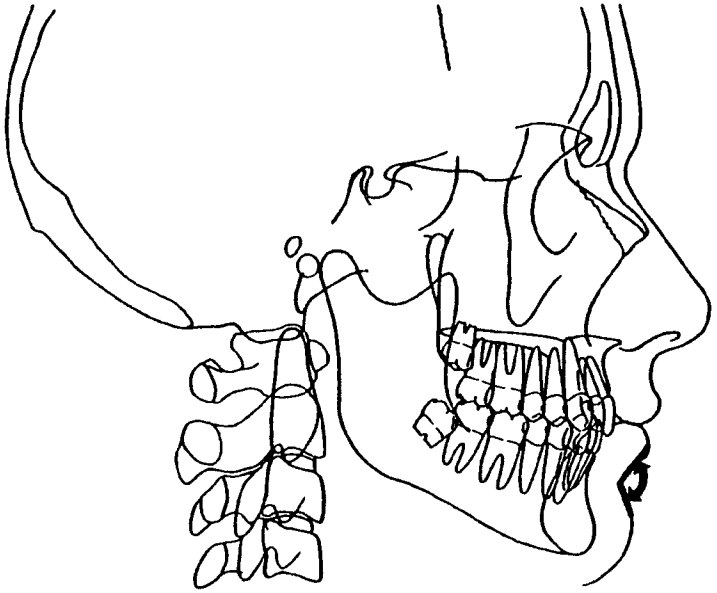
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
35	78	-4.3	7.0	8.7	-28.5	-3.6	.90

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	111.6	***	111.2	***	112.3	***	—	***	**	**	—	*	—	—	—
INITIAL	115.8		115.1		117.5										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	115.3	110.1	114.5	114.0	108.5
	SD	10.7	10.1	10.7	9.9	11.0
	N	84	31	63	36	39
FEMALE	MEAN	118.4	117.0	116.2	115.5	109.5
	SD	7.7	9.8	9.2	6.5	9.4
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 275

MEASURE 3PTA 83-84-85

NAME SOFT TISSUE: LOWER LIP ANTERIOR-B POINT-POGONION

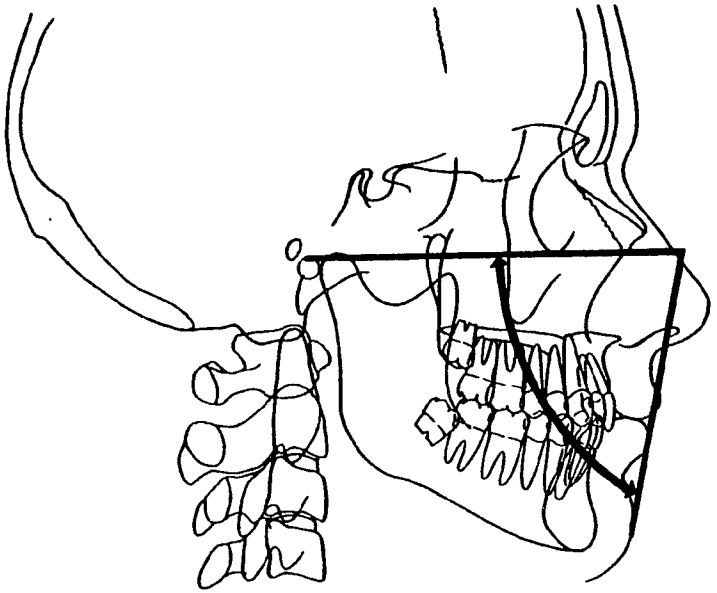
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
87	26	6.4	9.4	33.5	-22.8	5.4	.95

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	131.6	***	129.8	***	136.0	***	**	***	**	—	—	—	—	*	***
INITIAL	125.2		124.0		127.9										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	124.5	121.4	125.0	128.1	131.2
	SD	9.4	11.4	9.7	13.1	12.9
	N	84	31	63	36	39
FEMALE	MEAN	125.8	127.2	130.9	136.2	133.1
	SD	10.8	8.4	9.9	13.6	12.0
	N	39	24	29	27	15



INITIAL TO FINAL

CALCULATION 276

MEASURE 4PTA 57-44/83-85

NAME FRANKFORT PLANE / SOFT TISSUE: LOWER LIP-POGONION

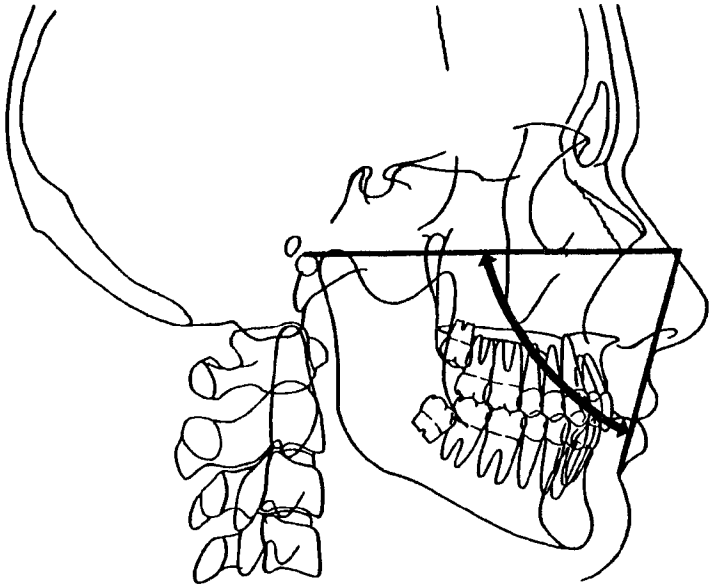
INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
84	29	3.7	5.5	20.4	-12.6	5.2	.99

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	77.8	***	77.6	***	78.3	***	—	—	—	—	—	**	—	—	—
INITIAL	74.1		73.8		74.8										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	72.8	74.1	76.6	77.0	79.9
	SD	7.7	7.7	7.5	7.8	7.7
	N	84	31	63	36	39
FEMALE	MEAN	73.2	74.9	72.1	79.1	79.7
	SD	7.2	6.6	7.0	8.4	4.6
	N	39	24	29	27	15



CALCULATION 277

MEASURE 4PTA 57-44/80-84

NAME FRANKFORT PLANE / SOFT TISSUE: A POINT-B POINT

INITIAL TO FINAL

UNTREATED							
GAIN	NO GAIN	MEAN DELTA	DELTA SD	MAX. DELTA	MIN. DELTA	MEAN %	R^2
72	41	2.0	4.3	15.0	-8.5	2.9	.97

INITIAL TO FINAL

	UNTREATED											TREATED		DENTAL	
	MEAN GROUP	T P	MEAN MALE	T P	MEAN FEMALE	T P	T SEX	T 25+	T 30+	T 35+	T 40+	T P	T UNTX	T P	T UNTX
FINAL	73.4	***	72.1	***	76.4	***	***	—	—	—	—	—	—	—	***
INITIAL	71.4		70.2		74.0										

UNTREATED BY AGE

SEX	STAT.	17-18	19-20	21-30	31-50	51-83
MALE	MEAN	70.4	71.5	71.4	70.7	73.7
	SD	5.3	6.3	6.1	6.4	7.1
	N	84	31	63	36	39
FEMALE	MEAN	73.5	75.0	71.5	78.2	76.2
	SD	5.8	5.5	5.4	9.1	5.4
	N	39	24	29	27	15

APPENDIX B

In Search of Truth for the Greater Good of Man:

A Chronological Account of the Bolton-Brush Growth Studies.

This account begins as all other significant research undertakings always begin: with researchers and their ideas preceding the research. Often, when opportunity is provided, men who are energetic, intelligent, committed, resolute, visionary, and interested in investigating man, significant contributions to humanity are possible. This is obviously true for those in the Bolton-Brush Growth Studies, beginning with the strong leadership of Dr. T. Wingate Todd and Dr. B. Holly Broadbent.

1907

The history of The Studies start with Dr. T. Wingate Todd (1885-1938) who in 1907, upon graduation with honors from the University of Manchester Medical School, subsequently served for four years there as a demonstrator and lecturer in surgical anatomy. He cultivated a lifelong interest in anthropology and developed interests in pediatrics and radiology.

1912

In this year Dr. Carl Hamann was named the Dean of the Western Reserve Medical School, and he requested Sir Arthur Keith, a world renouned anatomist and anthropologist, to recommend his own replacement in Anatomy. Dr. Keith suggested Dr. Todd. Thus, in 1912, Dr. Todd (Figure 1) was enticed to come to the United States to accept appointment in the Department of Anatomy in the School of Medicine of Western Reserve University as the first

①

Henry Wilson Payne Professor of Anatomy. In 1915 Dr. Todd interupted his teaching to join the Canadian army during WWI.

1918

Dr. Todd returned to teaching at his former post. He continued and expanded his early interests in the areas of comparative and human anatomy with a special emphasis on pediatric anatomy. During years following he expanded and developed a superb collection of human and primate skeletal materials in the anatomical museum initiated under his predescessor, Dr. Hamann. This was later to be known as the Todd-Hamann Collection comprising literally thousands of human and primate skeletons (now housed and actively utilized at the Cleveland Museum of Natural History). The human material of the collection resulted from Todd's keen interest in human anatomy, especially for children. In search of more and more knowledge in this area, he and others convinced the Ohio General Assembly to pass legislation permitting local hospitals, the Cleveland Workhouse, and undertakers to donate cadavers to medical schools for research and teaching. For a dozen years thereafter he was able to study the cadavers of unclaimed pauper children of Cleveland.

In these studies, in which it is said he studied as closely and tenderly as he did the living, the results were rewarding--resulting in numerous publications--but to him also limited and frustrating. Most of the children had secumbed to diseases such as tuberculosis.

Todd realized that disease had distorted and retarded the body growth processes and therefore results based on dissecting room material had limited applications to normal growth and development. He spoke of this often, apparently from frustration, as he felt science knew more about sickness and abnormality than health. As a result he felt medicine taught mainly only the recognition of established disease, and that the teaching of normal growth was based improperly on non-normal material.

In recognition of these limitations Todd desired:

> ...the opportunity to investigate developing organs under favorable circumstances, and anatomy plus radiography and observations of healthy children can provide this opportunity....forward from the cradle, not backward from the morgue.

1924

In this year a development which would later prove very significant began with the appointment of Dr. B. Holly Broadbent Sr. (1894-1977) as a research fellow in the Department of Anatomy under Dr. Todd.

Dr. Broadbent, in 1914 while working in a drafting room of Wellman, Sever & Morgan Co. (running a shop, preparing machine plans), met Dr. Varney Barnes through son Dick, who was a Boy Scout. This association led to an interest in dentistry, and in 1916 he entered the Western Reserve University Dental School. Studying anatomy under Dr. Todd, Holly Broadbent began to develop his life-long interest in facial morphology and growth. In 1919 he graduated from Dental School and then worked with Dr. W. E.

Newcomb as a clinical associate until 1921. He married Bernice Mathews and traveled to California to attend the famous Angle School of Orthodontia, from which he graduated in 1924.

In 1924, Dr. Broadbent, now an orthodontist, had become interested in dentofacial research. One of his first contributions was the idea to include a metric scale on Dr. Todd's craniostat (an instrument used to hold a skull in a fixed position) which permitted direct measurements of dentofacial structures on dry skulls (i.e., the craniometer).

1925

Dr. Broadbent, with Dr. Todd's help, extended the capabilities of the craniometer by adding an x-ray film holder (i.e., the roentgenographic craniometer). This made possible precise standardization of cranial x-rays using dry skulls.

During this time, in his orthodontic practice, Dr. Broadbent had been using non-standardized lateral head x-rays of his patients, obtained from the firm of Hill and Thomas, to help in diagnosis by determining facial and soft tissue relationships. However, it was obvious that without standardization these lateral x-rays could not meaningfully demonstrate changes through time.

1926

In this year, Dr. Broadbent adapted the roentgenographic craniometer, previously used for holding only dry skulls in a fixed

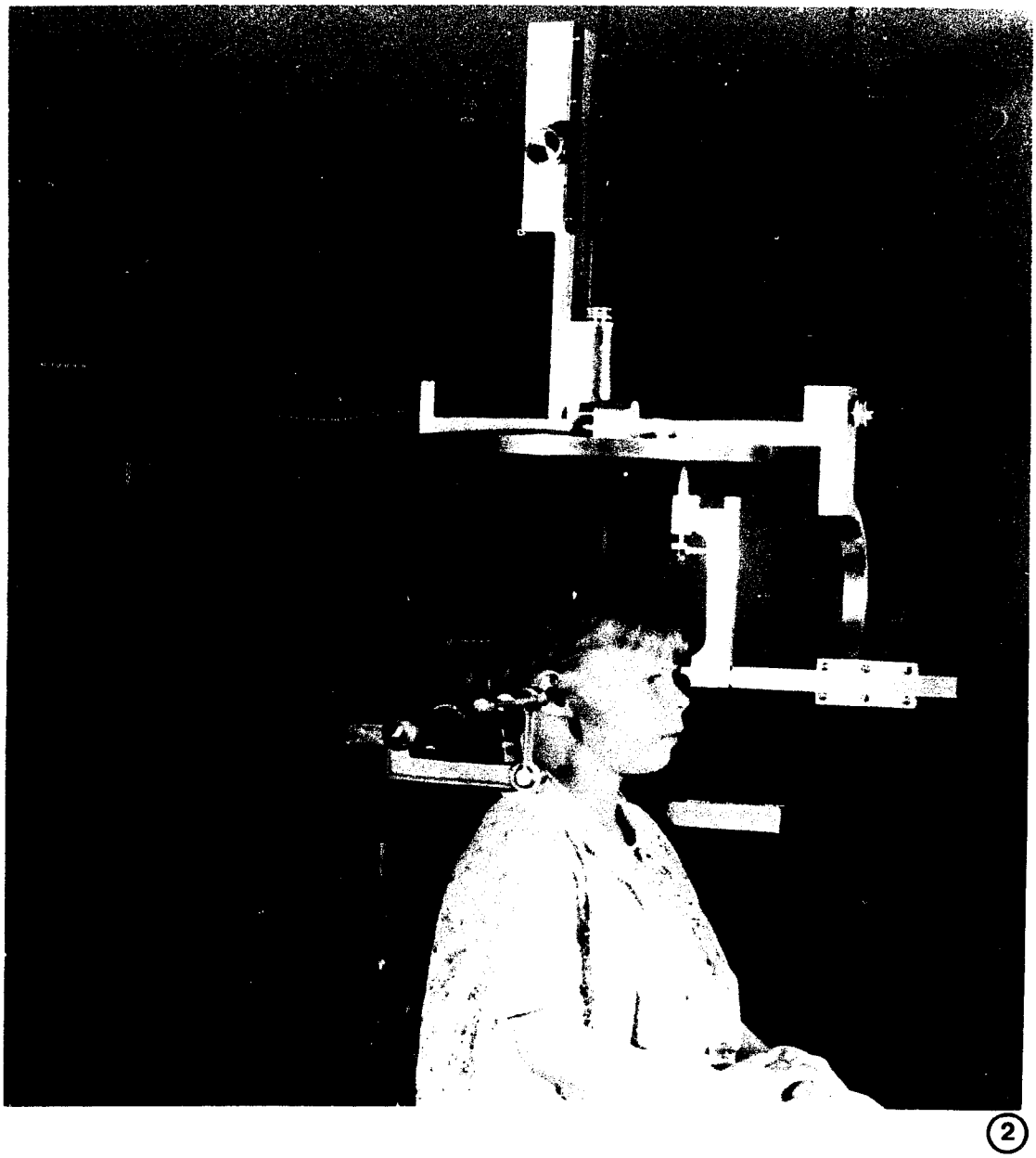
position, to hold the head of a living subject while precise lateral and posteroanterior radiographs were taken (i.e., the roentgenographic cephalometer). The prototype was made of wood and a short time later remade in metal in the Department of Anatomy machine shop, thus introducing a standardized piece of equipment, and the procedure to use it, permitting precise, reproducible, comparable x-rays of a child's growing face at intervals on through to adult life. Detailed internal study of the growing head and face in individual children through time had now become possible (Figure 2).

Dr. Broadbent demonstrated that:

1. The application of precise methods of measurement used by the physical anthropologist in orthodontic practice was a decided advantage toward a more scientific solution of orthodontic problems.

2. By means of a headholder and a standardized roentgenographic technique, it is possible to make accurate determinations of changes in the living head resulting from growth or orthodontic treatment.

3. Such a technique permitted study and measurement of these changes in the same individual. This eliminated the uncertainty of measuring changes by comparison of dimensions of different individuals at successive ages.



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4. This roentgenographic technique registered the craniometric landmarks of the face, cranial base of the living head which, heretofore, had only been measured on dead skulls with the craniostat.

5. Present (then) standards compiled from measurements of the dry skulls of children were largely a measure of inappropriate material. A dead child could represent an anatomically a defective one because growth could have been affected by whatever condition previously existed.

6. This craniometric technique has the decided advantage of not requiring determination of hard-tissue landmarks deep to the covering of soft tissues of uncertain thickness.

7. Such roentgenograms reveal areas in the cranial base that show little change between certain ages. These areas offer more stable reference structures for relating x-ray tracings and afford a very accurate base for measuring changes in the teeth, jaws and face.

1926

The Early Studies

In this year and continuing into 1927 Dr. Todd, working out of the Department of Anatomy with a small grant from the Cleveland Health Council and with the approval of the Cleveland

Board of Education, conducted a limited study (600 children) on the health of well-developed children in the Stearns Road Grade School. (Unfortunately these children were lost to follow-up due to a temporary interruption of funds in 1928.)

1927

The above mentioned project, provided impetus for continuing exploratory, longer-term studies into the characteristics of a healthy child, and a three year exploratory study was begun. Todd arranged summer exams for ages 6-14 through the Cleveland Board of Education and the staffs of two public schools. These exams were conducted as a health "contest" among the children, the reward being a short holiday at a summer camp under the auspices of the Cleveland Welfare Federation and the local press.

The study, involving more than 200 children and conducted with the assistance of graduate students and medical students, consisted of standard anthrpometric exams (external body measures), an assessment of present health, radiographs of 6 areas of the body, various behavioral responses and a recording of familial background. Children with problems were referred to family physicians. The results of the studies were reported to the administrators and teachers who had helped in conducting the study, and the winners went off to camp.

1928

This year was significant in many ways. The initial summer

examination study was again conducted with groups of children from other schools plus some of the original group recalled for a second examination. Thus at the end of the second summer just over 700 examinations of individual children had been conducted.

Also in 1928 the soundness and worth of the project was recognized locally and Nationally. It was realized that the nature of human growth processes were clarified when data collected consecutively was added to school records, parental observations and examinations by the family physician. In this regard new funds for conducting studies such as these now became available. Several philanthropic organizations (Laura Spelman Rockefeller Memorial, General Education Board of the Rockefeller Foundation, U. S. Public Health Service) matched community grants-in-aid for the longitudinal study of healthy children across the United States in order to improve the National standards for reference of growth. Community funds were given notably by the Brush Foundation and the Bolton Fund, among others (Cleveland Foundation, Associated Foundations, etc.).

The year of 1928 was notable, further, in regard to the input of Charles Francis Brush (1849-1929). This man (Figure 3) was a world famous inventor-genius responsible for the development, for example, of the arc light, open coiled dynamo, storage battery, and liquid air. His electric company later was consolidated to form the General Electric Company. He enjoyed lifelong interests in such diverse subjects as electricity, gravity, outer space, and race betterment. Following his son's untimely death, he created in

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his memory the Brush Foundation by establishing a research fund of $500,000. The mission was research and education toward "the end that children shall be begotten only under conditions which make possible a heritage of mental and physical health, and a favorable environment."

In October of 1928, the first research program undertaken by the Brush Foundation was entitled "Health Inquiry" under the direction of T. Wingate Todd. The purpose was to search out the "normal developmental growth process". Dr. Todd was chosen by Mr. Brush as a logical choice (described as: a skeletal anatomist, pediatrician, brave, persuasive, broadly cultivated, contagiously enthusiastic, and with demonic energy) for the first Director in addition to his duties as Professor of Anatomy in the School of Medicine.

Also in 1928 it had become clear that Dr. Broadbent's work was making a unique contribution to precision radiography. Discussions of this new technique with the Honorable Frances Payne Bolton had already began in 1926. This lady was well known for her lifetime devotion to public service (later serving in the Congress of the United States), philanthropy and interest in normal childhood growth (Figure 4). Subsequently, encouraged by Dr. Broadbent and Dr. Todd, Frances Payne Bolton and her son established the Charles Bingham Bolton Fund in October of 1928. It was designed to subsidize a period of study covering five years as an independent but coordinated study in conjunction with the Brush Inquiry. The intent of the study was to determine what occurred

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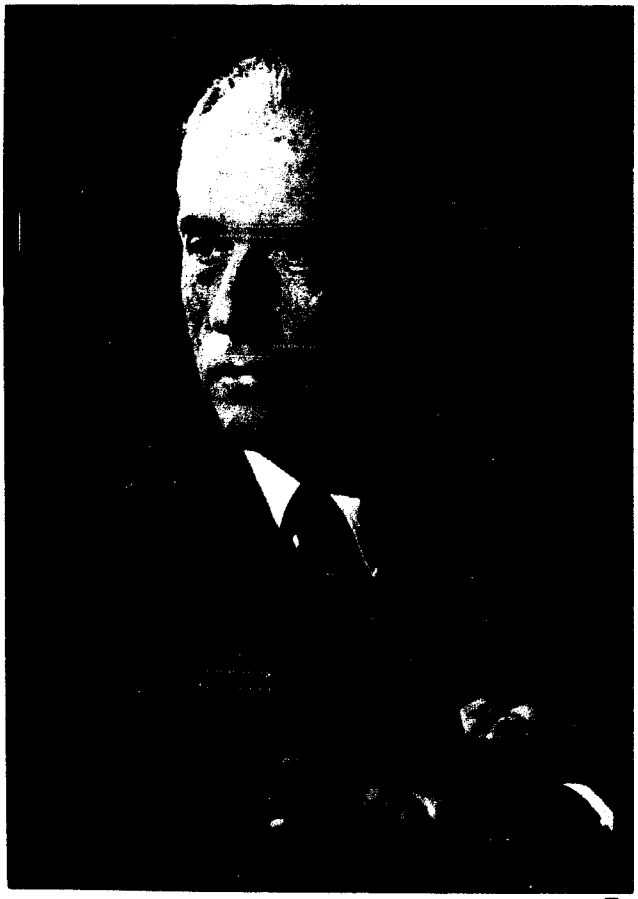

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in the facial skeleton and dental areas during growth and development. This major effort subsequently became known as the Bolton Study of the Development of the Face of the Growing Child. Support continued well beyond the initial five year period, with son Charles Bingham Bolton (Figure 5) participating as a prominent research associate. It was then the largest privately endowed research program in all of dentistry. Mrs. Bolton also encouraged other comparable studies over the years by providing some 40 cephalometers to many institutions and researchers throughout the United States as well as abroad (Table I).

1929

On May 29, 1929 it was announced to the public that a Cleveland center for the longitudinal study of children was to be established and to be named the Brush Inquiry.

It was hoped that the study of living children, with growth, development and maturation documented at successive intervals through the childhood years, would show why some thrived and others did not. The aim was more than saving children from disease, it was to determine how to confer on them such physical and mental superiority as to ensure life and happiness. The year 1929 was also historic in that in May, Dr. Broadbent presented a paper demonstrating the cephalometric technique which, along with some other of his papers and presentations, predate the landmark publication "A New X-Ray Technique and its Application to Orthodontia" (1931, Figure 6).

TABLE I

BOLTON ROENTGENOGRAPHIC CEPHALOMETERS SOLD OR DONATED TO INSTITUTIONS OR INDIVIDUALS

Institutions

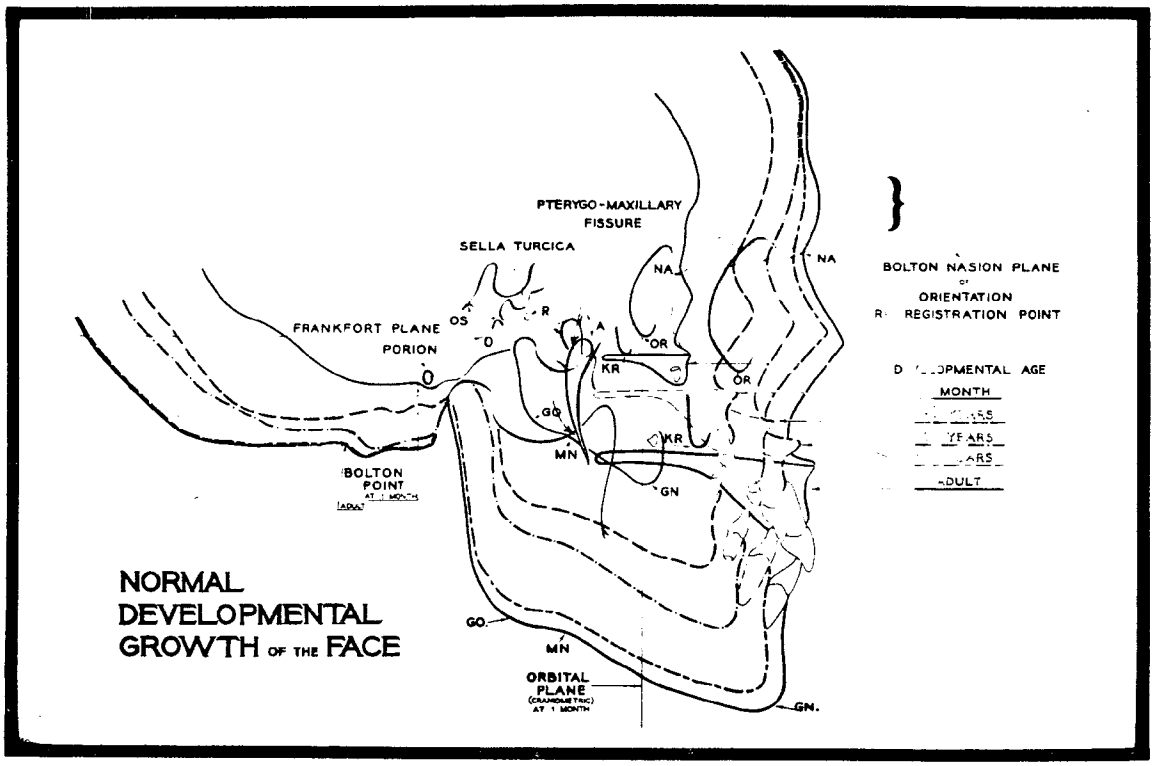
1. Army Medical Center, Army Medical Department and Graduate School, 1949, Washington, D.C.
2. Baylor University, 1963-1964, Dallas, Texas
3. University of Buffalo, 1953, Buffalo, New York
4. University of California, 1942, San Francisco, California
5. Eastman Dental Dispensary, 1960, Rochester, New York
6. Albert Einstein Medical Center, 1959, Philadelphia, Pennsylvania
7. Forsyth Infirmary attached to Harvard University, 1940, Boston, Massachusetts
8. Guy's Hospital Dental Department, 1955, London, England
9. Hebrew University, 1962, Jerusalem, Israel
10. Hillman Hospital, 1945, Birmingham, Alabama
11. University of Illinois, 1932, Chicago, Illinois
12. University of Indiana, 1960, Indianapolis, Indiana
13. University of Manitoba, 1960, Winnipeg, Manitoba, Canada
14. Marquette University, 1957, Milwaukee, Wisconsin
15. Mayo Clinic, 1958, Rochester, Minnesota
16. College of Medical Evangelists, Loma Linda University, 1955, Loma Linda, California
17. University of Melbourne, 1950, Melbourne, Victoria, Australia
18. University of Minnesota, 1954, Minneapolis, Minnesota
19. Mount Sinai Hospital, 1955, Cleveland, Ohio
20. National Institutes of Health, Department of Health, Education and Welfare, 1954, Bethesda, Maryland
21. University of Nebraska, 1954, Lincoln, Nebraska
22. New York University, 1949, New York, New York
23. Northwestern University, 1942, Chicago, Illinois
24. Northwestern University, 1963, Chicago, Illinois
25. Ohio State University, 1954, Columbus, Ohio
26. University of Oregon, 1949, Portland, Oregon
27. Oxford University, 1954, Oxford, England
28. University of Pennsylvania, T. W. Evans Museum, 1949, Philadelphia, Pennsylvania
29. University of Pennsylvania, 1964, Bryn Mawr, Pennsylvania
30. University of Pittsburgh, 1963, Pittsburgh, Pennsylvania

TABLE I CONTINUED

31. Seton Hall University, 1958, Orange New Jersey
32. University of Southern California, 1950, Los Angeles, California
33. University of Tennessee, 1954, Memphis, Tennessee
34. University of Texas, 1955, Houston, Texas
35. University of Toronto, 1950, Toronto, Ontario, Canada
36. University of Washington, 1949, Seattle Washington
37. Washington University, 1949, St. Louis, Missouri
38. West Virginia University, 1960, Morgantown, West Virginia

Individuals

1. Dr. J. William Adams, 1954, Indianapolis, Indiana
2. Dr. Arthur Lewis, 1949, Dayton, Ohio
3. Dr. Phelps J. Murphey, 1954, Dallas, Texas
4. Dr. Morse R. Newcomb, 1950, Shaker Heights, Ohio
5. Drs. Frederick and Harold Noyes, 1939, Chicago, Illinois
6. Dr. William M. Thompson, 1954, Pittsburgh, Pennsylvania


PTERYGO-MAXILLARY FISSURE
SELLA TURCICA
NA
NA
FRANKFORT PLANE
PORION
OS
R
A
OR
KR
OR
GO
KR
MN
GN
BOLTON POINT
AT 1 MONTH
ADULT
GO.
MN
ORBITAL PLANE
(CRANIOMETRIC)
AT 1 MONTH
GN.
BOLTON NASION PLANE
OR
ORIENTATION
REGISTRATION POINT
DEVELOPMENTAL AGE
MONTH
YEARS
YEARS
ADULT
NORMAL
DEVELOPMENTAL
GROWTH OF THE FACE

6

Charles Brush died June 15, 1929 at the age of eighty. His will provided for the study of race improvement and the rationale for world-wide population limitation. A grant-in-aid for a period of five years was provided from his estate to extend the Western Reserve University Study into a comprehensive longitudinal study of the attributes of healthy growth.

Thus, with a continuation study established, the third annual health contest was extended over a six month period in 1929, and it took on special importance. Each school homeroom was asked to select a boy and a girl who best exemplified ideal health. Teachers and students also selected those who were judged as the scholastic and social best. In that summer, 104 finalists were examined and on the basis of some 900 factors, the winners were named.

More importantly, perhaps, this contest was also used to broaden the scope of previous examinations and evaluate a carefully structured set of research tests for the long term studies. Many notable Cleveland specialists and other Nationwide scientists aided Dr. Todd in preparing the record protocol used in 1929 and eventually in the longitudinal study. Tests were organized in five different areas (Table II).

The 1929 recruitment of subjects was also carefully planned in regard to preparing for a longitudinal study and consideration of the attributes of optimum growth rates and the conditions affecting them. Many more schools had become involved in the contests (Table III).

TABLE II

TESTS

1. Physical

   list of body measures (25)
   radiographs of 6 skeletal areas (hand, elbow, shoulder, hip, knee and foot)

2. Mental

   psychological tests
   behavioral tests

3. Functional Health Inquiry

   family physician reports
   hand-eye coordination tests
   psychomotor development
   food preference inquiry
   strength of muscle test
   foot prints in weight bearing and sitting

4. Genetic and Environmental Antecedents

   questionnaire about personal and family education, health status, familial illnesses tendencies, occupation and recreation

5. Dentofacial

   photographs
   tooth and mouth conditions
   unique radiographs of jaw alignment
   tooth impressions

TABLE III

SCHOOLS INVOLVED IN THE STUDIES

Public Schools

Cleveland
East Cleveland
Cleveland Heights
Shaker Heights
Lakewood
Euclid

Private Schools

Western Reserve Academy
University School
Hawken School
Hathaway Brown School
Laurel School
Park School

Nursery Schools

School of Education
Western Reserve Nursery School
Day Nursery Association

By the fall of 1929 all plans and forms had been finalized, and Drs. Todd and Broadbent were actively recruiting participants for the longitudinal study about to begin.

1930-1938

This period was marked by intense activity by both the Brush and Bolton Studies. Every three months in babyhood (0-1 year of age); every six months until 5 years and then every year through adolescence, children returned to the study (usually on birthdays) for sometimes two full days of testing during which they shuffled about in paper slippers, were measured, x-rayed, put blocks in holes, were tested for steadiness of hand, drew pictures, took tests, etc.

At one time Dr. Todd had some 50 assistants making every relevant observation and test at every visit. In spite of the ever increasing activity all tests were performed in a way as to provide comfort, instill confidence and provide for a sense of security for the children. Most children looked forward with enthusiasm to the next visit.

Also during this time new participants were continually recruited into the study, or rather were invited. At various times babies were selected, at other times adolescents, and some adults. All were studied consecutively (serially) for varying numbers of years (Figures 7-11).

The participants have often been characterized as selected from the privileged, rich, upper class, and families where the hus-

THE
BRUSH FOUNDATION

1931

2109 ADELBERT ROAD
CLEVELAND

Dear Mr. and Mrs.

Would you be interested in having your child undergo a physical examination by the Brush Foundation at regular time intervals for several years? Our research division is making a study of the physical and mental development of young children and we are particularly anxious to carry on an intensive study of three hundred selected children over a period of years. The plan of this study involves the examination of:

1. Children under one year of age every three months.
2. Children between one year and five years of age every six months.
3. Children over five years of age once a year.

We believe that your child is in the----------age group. If you decide to join us in this endeavor it is essential that you do your part by keeping a record which would involve about a half hour's work each week. We will, of course, explain this in greater detail at your first visit. The record thus made will form an exhaustive story of your child's development and will be your property as soon as copies can be made.

It is customary for us to furnish the parents and the child's physician a report after each examination. We are glad to consult the latter concerning the child's record. We give advice concernihg the well-being of the children we examine, point out the need for professional attention when such is indicated by our X-ray findings and physical examinations. We do not give professional medical advice but refer all such matters to the physician in charge of the child.

Please signify your interest in participating in this research by filling out and returning the enclosed form to us.

Very truly yours,

Brush Foundation Study of Growth and Development

I wish to enroll my child in this study of growth and development.

Name _____

Address _____

Telephone number _____

Name of Child _____ Birthdate _____

Father's Name _____ Age _____

Mother's Name _____ Age _____

Name of child's physician _____

Address _____

Do you consider that you are permanent residents of greater Cleveland?

_____

Are you reasonably certain that your child will not be away from Cleveland for long periods of time during the next four years? _____

_____

Can you be reasonably certain of having your child in our offices within four days after notice? _____

Data concerning other children

Name	Birthdate	Birthplace	Sex

Do you desire to enroll your older children if they fall within one of our age groups? _____

Do you wish to consult with a member of our staff before making a final decision? _____

(1931)

Dear Mr. and Mrs.

The Brush research studies of the growth and development of young children in their progress to maturity has entered the third year. During the course of this investigation we have regularly examined the children in attendance at the Western Reserve Nursery School. The name of your child appears on the waiting list at the nursery school. We are anxious to enroll your child in our regular bi-yearly examinations now.

Our examinations consist of

1. An X-ray determination of skeletal development.
   (This is not to be confused with a regular routine physical examination.)
2. An X-ray determination of tooth and jaw development.
3. Psychological examinations of motor and mental development.

We wish to examine your child once every six months until he is five years old, and thereafter once a year. These examinations are to made within two days of his birthday and of the day marking the six months age interval.

The child's physician receives a full report after each examination and we appreciate information from him concerning the child's record. We do not give professional medical advice but refer all such matters to the physician in charge.

Please signify your interest in participating in this research by filling out and returning the enclosed form to us.

Very truly yours,

T. Wingate Todd

I

THE
BRUSH FOUNDATION

2109 ADELBERT ROAD
CLEVELAND

Dear

In reply to your inquiry the serial health examination of the Brush Inquiry is a study of the well child with a view to registering his health reserves.

The examination consists of determinations of

1. Physical growth by measurement.
2. Physical development by X-ray.
3. Neuro-muscular development by tests of muscular strength, control and coordination.
4. Mechanical ability and mental progress.

In addition, by cooperation with the Bolton Study, an investigation of the growing face, teeth and respiratory passages is made on each child.

The examination lasts about two hours and its actual cost to the Foundation is $50.00.

The Board of Admissions reviews each application. If the child can be fitted into the research program, the parents pay the sum of $25.00 per year toward the cost of examination. This sum is set as an annual subscription so that examinations can be made at whatever interval the ascertained progress of the child may indicate, without further cost to the parents.

If the parents of a child handicapped by disability or debility desire his inclusion this can be done on a consultation basis.

(10)

No child is admitted to the program without the consent of the pediatrician or family physician in charge of the child. All the technical reports of progress are made only to that physician chosen by the parents, though the parents themselves receive a shorter and more general report.

These reports are made as quickly as the facilities at the Inquiry's disposal permit. The physician in charge can always get an oral report on request a few days after the examination.

Children are examined as a routine at the following intervals.

Infants:	Every three months; i.e., 3 months, 6 months, 9 months, 12 months.
Young Children:	Every six months; i.e., on or about the birthday and mid-way between two birthdays.
Older Children:	Every year on or about the birthday.

The part which the parents undertake is full cooperation in regularly bringing in the child for examination and in providing us with a diary of dietetic and medical history as requested from time to time.

If these provisions meet your approval please notify the Admissions Secretary who will then transmit your application to the Board and report their decision to you.

Yours sincerely,

T. Wingate Todd.

band held a professional or upper managerial position. The heritage of these children has also been characterized as American-born children of Anglo-Saxon or Teutonic origins, children of Sicilian immigrants or black children. This, however, is not entirely accurate. It is an outsider's average view and, to the extent it is true is more likely incidental and not an intent. The best normal people ("well born") were selected, not the richest by any means. Dr. Todd had only a few requirements (Figure 12). In those days, these were in essence easy to satisfy if the family physician recommended participation and the parents did likewise. However, acceptance was not viewed lightly; being identified as a well-born healthy child and being included in this famous Cleveland study was considered an honor as a mark of distinction and good health. Parents also felt that inclusion in the study might directly benefit their child, because the study gave recommendations, and made referrals should a problem be noted (preventive medicine!); they also felt they were participating in valuable research which would benefit generations to come (Figure 13). (Indeed the selection factors may be fortuitous in terms of applying the findings to present day children.)

The x-ray studies were considered an invaluable tool in establishing permanent records of the child's growth and development. Because bones are acutely sensitive for reflecting other body conditions, they provide permanent records with regard to effects on the growth process of race, sex, age, maturity and the history of ailments, accidents, stress, strain and other shortcomings of health. For many years thousands of x-rays were taken by

Participation in the Research Studies of the Brush Inquiry requires:

1. Approval of the family physician, or the special physician taking care of the child.

2. X-rays at stated intervals. In the study of adolescence these are to occur once a year on or near the birthday.

3. Psychological examinations on or near birthday.

4. Complete cooperation of the parents in providing all information and records concerning the child required by the Inquiry. This will include current records on the health and behaviour of the child.

5. A permanent residence in Cleveland or its vicinity.

6. Responsibility of parents to see that the child arrives at the place of examination promptly at the time set on the appointment date.

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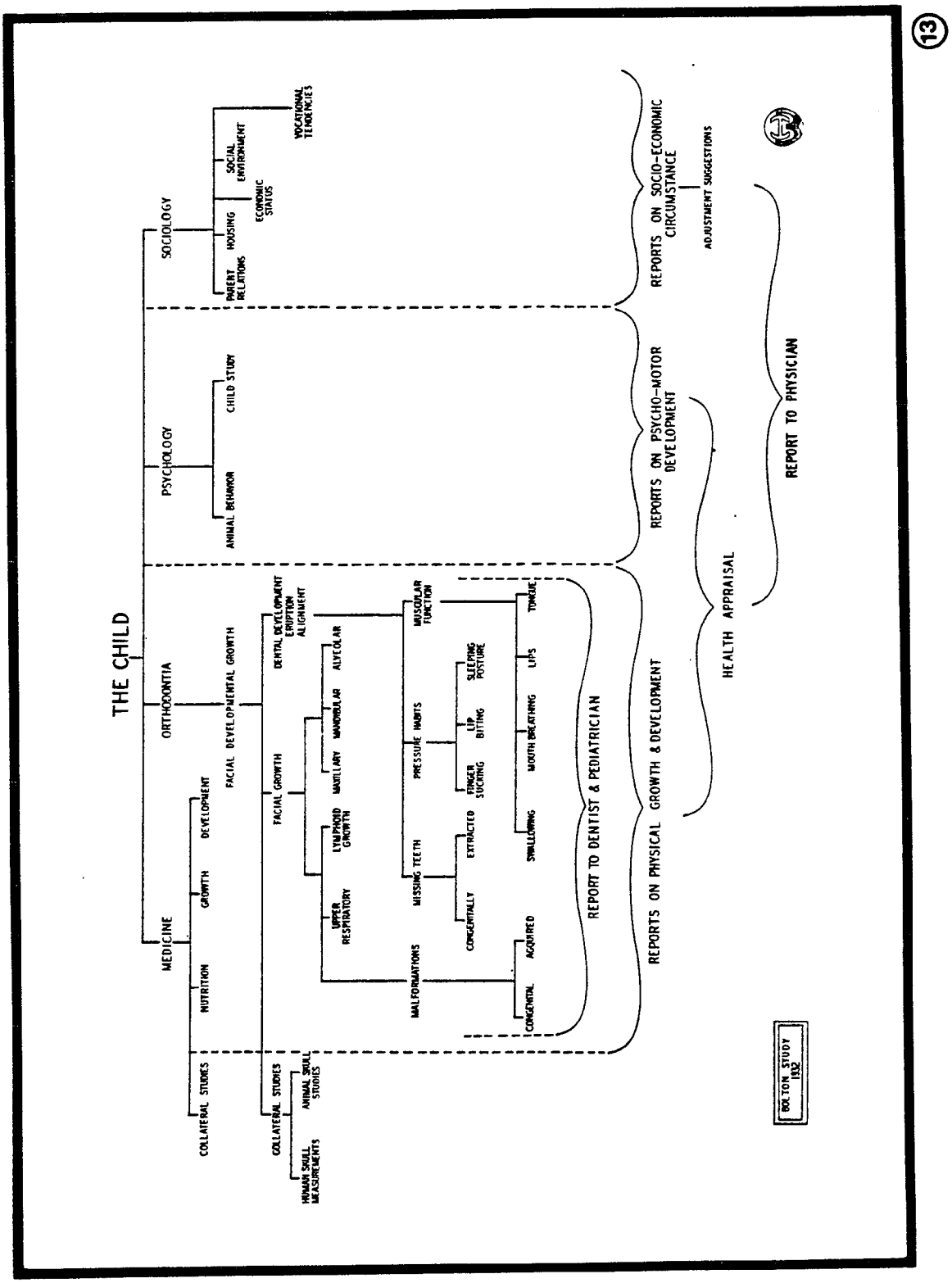
1. A report of the Inquiry of findings and results of each examination will be sent to the designated physician as soon after the examination as available data can be collected.

2. The Inquiry guarantees the strict privacy of all records.


THE CHILD
MEDICINE
ORTHODONTIA
PSYCHOLOGY
SOCIOLOGY
NUTRITION
GROWTH
DEVELOPMENT
FACIAL DEVELOPMENTAL GROWTH
ANIMAL BEHAVIOR
CHILD STUDY
PARENT RELATIONS
HOUSING
SOCIAL ENVIRONMENT
ECONOMIC STATUS
VOCATIONAL TENDENCIES
COLLATERAL STUDIES
ANIMAL SKULL STUDIES
HUMAN SKULL MEASUREMENTS
FACIAL GROWTH
DENTAL DEVELOPMENT ERUPTION ALIGNMENT
UPPER RESPIRATORY
LYMPHOID GROWTH
MAXILLARY
MANDIBULAR
ALVEOLAR
MALFORMATIONS
MISSING TEETH
PRESSURE HABITS
MUSCULAR FUNCTION
CONGENITAL
ACQUIRED
CONGENITALLY
EXTRACTED
FINGER SUCKING
LIP BITING
SLEEPING POSTURE
SWALLOWING
MOUTH BREATHING
LIPS
TONGUE
REPORT TO DENTIST & PEDIATRICIAN
REPORTS ON PHYSICAL GROWTH & DEVELOPMENT
REPORTS ON PSYCHO-MOTOR DEVELOPMENT
REPORTS ON SOCIO-ECONOMIC CIRCUMSTANCE
ADJUSTMENT SUGGESTIONS
HEALTH APPRAISAL
REPORT TO PHYSICIAN
BOLTON STUDY 1952
13

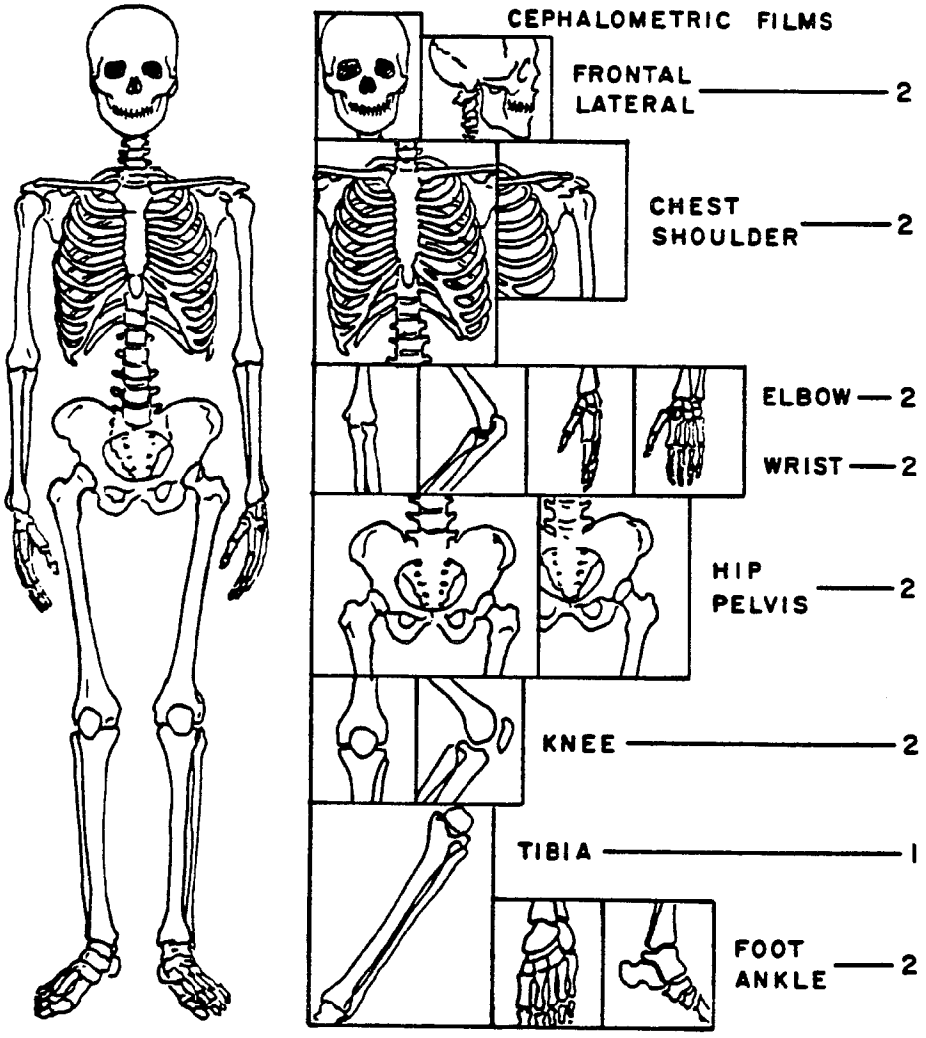
Mrs. W. Kuenzel and her assistants as indicators or milestones of biological process (Figure 14). (Dr. Todd called Mrs. Kuenzel an expert and a genius. Today a healthy recall participant at 82 years of age, she recalled much of the present information for the present historical review.)

Some previous ideas of maturity (simply to be tall and thin was thought to be well developed and mature; just to be short and fat was regarded as poorly developed and immature) were clarified and expanded considerably. Skeletal maturation as another key measure of physical health, less subject to fluctuations than merely height and weight, was soon noted to be a most reliable source of indication of maturity of the individual child.

The roentgenographic cephalometric technique received special distinction throughout the years. Remembered by participants as the "ear torture machine" this apparatus and the findings it yielded became very important to the orthodontist and other health disciplines (Figures 15-17). It was clear that the face quickly reflected the health of the patient, and that many diseases of childhood influence the growth patterns of the head and face. This understanding gleaned from cephalometric research came to exemplify the basic intent of the studies and their application.

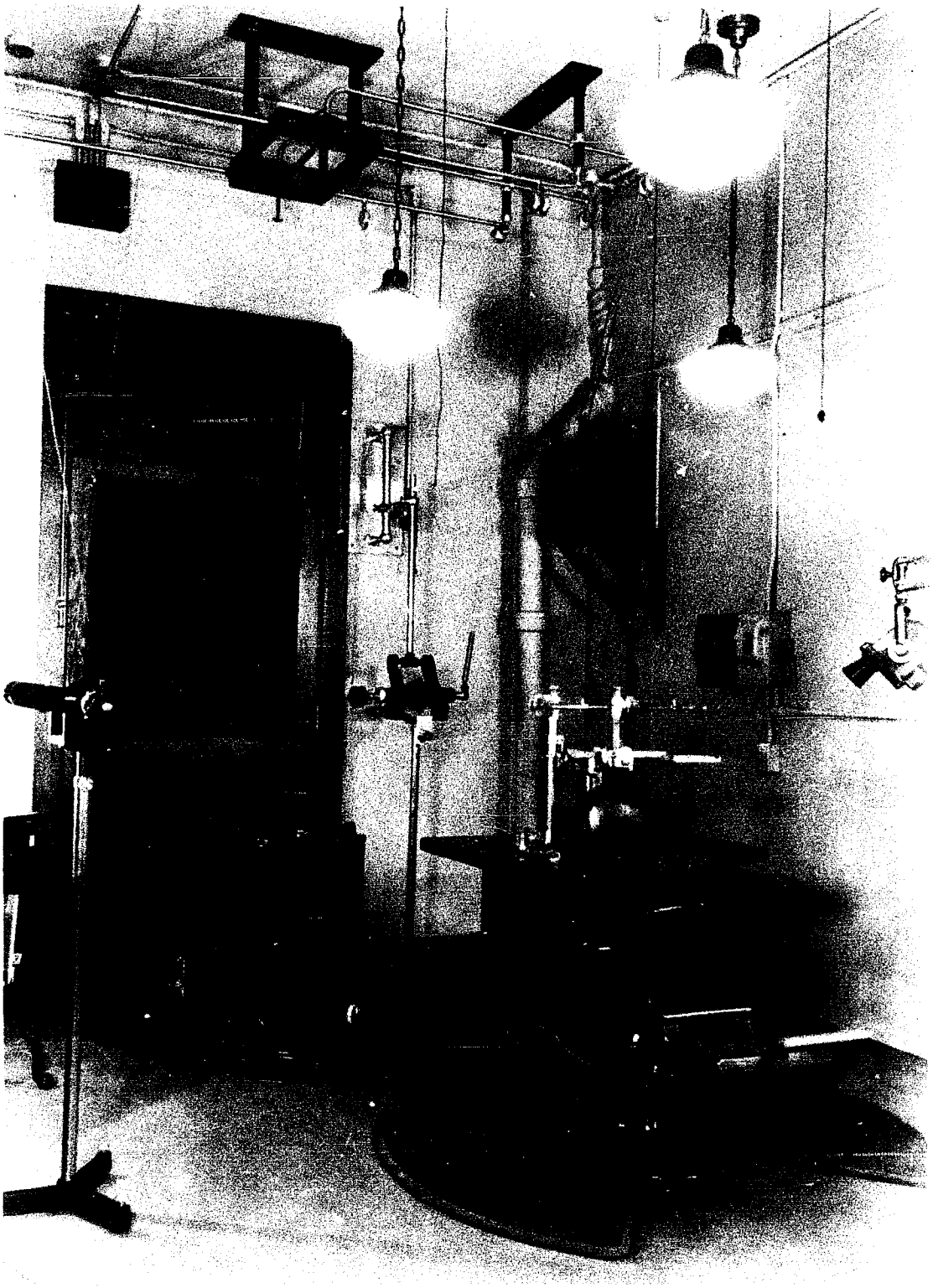
The animated motion picture "Normal Dentofacial Growth", developed by the Bolton Study with the active participation of Charles Bingham Bolton, provided a graphic representation of the changes that occur during childhood. The importance of these achievements, exemplified as "cephalometrics", has become realized, and they have become adopted by the orthodontic profession as

RADIOGRAPHIC DATA
OBTAINED AT EACH EXAMINATION




THE BOLTON ROOM
1
2
3
4
5
BROADBENT - BOLTON
ROENTGENOGRAPHIC CEPHALOMETRIC
BUILT IN
THE ANATOMICAL LABORATORY
WESTERN RESERVE UNIVERSITY
CLEVELAND
1929

(15)



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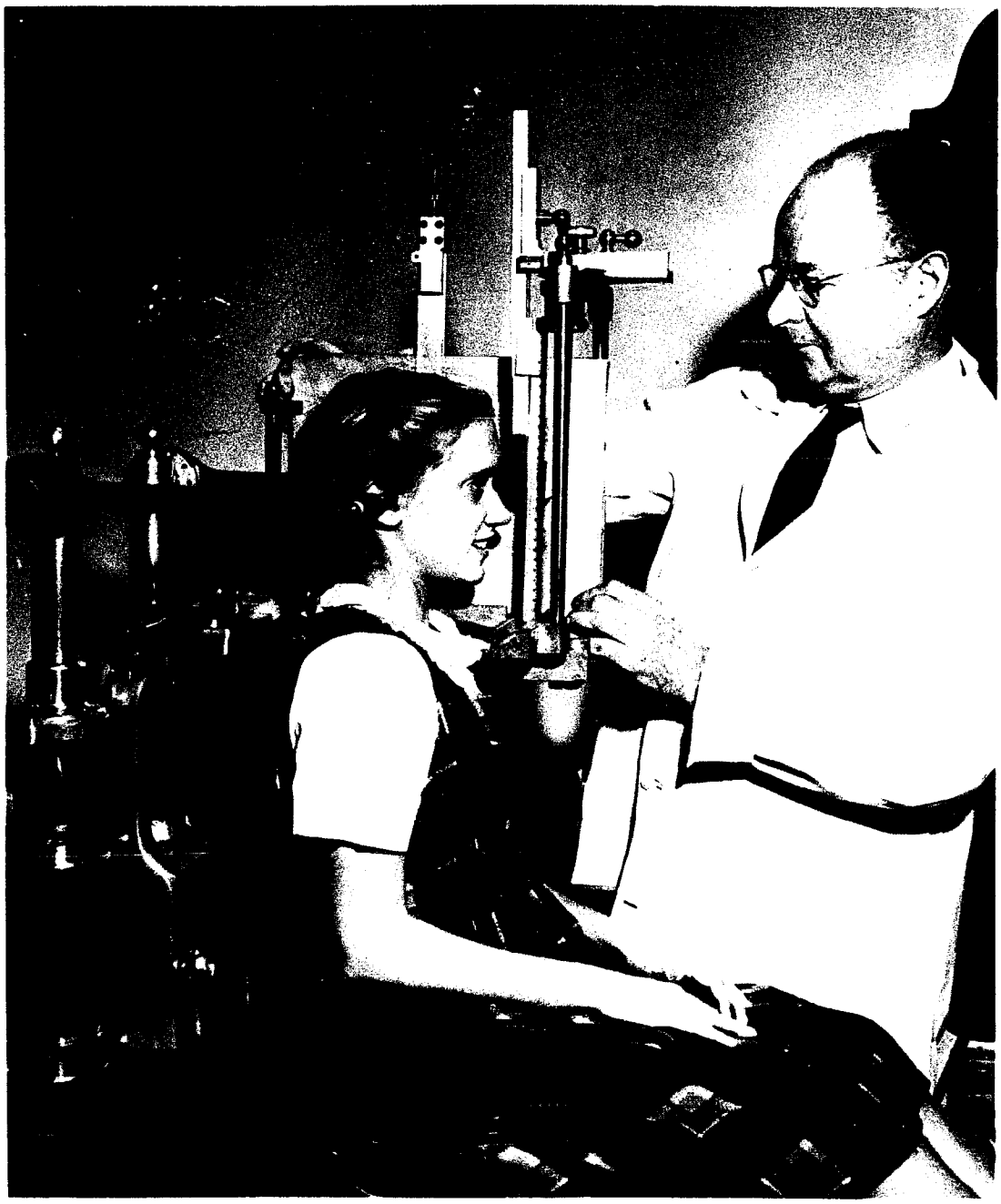


17

standard practice and are taught in all orthodontic training programs. Also an integral part of teaching, the subject facial growth and development reflects largely the foundations laid by "cephalometrics". In view, cephalometrics represents the greatest single advance in the science and practice of orthodontics (Tanner, 1981).

A full inventory of phychological testing was also performed. Forty different mental, skill, aptitude and personality tests were conducted. Home behavior, sleep behavior and other traits assessed (the yearly questionnaire had 588 entries). Many standard tests commonly used in psychology to assess "abnormal" had to be discarded when the study began because these tests were not applicable to "normal" children. Rorschach ink-blot tests were revised.

Some interesting results were noted in the "brain wave" tests. All previous work in this area was based on abnormal or brain-injured children. It had been previously published elsewhere that a "problem brain wave" indicated a problem child. This was totally discredited by the study as this "problem brain wave" was seen time and time again in happy, balanced children who presented no problem at all.

1938

Dr. T. Wingate Todd died in December of a heart attack. His life-long work was widely acclaimed. In 26 fruitful years he had introduced many innovative methods in the teaching of anatomy, developed vast collections of human and primate skeletal material, established an astonishing Departmental Library, was editor of Child

Development, was a member of the White House Conference, and was elected a Fellow of the Royal College of Surgeons. At his death many study participants wrote the lab urging continuation of his work, and more funds were extended from the Rockefeller Foundation to this end.

1939

Realizing the demanding positions Todd had held, Dr. Normand Hoerr was named as Todd's successor for the Chair of Anatomy, and Dr. William Walter Greulich became the second Director of the Brush Inquiry in the Department of Anatomy. Dr. Greulich's appointment would later result in one of the Brush Inquiry's main achievements; that of the timing of human ovulation by means of body temperature fluctuations. This is still used to supplement other, newer methods for either achieving or avoiding pregnancy. Dr. Broadbent continued as Director of the Bolton Study in addition to his extensive private practice of orthodontics.

1939-1942

During this period the examinations continued and new enrolees were accepted. However, due to the mounting pressures of war the program began to reduce in scope and magnitude. The mental and physical tests were at first shortened, then discontinued, and finally summarized for publication. Also, in 1942, because of the lack of x-ray film and technical help, films of the hand, elbow, shoulder, hip, knee and foot were discontinued as a full series. Recordings for height, weight and x-rays of the hands

were transferred to the Bolton Study. By the end of 1942, it was decided that active testing for the Brush Study would cease. It had become, however, the largest, longest-term, most extensive study on children and adults yet accomplished (Figure 18). Two-hundred and fifty thousand x-rays had been taken, 22,000 physical examinations, 90,000 mental and psychological tests had been made all on some 4,000 children (Figure 19). Emphasis would now be given to the compiling and publication of results.

1944

Dr. William Greulich was elected Professor of Anatomy in the School of Medicine at Stanford University but continued as Director of the Brush Foundation until 1950.

1946

Dr. Idell Pyle, who had been associated with the study since 1940, was asked by Dr. Hoerr to complete her doctoral credits under him by compiling films for an atlas. This was subsequently accomplished, as were four other atlases of normal growth of various body regions. Dr. Pyle continued her lifelong dedication to the study of human skeletal maturation until retirement, for health reasons, in 1981.

1948

Realizing the value of its work, the Bolton Study became a Department of the Dental School and organized a curriculum to teach normal craniofacial growth to dental students.

WESTERN RESERVE UNIVERSITY
SCHOOL OF MEDICINE
2109 ADELBERT ROAD
CLEVELAND, OHIO

BRUSH FOUNDATION

In accordance with the original plan, the Brush Foundation study of the growth and development of normal children will be completed on June 30 of this year. Next year will be devoted to working up and preparing for publication the vast amount of data which has been collected during the period of study. Those publications will make available to physicians, parents, and all others interested in children a summary of what has been learned about human growth and development in this, the most comprehensive investigation of its kind that has ever been undertaken. It is gratifying to me to be able to announce that this important study of child development made by the late Dr. T. Wingate Todd has been successfully completed, and that we believe that the assessment of the work will establish a signal advance in existing knowlege in this field.

Our study has been aided by substantial grants from the General Education Board of the Rockefeller Foundation, the Cleveland Foundation, and other co-operating agencies. In a very real sense, however, it was made possible only by the generous cooperation of the participating children and their parents. Let me thank you most sincerely for what you personally have done to make this project a success.

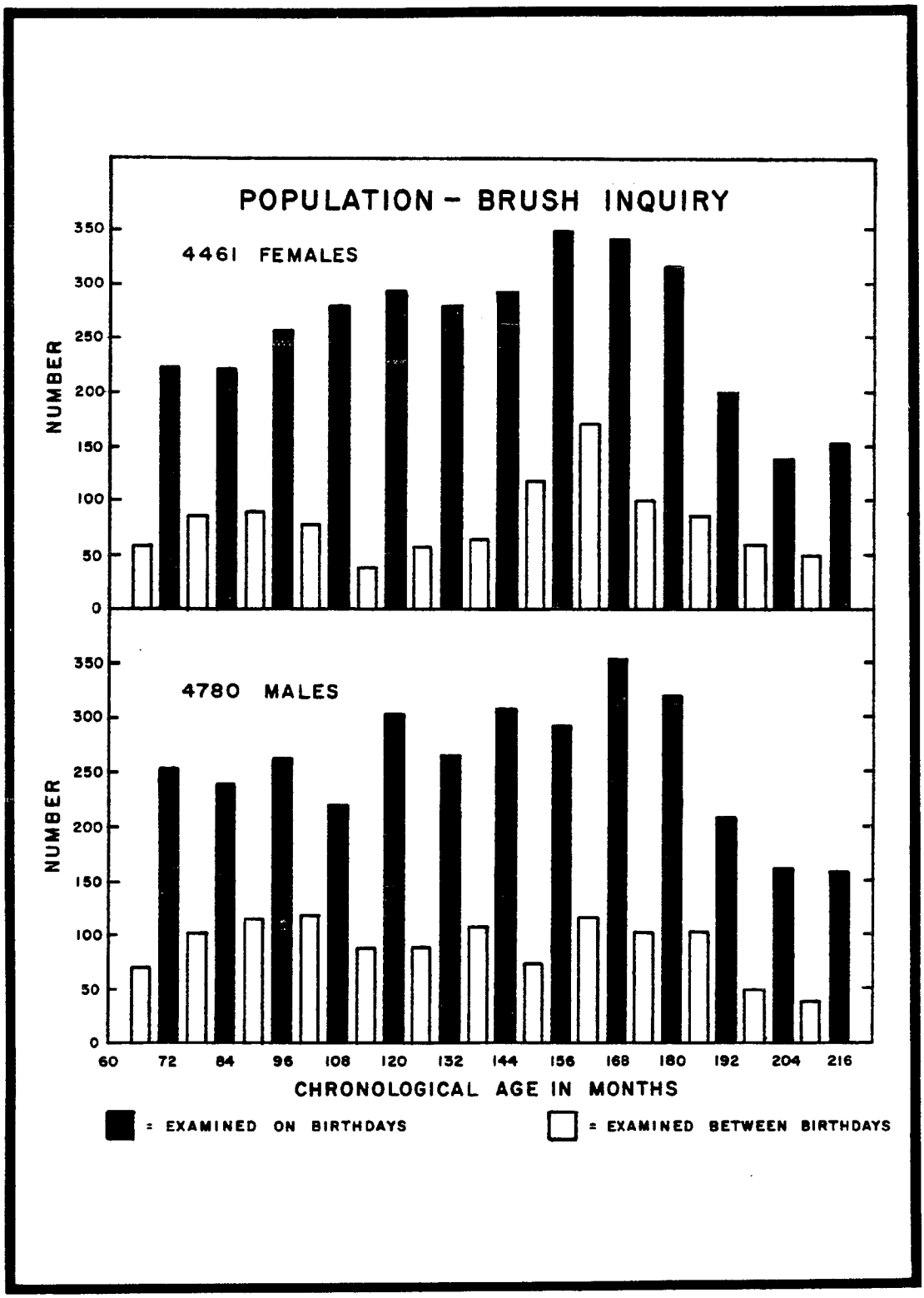
For the duration of the war, the major activity of the Brush Foundation will be its chemical and endocrine studies pertaining to the war effort which were undertaken recently at the request of the National Research Council. Its maternal health progras, its investigation of the causes of sterility, and its study of the sociological and biological implications of feeble-mindedness will also be continued. In these as well as in its future activities, I trust that the Brush Foundation will have your continued interest and support.

Yours very truly,

W. W. Greulich,
Director, The Brush Foundation.

WWG:MD

P.S. The Bolton Study of the development of the face and eruption of the teeth, which is under the direction of Dr. B. Holly Broadbent, will be continued, thus making available to the participants further progress reports on dento-facial development.


POPULATION - BRUSH INQUIRY
4461 FEMALES
4780 MALES
NUMBER
0
50
100
150
200
250
300
350
60
72
84
96
108
120
132
144
156
168
180
192
204
216
CHRONOLOGICAL AGE IN MONTHS
= EXAMINED ON BIRTHDAYS
= EXAMINED BETWEEN BIRTHDAYS

(19)

1952

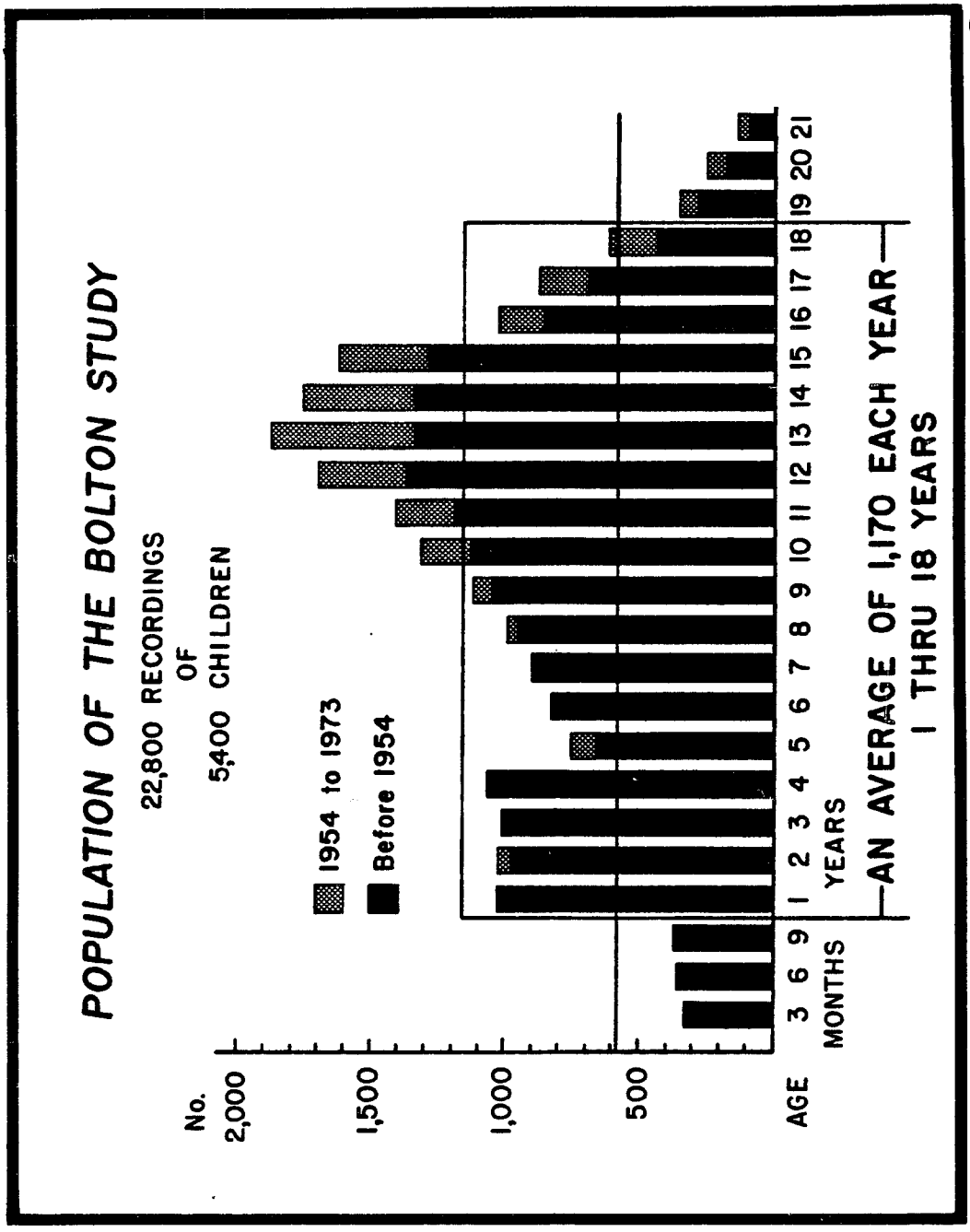
In 1952 another event occurred which was to have considerable impact on the Bolton Study. This was the addition of Dr. B. Holly Broadbent, Jr. as a research and teaching associate. He had graduated from Western Reserve University Dental School, studied orthodontics under his father's guidance, and then began conducting a busy orthodontic practice with his father; like the father, the son was deeply interested in the study of facial growth.

1959

In 1959, it was decided that the Bolton Study would essentially terminate and active enrollment ceased. More time was now to be spent studying and collating the vast pool of information collected. Since the study recruited subjects for some 30 years, with ongoing studies continuing for many years on the original children, the ages obtained now included many young adults. The number of subjects included approached 6,000. Forty to fifty thousand plaster casts of children's teeth were gathered from the period of the deciduous dentition through the eruption of third molars, some 40,000 x-rays were on record for study, an average of 15 films were taken per participant, 600-2,000 x-rays were available per age (average of 1,170), 3 pure longitudinal cohorts existed, etc (Figure 20).

1967

In 1967 Dr. Broadbent, Sr. suffered a stroke, which even-


POPULATION OF THE BOLTON STUDY
22,800 RECORDINGS
OF
5,400 CHILDREN
1954 to 1973
Before 1954
No.
2,000
1,500
1,000
500
AGE
3 6 9
MONTHS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
YEARS
AN AVERAGE OF 1,170 EACH YEAR
1 THRU 18 YEARS
20

tually necessitated his retirement in 1969. To ensure that his work was carried on, Dr. B. Holly Broadbent, Jr. was named Director of the Bolton Study.

1970

In 1970 under the direction of Mr. Charles Bolton, Dr. David Weir (Chairman of the Board of Managers of the Brush Foundation), Dr. B. Holly Broadbent, Sr. and Dr. B. Holly Broadbent, Jr., it was decided that the Brush Inquiry records still housed in the School of Medicine could be best utilized in research and teaching by combining all materials in one center to be called the Bolton-Brush Growth Study Center. This was to be located in the new Bolton Dental Building of Case Western Reserve University (Figures 21-22), where the Center continues today.

1973-1975

This was a landmark period when the "Bolton Standards" were first presented at the Third International Orthodontic Congress in London (1973). The Standards were then methodically and meticulously prepared and published in 1975 (Figure 23). This provided clinicians and researchers with an invaluable tool for understanding and assessing the growth of the craniofacial complex.

Mr. William Golden, a research associate with the Bolton Study from 1945 to 1981, was a co-author of the Standards. He contributed his unique artistic and technical abilities to both the research and the teaching activities of the Center. He exemplifies the dedication of the many persons involved in the work of the

THE BOLTON-BRUSH GROWTH STUDY CENTER
SCHOOL OF DENTISTRY, C.W.R.U.

AN ASSOCIATION BETWEEN THE BOLTON STUDY AND THE BRUSH INQUIRY

Submitted by: Mr. C. B. Bolton, Dr. D. R. Weir, Dr. B. H. Broadbent, Sr. and Dr. B. H. Broadbent, Jr.

To: Dean David Scott, C.W.R.U. School of Dentistry and President Robert Morse, C.W.R.U.

Background

Since their origin in the late 1920's, the Brush Inquiry and the Bolton Fund have been a functional part of the teaching and research programs of the C.W.R.U. School of Medicine. Although each has maintained its autonomy and carried on investigations of the same children and youths through independent financial support, there has been a direct association between them, with the Department of Anatomy, and also the School of Dentistry.

The Bolton Study has directed its interests primarily to the investigation of dental-facial developmental growth and cephalometric techniques, while continuing to take records of many returning patients who were in the Brush Inquiry. The Brush records of human development, since the cessation of active data collection in 1942, have been stored intact with their primary use in the development of skeletal x-ray standards by Drs. William Walter Greulich, the late Normand L. Hoerr, S. Idell Pyle, and their associates.

Since 1965, Dr. Pyle, in addition to other activities, has been engaged in the training and advising of medical students in the reading of wrist x-rays under the auspices of the Division of Health, Education, and Welfare for determination of skeletal maturation for the National Health Examination Survey of a representative sample of children and youths from forty areas of the United States.

An Association for Productive Use of the Collected Data

With the physical move of the Bolton Study to its new quarters in the School of Dentistry, and because of the close correlation of the records and individuals in the Bolton Study with the Brush Inquiry, it was deemed practical and agreed upon by both groups to officially associate by establishing the Bolton-Brush Growth Study Center. Potential areas of co-operation in this association lie in:

A. The joint records offering unlimited possibilities for research and investigation into the areas of human developmental growth both for interested individuals of C.W.R.U. and also those from other areas in the country including the National Institutes of Health.

B. The continuation of the collection of long-term records to further expand the research information available (second and third generations, etc.), and, more importantly, to reassess individuals with original records.

C. The training of medical and dental personnel in the area of record interpretation and clinical utilization. The routine use of wrist x-rays and skeletal-maturation information by the orthodontic students has been limited in the past, but offers a fine opportunity for correlation of skeletal age with dentofacial development.

D. The computerization of the information contained in the studies for exchange with other growth centers could be workable and very advantageous.

Future Relationship

The Bolton Study and the Brush Foundation will remain autonomous with their respective Boards of Trustees and Managers continuing as before. The "Bolton-Brush Growth Study Center" will be a distinct entity under the functional structure of the School of Dentistry. Within the University structure, appointment of the Director of the Center and the Advisory Committee will be the responsibility of the Dean of the School of Dentistry upon recommendations from the Bolton and Brush Boards. Upon formal recognition of the Growth Study Center by the University, the Advisory Committee, as suggested on the attached organizational chart, will be developed. The Committee Members will be selected on the basis of their willingness and ability to lend guidance in the areas of research projects.

Visiting researchers will have their names submitted to the Dean by the Director of the Study for formal recognition as University affiliates. Their designation will be determined by the individual circumstances; such as, "Research Associate, Research Fellow," etc.

The financial responsibility of both the Bolton Study and the Brush Foundation will continue independently except in the area of a possible agreed sharing of remuneration to an appointed "Research Supervisor" of the Brush records and other future "joint ventures." No firm financial commitments are to be made at this time; and there will be no financial responsibility on the part of the University except regarding physical space.

Under a current verbal agreement with Dean Scott of the School of Dentistry, the physical area of the Bolton Study (the west end of the third floor of the Bolton Dental Building) will be available rent, utilities, and maintenance free, for an undetermined length of time. In this space, the Brush records will continue to be housed, and a location for the prime Research Supervisor supplied. General working area for students and researchers will be available as agreed by the joint Directors of the Bolton-Brush Growth Study Center. The Bolton Study will maintain the basic responsibility for the physical space utilization.

Formal Action

Since it is desirable to have the Bolton-Brush Growth Study Center a recognized entity within the University, both from the standpoint of inter-faculty appointments and formal relationships with outside investigators, the Trustees of the Bolton Study and the Board of Managers of the Brush Foundation are pleased to accept formal recognition of the Center as an integral part of the School of Dentistry of Case Western Reserve University.

Date _____

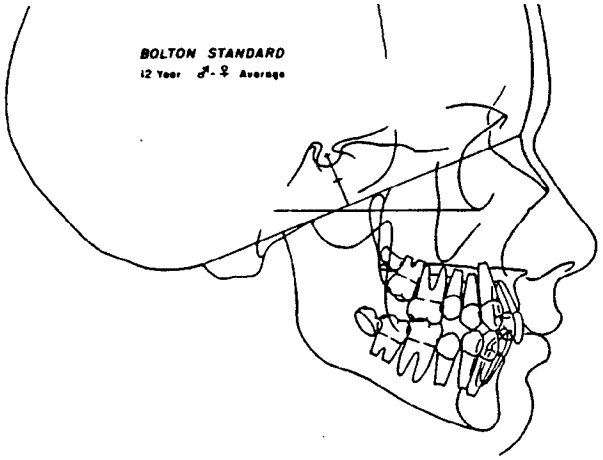
Dr. Robert Morse
President
Case Western Reserve University

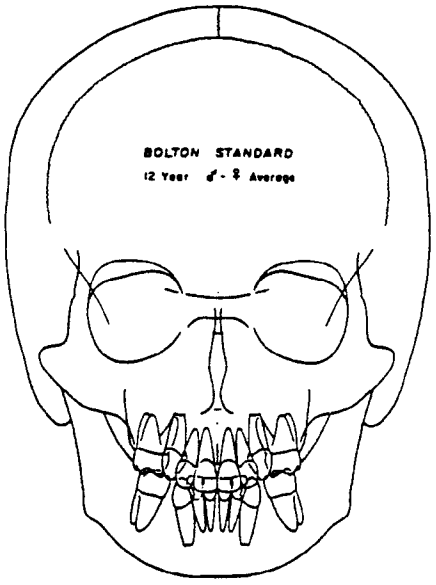
Dean David Scott, D.D.S.
School of Dentistry

David Weir, M.D.
for the Brush Foundation

B. Holly Broadbent, Jr., D.D.S.
for the Bolton Study

BOLTON STANDARDS OF DENTOFACIAL DEVELOPMENTAL GROWTH





BOLTON - BROADBENT - GOLDEN

23

Bolton investigations over the years.

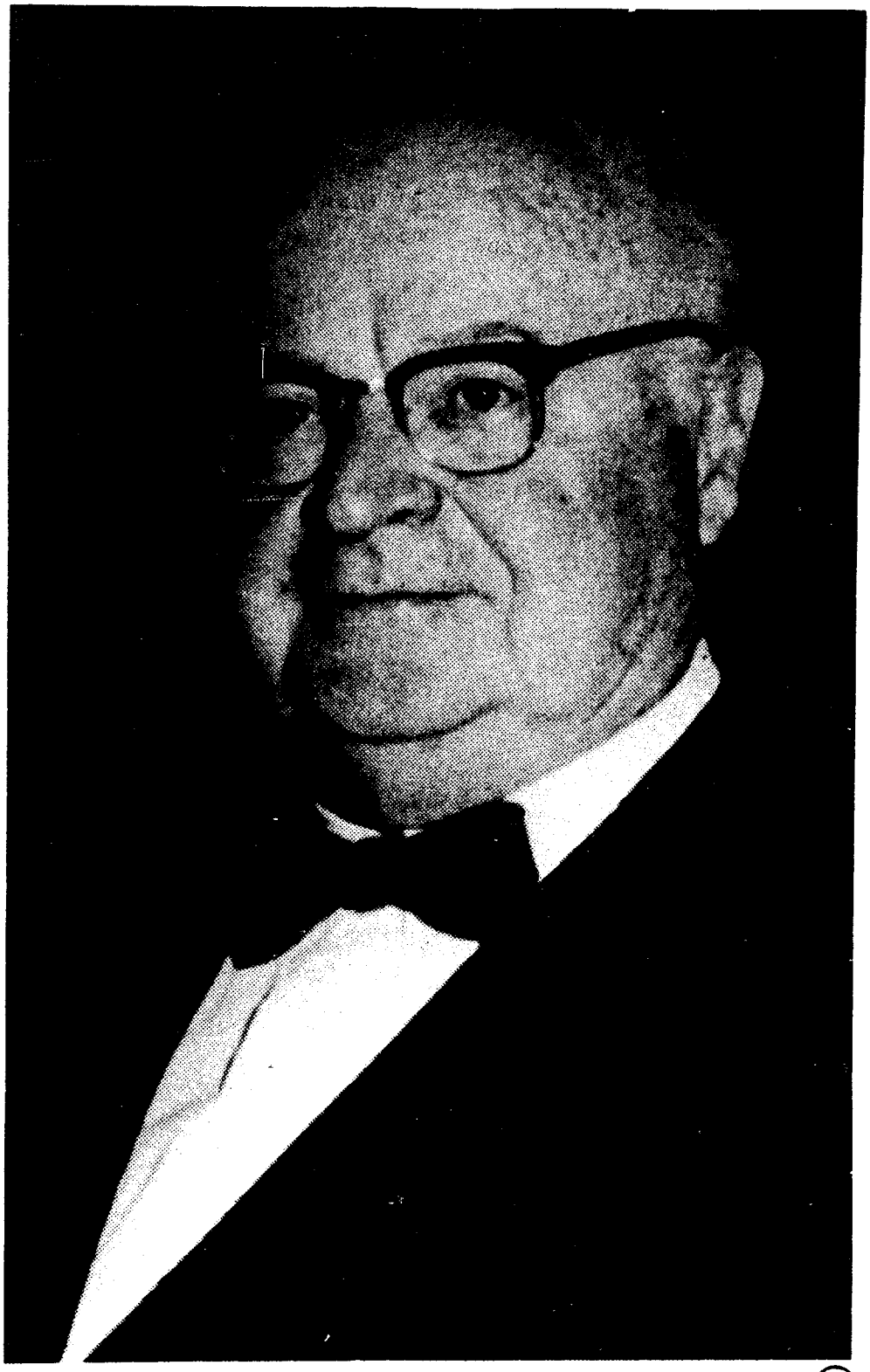
1977

In this year Dr. Broadbent, Sr. passed away. Suffice it to say that Broadbent cephalograms are still a prime instrument in diagnosing and treating disorders of facial growth, just as are Todd's skeletal maturation atlases used in diagnosing and treating children with more general growth disorders. Broadbent's accomplishments were many as a dedicated scholar and Professor of Dentofacial Anatomy since 1929 (Figure 24), but he will probably be most remembered for the cephalometric procedure designed to uncover fundamental aspects of facial growth(Figure 25). Perhaps his own words say it best:

> B. Study was at 9th and St. Clair. Used Anat. & (?) quarters. No office, no secy., no technicians, no filing cabinets. Just the idea, determination, and willingness to give of my time, and effort.

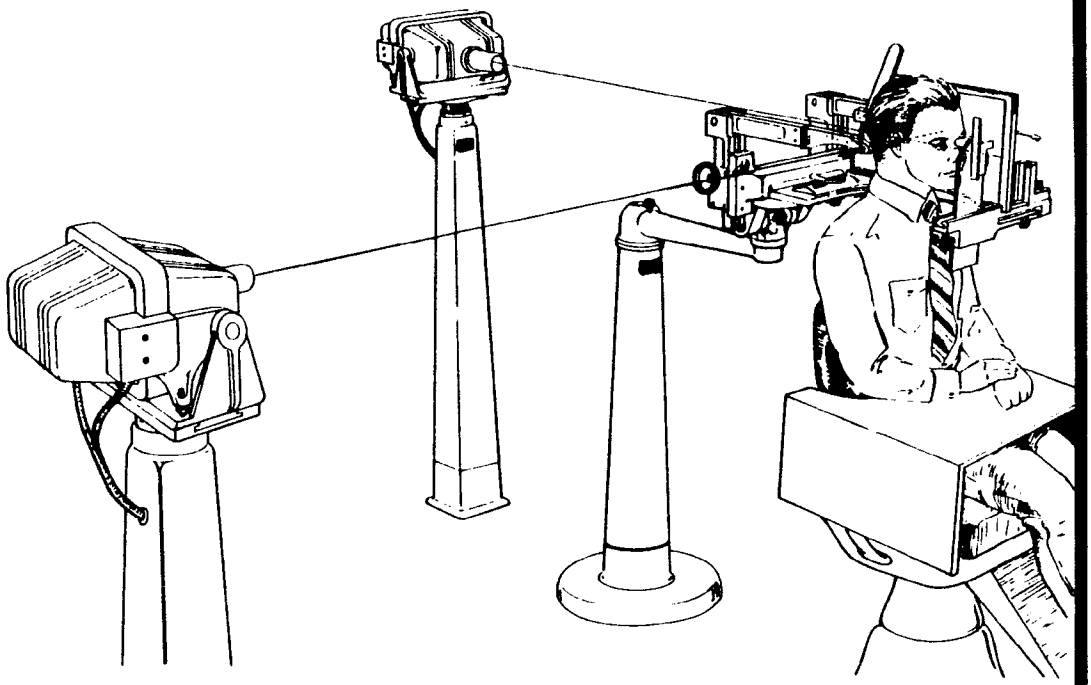
Also in this year a long-term recall project was begun under the leadership of Dr. B. Holly Broadbent, Jr., Dr. David Weir, Dr. Greulich and Dr. Pyle. It was designed to recall the "Bolton Faces" (balanced faces) and a group of individuals who had previously been studied extensively as babies and young children. The objective is to assess their present health status, and this sizable study continues today.

In this year after the death of The Honorable Frances Payne Bolton, after many, many years of personal and financial support, such assistance ceased. The study of Growth and Development lost an invaluable benefactor.



(24)

CEPHALOMETRIC RADIOGRAPHY



BROADBENT – BOLTON CEPHALOMETER

Summary--A Beginning

Much is left out in a brief historical review such as this. Over the years many students of child maturation and dentofacial development have utilized the records, and a multitude of excellent research publications has emerged. Space does not permit a full account of the monographs, papers and books which have been based on these records, but there are literally hundreds.

It is also evident that this wealth of data continues to be an invaluable and one-of-a-kind resource, and these stored records continue to be vital growth records whose appreciation is not unique to a single generation. The work accomplished with meticulous perfection will not likely ever be undertaken again, and it will provide insight into the continuum of growth and development of individuals for generations to come. With these materials we can continue to clarify and understand the marvels of the laws governing growth and development to provide for new vistas in medicine and dentistry.

Today, there are continued extensions of Todd's and Broadbent's work as the Bolton-Brush Growth Study Center, under the watchful eye of Dr. B. Holly Broadbent, Jr., continues to carry on research in developmental growth according to some of its original goals. The ultimate and continuing goal of the Study is the compilation of standards of developmental growth that may be used as frames of reference for the assessment of the myriad changes that take place in the growth processes of the human body.

Regarding the participants presently being recalled, now adult, it is clear they still remain enthusiastic and optimistic ("why did it take so long to call us back?"). They are very interested in the results of the research, and are continually giving in terms of adding to knowledge by participating in this valuable undertaking, as it may benefit others. That they remain in good health, which was what brought them to the original study years ago, is a mark of distinction which remains. It was an honor to be included in the study; faith in the future has drawn them back, for they still feel the honor, the caring of the investigators, and progress for humanity, is apparently their goal. They were and still are indeed distinctive in health, and they remain special in deed. Thus, this history is dedicated to the participants in the studies.

THIS HISTORY IS EXERPTED FROM
THE FOLLOWING SOURCES:

Atlas of Skeletal Maturation, by T. Wingate Todd, C. V. Mosby, 1937.

Life in Our Hands, the Story of the Brush Foundation, by Theodore Hall, The Brush Foundation, 1946.

"Frances Payne Bolton Honored", editorial reprinted in the American Journal of Orthodontics, May, 1950.

A Radiographic Standard of Reference for the Growing Knee, by S. Idell Pyle, Charles C Thomas, 1969.

Bolton Standards of Dentofacial Developmental Growth, by B. Holly Broadbent, Sr., B. Holly Broadbent, Jr. and William H. Golden, C. V. Mosby, 1975.

The Brush Foundation, by David R. Weir (editor), The Brush Foundation, 1980.

"Dr. Todd's Bones: The Macabrae Collection that is Making Scientific History Here", by Mark Gottlieb, Northern Ohio Live, 1982.

APPENDIX C

PATIENT, ORTHODONTIST CORRESPONDENCE

THE BOLTON – BRUSH
GROWTH STUDY CENTER

BOLTON DENTAL BUILDING
2123 ABINGTON ROAD
CLEVELAND, OHIO 44106

CASE WESTERN RESERVE
UNIVERSITY
(216) 368-3469

Name
Address

Dear

This letter is directed to you as a former participant in the Bolton Study; an investigation about normal developmental growth which began during the 1930's at the School of Medicine of Western Reserve University. As you may recall, the Bolton Study investigation was conducted by Dr. B. Holly Broadbent, Sr. for the purpose of gathering dental and facial development information on "normal, well-developed" children which could be used as a unique baseline for comparison to pathological or "abnormal" developmental growth processes. This study continued actively until the 1960's, and intermittent records have been gathered since then. The anonymous records of the Bolton Study were used in developing standards of facial growth entitled "The Bolton Standards of Dentofacial Developmental Growth" which was published by the C.V. Mosby Company in 1975. This valuable book is now used world-wide as a standard reference.

The Bolton Study Records are now housed in the Bolton-Brush Growth Study Center in the Bolton Dental Building, Case Western Reserve University. We are privileged to have a small but active staff who are working with and have curatorship of the long term records of the Bolton Study. We are sure that you appreciate the value of these records, since comprehensive radiographic studies of "normal" individuals are no longer being carried out and probably will not be conducted again in the foreseeable future.

Incidentially, Dr. Broadbent, Jr. is pleased, as are his three sisters who are between 48 and 56 years of age, to have been part of such unique and well planned investigations.

Our reason for writing at this time is to gain information on a question which is of significant interest to all researchers in growth and development. The question is: How does early growth and development, with their accompanying health related events, determine or modify the aging process?

It has been the latent desire of all those who have worked with the data to recall all the participants who can be located in order to determine their development and health record, since the original studies were completed, and to study the aging process. Attached is a simple questionnaire about your past and present health with an inquiry as to whether or not you would be willing to have an examination. If you do not live in the Cleveland area, special arrangements to do this could probably be made in your city of residence. We hasten to add that, as in the past with all Bolton records, complete anonymity will be scrupulously observed. We would appreciate very much if you would make all the entries on the enclosed sheet and return it to us in the enclosed stamped envelope. Of course, there would be no charge for the examination.

This study is being coordinated by Dr. Rolf G. Behrents, Director of the Orthodontic Clinic; you may contact him for an appointment at 368-3272.

If you have any questions or suggestions relative to the above, Dr. Broadbent, Jr. will be most pleased to talk with you. He may be reached either at the Bolton Dental Building in the Case Western Reserve University Health Science Center (telephone 368-3268) on most any Wednesday or Thursday morning or, at other times, in his private office in Beachwood (telephone 464-7840). We would further like to emphasize that, because of the small number of persons being contacted, your individual assistance is extremely important if the recall studies are to be significant!

Allow us, also, to express our sincere appreciation for your assistance in taking time to read this request and, hopefully, lending us your cooperation.

Cordially yours,

B. Holly Broadbent, Jr., D.D.S.
Donald H. Enlow, Ph.D.
Rolf G. Behrents, D.D.S., M.S.

BOLTON STUDY

ADULT-AGING RECALL

Name_____ Age_____Sex_____
(Please Print or Type)
Address_____Phone_____

Name of Physician_____Name of Dentist_____
(Optional) (Optional)
Office Phone_____

HEALTH HISTORY

Please place checkmark under Yes or No in ALL spaces provided. If the answer is YES please describe on the reverse side of this sheet giving details such as dates, severity, resulting disability, and medications being taken now or taken in the past.

	Yes	No		Yes	No
1. Has your health been impaired?	___	___	10. Diabetes?	___	___
2. Are you under physicians care for other than routine check-ups?	___	___	11. Rheumatic fever?	___	___
			12. Tuberculosis?	___	___
Have you had any of the following:			13. Arthritis?	___	___
3. Oral, facial or neck surgery?	___	___	14. Thyroid disorder?	___	___
4. Tonsillectomy? Age___	___	___	15. Blood disorder?	___	___
5. Adenoidectomy? Age___	___	___	16. Bleeding tendency?	___	___
6. Other surgery?	___	___	17. Leukemia?	___	___
7. Is surgery planned?	___	___	18. Skin tumors?	___	___
8. Heart Trouble?	___	___	19. Cancer, other tumors?	___	___
9. High blood pressure?	___	___	20. Joint problems?	___	___

21. For Females: Age of onset of menses___Menstrual problems: Yes___No_____
(Describe over)

22. Your ages at time of normal live-birth deliveries___ ___ ___ ___

23. Your ages at time of still births or miscarriages___ ___ ___

24. Has menopause occurred? Yes___No___If yes at what age?___

Signature:_____Date:_____

(Continued on Reverse Side)

BOLTON STUDY

The examination would consist of:

1. Examination of the head and neck
2. General dental examination
3. Dental impressions
4. Frontal and lateral cephalometric (head) x-rays
5. Hand-wrist x-ray.

The purpose of this study is to study the effects of aging on the craniofacial skeleton. Selection of persons for this study is based on their prior participation in the Bolton Study. Persons involved in this study should be aware that it is the concensus of the Orthodontic Department, the Bolton Study and the University that the examinations to be conducted do not pose a relevant health risk to the participant and that the examinations are the routine, customary procedures carried out in the usual orthodontist's office. Participation in this study is voluntary and as such will in no way jeopardize future health care at this University. The records obtained will be available to your physician, otherwise complete confidentiality will be observed.

I am_____am not_____willing to have these examinations performed.

Signature:_____

(Description of Health Problems Noted in Health History)

THE BOLTON – BRUSH
GROWTH STUDY CENTER

BOLTON DENTAL BUILDING
2123 ABINGTON ROAD
CLEVELAND, OHIO 44106

CASE WESTERN RESERVE
UNIVERSITY
(216) 368-3469

Name
Address

Dear

Please read the enclosed letter and forward to your CHILD OR CHILDREN, NAMES.

If this is not possible, please return the letter along with a notation. Thank you very much for your support and interest.

Sincerely,

B. Holly Broadbent, Jr., D.D.S.
Donald H. Enlow, Ph.D.
Rolf G. Behrents, D.D.S., M.S.

THE BOLTON – BRUSH
GROWTH STUDY CENTER

BOLTON DENTAL BUILDING
2123 ABINGTON ROAD
CLEVELAND, OHIO 44106

CASE WESTERN RESERVE
UNIVERSITY
(216) 368-3469

Name
Address

Dear

RE: Letter and questionnaire
mailed a few weeks ago

We are hopeful that you have retained our letter regarding the Growth Study's current project of determining the present health status, and its relation to growth and development processes, of individuals who participated in a select portion of the Bolton Study Investigations carried out in the 1930's and the early 1940's.

Since we have not received your reply or had the envelope returned by the Post Office, we are still hopeful that it arrived in your hands and that you are considering helping our important study.

To date we have mailed out some 300 such informational letters and questionnaires and have received a return of %. Of these, there has been a very favorable reply to the health history questions and also a very gratifying willingness, from nearly all, to participate in the additional examination suggested.

We would appreciate it, very much, if you would review the letter and complete the enclosed duplicate questionnaire so that we might have a much needed increase in the total number of responses. As I am sure you understand, the greater the number of responses we have the more validity there will be to the results and their interpretations. I would like to stress that this is tremendously unique data and we will have results never before obtainable!

We do understand the imposition on your personal time and we are sincerely grateful for your assistance!

Cordially yours,

B. Holly Broadbent, Jr., D.D.S.
Donald H. Enlow, Ph.D.
Rolf G. Behrents, D.D.S., M.S.

THE BOLTON – BRUSH
GROWTH STUDY CENTER

BOLTON DENTAL BUILDING
2123 ABINGTON ROAD
CLEVELAND, OHIO 44106

CASE WESTERN RESERVE
UNIVERSITY
(216) 368-3469

Name
Address

Dear

Thank you so much for returning the questionaire and expressing your willingness to participate in an examination.

In a very short time we will be calling you to set up an appointment. We would prefer to schedule your examination at the School of Dentistry of Case Western Reserve University on a Wednesday morning or afternoon or a Thursday morning. However, if the location or times are not convenient for you, other arrangements will be made.

If you have any questions, please feel free to give us a call (368-3272).

Thank you again for your continued support of our efforts.

Sincerely,

Rolf G. Behrents, D.D.S., M.S.
B. Holly Broadbent, D.D.S.
Donald H. Enlow, Ph.D.

THE BOLTON – BRUSH
GROWTH STUDY CENTER

BOLTON DENTAL BUILDING
2123 ABINGTON ROAD
CLEVELAND, OHIO 44106

CASE WESTERN RESERVE
UNIVERSITY
(216) 368-3469

Name
Address

Dear ,

Thank you very much for taking the time to fill out and return the questionairre. We also appreciate your willingness to come in for an examination.

Your appointment is scheduled for DAY, DATE, TIME.

On the enclosed sheet is a map to guide you to the Dental School. When you arrive, please park in the visitor parking lot under the school (lower level); find an entrance (an orange door with a large "D") and the elevator; come to the first floor and check in with the Orthodontic receptionist. Please bring your parking ticket with you.

Thank you again for lending your support to this most important study.

Sincerely,

Rolf G. Behrents, D.D.S., M.S.
B. Holly Broadbent Jr., D.D.S.
Donald H. Enlow, Ph.D.

B

BIRTH NAME _____ MARRIED NAME _____ SS

ADDRESS _____ PHONE _____

PARENTS

STATUS

CORRESPONDENCE

LETTER #1		LETTER #2		PHONE	QUESTIONAIRE RETURNED	APPOINTMENT DATE	TIME	WEIR/SCOLES	FOLLOW-UP LETTER

APPOINTMENT

ADDRESS VERIFIED	CONSENT FORM	EXAM	DENTAL CASTS	CEPHALOGRAMS L	CEPHALOGRAMS F	HAND-WRIST FILM	PHOTOGRAPHS	

ADULT-AGING RECALL

1982-1983

BOLTON STUDY

BOLTON STUDY

RECORD OF FACIAL & DENTAL EXAMINATION

DATE _____ EXAMINER _____

NAME _____

SEX _____ RACE _____ BIRTHDATE _____ AGE _____ HEIGHT _____ WEIGHT _____

HEAD AND NECK EXAMINATION

DENTAL EXAMINATION

ANGLE CLASSIFICATION_____

TREATED_____

	8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8
right																
	8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8

left

Indicate:
A - Ankylosed
B - Broken, chipped, cracked
C - Caries
D - Defective restorations
H - Hypoplastic or decalcified
I - Impacted
M - Missing (for age)
N - Nonvital or discoloration
S - Supernumary
T - Transposed

DENTAL IMPRESSIONS _____ MAX _____ MAND _____ BITE

PHOTOGRAPHS _____ FRONTAL _____ LATERAL _____ SMILE

X-RAYS

LATERAL	MA	SEC	TS	KVP	ML
FRONTAL	MA	SEC	TS	KVP	P-
HAND	MA	SEC			

NOTES

BOLTON STUDY

ADULT-AGING RECALL

CONSENT FORM

The examination would consist of:

1. Examination of the head and neck
2. General dental examination
3. Dental impressions
4. Frontal and lateral cephalometric (head) x-rays
5. Hand-wrist x-ray.

The purpose of this study is to study the effects of aging on the craniofacial skeleton. Selection of persons for this study is based on their prior participation in the Bolton Study. Persons involved in this study should be aware that it is the concensus of the Orthodontic Department and the Bolton Study that the examinations to be conducted do not pose a relevant health risk to the participant and that the examinations are the routine, customary procedures carried out in the usual orthodontist's office. Participation in this study is voluntary and as such will in no way jeopardize future health care at this University. The records obtained will be available to your physician, otherwise complete confidentiality will be observed.

I understand the nature and purpose of this study and am willing to have these examinations performed.

Signature:_____

Witness:_____

Date:_____

THE BOLTON – BRUSH
GROWTH STUDY CENTER

BOLTON DENTAL BUILDING
2123 ABINGTON ROAD
CLEVELAND, OHIO 44106

CASE WESTERN RESERVE
UNIVERSITY
(216) 368-3469

Name
Address

Dear ,

We wish to sincerely thank you for taking the time to return to the Bolton Study for an examination. The additional information that was provided by the examination will be very valuable in terms of the over-all results of the study. After the results of the study are gathered together in a manuscript, you will receive a copy of our findings. This will probably occur in the fall.

In your particular case we did want to report that on viewing the x-rays it is apparent that ANY ABNORMAL CONDITION NOTED.

While we do not feel there is any cause for alarm in this regard we did feel that you should know about this, and perhaps this should be broughts to your dentist's attention at your next visit.

Again, thank you for your time and effort.

Sincerely,

Rolf G. Behrents, D.D.S., M.S.
B. Holly Broadbent Jr., D.D.S.
Donald H. Enlow, Ph.D.

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GROWTH STUDY CENTER

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2123 ABINGTON ROAD
CLEVELAND, OHIO 44106

CASE WESTERN RESERVE
UNIVERSITY
(216) 368-3469

Name
Address

Dear

Thank you very much for responding to our inquiry about your health and for expressing your willingness to participate in our project by having a dental examination.

Realizing that you reside quite a distance from Cleveland, and assuming you will not be returning to Cleveland in the near future, we will be in contact with an orthodontist near your residence to arrange an appointment. This may take us some weeks, but do expect a local orthodontist to contact you to arrange an appointment. In the meantime, if you have any questions what-so-ever, feel free to give us a call (368-3272).

Again, thank you for returning the health questionnaire and indicating you are willing to participate further.

Sincerely,

Rolf G. Behrents, D.D.S., M.S.
B. Holly Broadbent, Jr., D.D.S.
D. H. Enlow, Ph.D.

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CLEVELAND, OHIO 44106

CASE WESTERN RESERVE
UNIVERSITY
(216) 368-3469

Name
Address

Dear

Thank you so much for returning the health history form and for being willing to stand for a follow-up examination.

We would be happy to exam you on one of your trips to Cleveland, and all you need do is give me a call when you are in town (368-3268). If, however, you do not anticipate coming to Cleveland before the end of the summer we would prefer to have you examined by an orthodontist near your residence. If this is the case, and such an examination would not be too inconvenient for you, please advise us and we would make the arrangements for the exam from here.

Again, thank you for your time and effort in helping us with this unique research project.

Sincerely,

Rolf G. Behrents, D.D.S.,M.S.

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CLEVELAND, OHIO 44106

CASE WESTERN RESERVE
UNIVERSITY
(216) 368-3469

Name
Address

Dear

Thank you so much for responding to our inquiry about your health. Regarding assisting us by having an examination, we probably have not explained ourselves well enough for you to make a decision.

While most of the participants still reside in the Cleveland area, many people have scattered across the country. Because we feel the study is quite unique and important we would like to have as many people as possible participate in this follow-up study.

Thus, if you were willing to participate further, and anticipating you will not be returning to Cleveland in the near future, we would be in contact with an Orthodontist near your residence to arrange an examination at no cost to you and at a mutually convenient time.

In this regard we are returning the questionairre to you so that you many indicate your decision regarding the examination. Whatever your decision, we wish to thank you for your interest and time in this unique research project.

Sincerely,

Rolf G. Behrents, D.D.S., M.S.
B. Holly Broadbent Jr. D.D.S.
Donald H. Enlow, Ph.D.

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CLEVELAND, OHIO 44106

CASE WESTERN RESERVE
UNIVERSITY
(216) 368-3469

Name
Address

Dear Dr.

We are writing to you to ask for your assistance in a unique research project being conducted out of the Bolton-Brush Growth Study Center and the Department of Orthodontics of the School of Dentistry, Case Western Reserve University. Please take a few moments to read this letter and consider assisting us.

Since these present studies likely will benefit you as an orthodontist, we would like to explain exactly what we are attempting to do. As you may recall, the Bolton-Brush Study, under the direction of Dr. B. Holly Broadbent, involved studying "normal" development of some 6,000 individuals (children and some young adults), was actively conducted during the 1930's and 1940's with intermittent records gathered to the present. From the vast number of recordings (22,000 x-rays) in this study and from other growth studies, important aspects of growth and development have been learned and applied to the treatment of our adolescent patients.

However, today's practice of orthodontics involves the treatment of a great many adult patients, and thus it might also be prudent to determine the nature and extent of any craniofacial changes which might be taking place during adulthood and aging.

This may seem at first thought, to be an unproductive task as we fairly well assume that an adult is "grown-up", the craniofacial skeleton does not change, and "growth" will not be a factor in treatment. However, for the most part this assumption has not been validated and in fact a pilot study of Bolton Study Participants, with an age range of 18 - 78 years of age, demonstrated change in craniofacial architecture was a consistent measurable finding. Unlike growth during puberty, the yearly increments are small, but the overall effect is continued change of a clinically significant nature. Thus we way be erroneously making assessments about our adult patients by comparing <u>adult</u> "numbers" to <u>adolescent</u> "standards". At present we do not have at our disposal an adult set of "numbers" and it is clear from our pilot studies that adults do indeed change through time.

To study this apparent phenomenon, we have begun to recall some 400 former Bolton Study Participants who had records taken as young adults. New records will be gathered on these people (now 40 - 50 years older). For the most part the participants still reside in the Cleveland area and are being actively recalled at present.

In addition some of the participants who have expressed their willingness to participate in further examinations now reside close to your practice, and will not be returning to the Cleveland area in the foreseeable future. Therefore, we would like to solicit your help in gathering valuable information on these people. Would you be so kind as to have the person listed at the end of this letter called and appointed for a set of records consisting of:

lateral and P.A. cephalograms
hand-wrist x-ray
dental impressions (untrimmed)
dental examination
head and neck examination

(Note: make sure the mm. measurement from the midsaggital plane (lateral) and transporionic axis (frontal) are recorded off your cephalometer --- very important!).

Because the Bolton Study is privately funded and the funds for this study are extremely limited, we are not in a position to pay for your efforts. It is also very important that the participant not be charged. We hope that you will see fit to perform this courtesy as a contribution to the profession.

When you send us the records, please tape the enclosed envelope to the box so that the postage will be charged to us.

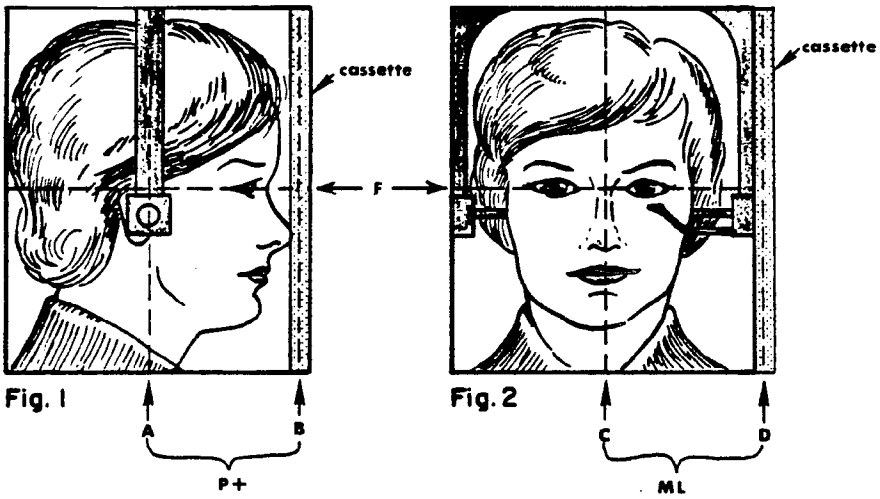
Thank you so much for taking the time to read this letter and we earnestly hope you will lend us your assistance in this valuable research endeavor. We will be in contact with you shortly to determine your decision. Please feel free to give us a call (216-368-3272) if you have any questions.

Sincerely,

B. Holly Broadbent, D.D.S.
Rolf G. Behrents, D.D.S., M.S.
Donald H. Enlow, Ph.D.

BEST METHOD

The purpose of these directions is to insure the current cephalograms are comparable to past cephalograms in terms of magnification.



NOTES:

Both drawings shown without nose bridge support.

Frankfort Plane (F) should be parallel to the floor.

Record the ML distance for the lateral film (C to D). ML distance=distance from the midsaggital plane to the film inside the cassette.

ML distance_____

Record the P+ distance for the P.A. film (A to B). P+ distance=distance from the center of the earposts to the film inside the cassette.

P+ distance_____

Exposure Settings: Lateral film _____sec. _____MA_____KVP

P.A. film _____sec. _____MA_____KVP

The cassette should be as close to the head as possible.

ALTERNATE METHOD

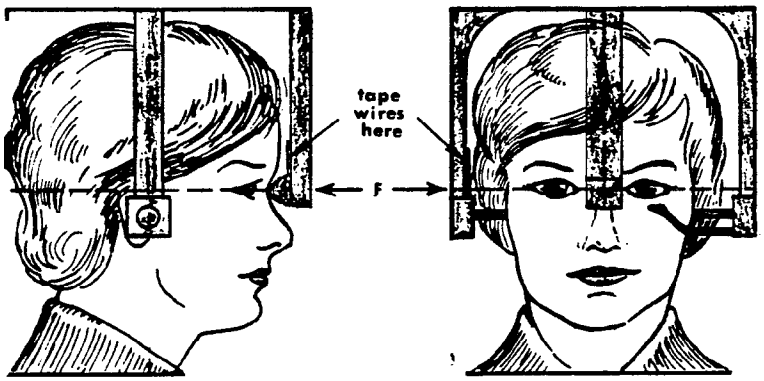


Fig. 3 Fig. 4

NOTES:

An alternate method involves cutting 2 straight pieces of .030" wire each approximately 2 inches in length, and taping one vertically on the inside surface of the nose bridge support and the other vertically on the inside surface of the right ear rod support. After taking and developing the films, take the wire from the nose bridge support and tape it to the lateral cephalogram and take the wire from the right ear support and tape it to the P.A. cephalogram. Please record your exposure settings.

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2123 ABINGTON ROAD
CLEVELAND, OHIO 44106

CASE WESTERN RESERVE
UNIVERSITY
(216) 368-3469

Name
Address

Dear Dr. ,

Regarding our recent request for assistance in our Adult-Aging Recall Study, we are writing to you at this time to see whether you would be willing to help us in this project. We hope that you have had a chance to look over the materials we sent you recently and hope that you will help us in this unique study.

However, we do understand you are a busy professional person, and you may not have the time nor the inclination to assist us. Whatever your decision we do apprectiate your consideration of this matter.

Please indicate your preference and return this letter in the enclosed envelope.

_____ I will try to help in this project.

_____ Sorry, but I cannot help in this project.

Sincerely,

Rolf G. Behrents, D.D.S., M.S.
B. Holly Broadbent, D.D.S.
Donald H. Enlow, Ph.D.

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CLEVELAND, OHIO 44106

CASE WESTERN RESERVE
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(216) 368-3469

Name
Address

Dear

Just to keep you up-to-date regarding your dental examination, we have arranged for you to be seen by:

His office will be in touch with you to arrange a mutually agreeable appointment time.

Thank you, very much, for your interest and willingness to assist us in this extremely unique and worthwhile project.

Sincerely,

Rolf G. Behrents, D.D.S., M.S.
B. Holly Broadbent, Jr., D.D.S.
D. H. Enlow, Ph.D.

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Name
Address

Dear

Thank you so much for taking the time to have an examination as part of our recall study. The responsiveness of all the participants, in the Cleveland area and across the country, has been overwhelming and thus the study proceedes very well. When the results of the study are compiled we will be sending a report to all who participated.

Thank you again!

Sincerely,

Rolf G. Behrents, D.D.S., M.S.
B. Holly Broadbent, Jr., D.D.S.
D. H. Enlow, Ph.D.

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Name
Address

Dear Dr.

We gratefully acknowledge the receipt of the orthodontic records we requested you gather on a participant in our Adult-Aging Recall Study. We sincerely thank you for your help in this unique study and your assistance will be acknowledged appropriately.

As the results of our study are compiled we will be forwarding a report to all who participated.

Thank you again!

Sincerely,

Rolf G. Behrents, D.D.S., M.S.
B. Holly Broadbent, Jr., D.D.S.
D. H. Enlow, Ph.D.

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CASE WESTERN RESERVE
UNIVERSITY
(216) 368-3469

Name
Address

Dear

Greetings from the Department.

We are writing to you at this time to solicit your help in a very important research project being jointly conducted by the Bolton Study and the Department of Orthodontics.

The purpose of the present research is to determine the nature and extent of craniofacial changes during maturation and aging. To accomplish this task we are seeking to recall some of the patients of the original Bolton Study. The people we recall will have cephalograms taken and compared to the previous records. We earnestly believe that maturational changes will occur, and if this is so, the information gained will be invaluable in terms of its impact on orthodontics (adult treatment), prosthodontics (denture construction), orthognathic surgery and other aspects of reconstructive dentistry.

We need your help in this endeavor. Some of you may not remember, but cephalograms were made on you while you in the graduate program. In certain cases some wives and children also had cephalograms made which became part of the Bolton Study. Thus, we would like to have you participate in this recall study by providing us with current cephalograms (P.A. and lateral). It would be preferable for you to return to the school so that we could use the Bolton Cephalometer, but time and distance may make that inconvenient for you. If you cannot return, please follow the enclosed directions in using your own cephalometer.

If you have any questions regarding this study, please feel free to give me a call (216-368-3272).

By the way, Mark Hans ('81) recently was named the recipient of the A.A.O. Harry Sicher Award for his master's research. That's five awards in the last seven years for research in the Department.

Sincerely,

Rolf G. Behrents D.D.S., M.S.
Director of Clinics
Department of Orthodontics

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CLEVELAND, OHIO 44106

CASE WESTERN RESERVE
UNIVERSITY
(216) 368-3469

Name
Address

Dear

I am writing to you in regard to the previous letter about the present ongoing research in the Department and the Bolton Study. The previous letter requested that cephalograms be taken on yourself at this time so that you might be a participant in an "Adult-Aging" Recall Study presently being conducted in the Bolton Study. We would still like you to do this.

Since these present studies likely will benefit you as an orthodontist, I would like to explain exactly what we are attempting to do. As you may recall, the Bolton-Brush Study which involved studying "normal" development of some 6,000 individuals (children and some young adults), was actively conducted during the 1930's and 1940's with intermittent records gathered to the present. From the vast growth studies, important aspects of growth and development have been learned and applied to the treatment of our adolescent patients.

However, today's practice of orthodontics involves the treatment of a great many adult patients, and thus it might also be prudent to determine the nature and extent of any craniofacial changes which might be taking place during adulthood and aging.

This may seem at first thought, to be an unproductive task as we fairly well assume that an adult is "grown-up", the craniofacial skeleton does not change, and "growth" will not be a factor in treatment. However, for the most part this assumption has not been validated and in fact a pilot study of Bolton Study Participants, with an age range of 18 - 78 years of age, demonstrated change in craniofacial architecture was a consistent measurable finding. While the yearly increments may be small, the overall effect is continued change of a clinically significant nature. Thus we may be erroneously making assessments about our adult patients by comparing adult "numbers" to adolescent "standards". At present we do not have at our disposal an adult set of "numbers" and it is clear from our pilot studies that adults do change through time.

To study this apparent phenomenon, we have begun to recall some 400 former Bolton Study participants who had records taken as young adults. New records will be gathered on these people (now 40 - 50 years older).

In your particular case, cephalograms were taken on you when you were in graduate school. Therefore, we would like to solicit your help in this most valuable study. Please take a few moments to have a set of cephalograms taken (record mm. measurements off the cephalometer) and then send them to us.

Your help in this unique project would be greatly appreciated.

Sincerely,

Rolf G. Behrents, D.D.S., M.S.
B. Holly Broadbent, D.D.S.
Donald H. Enlow, Ph.D.

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UNIVERSITY
(216) 368-3469

Name
Address

Dear Dr. ,

Just a short note to inform you of the progress which has been made in our Adult-Aging Recall Study and to again request your assistance in this unique research project.

To date we have contacted some 200 former Bolton Study participants and requested they return for an additional examination. They have been surprisingly willing to participate and as a result approximately 100 exams have been accomplished here at C.W.R.U. (people have flown in from Canada, California, Oregon....all over!). Also we have been able to arrange examinations across the country for those participants who were willing to be examined, but could not return to the Cleveland area. Some 40 orthodontists all over the country have been very helpful in doing the exams for us in this regard. As a result of this generous participation, the study procedes very nicely and we are learning a great deal about adults especially in the areas of craniofacial growth, T.M.J., and Third molars.

Because we expect this study will make quite an impact on our profession in particular we still desire to increase the size of our sample. In this regard we again request your assistance. Only of the former graduate students we have contacted have sent cephalograms, and this is most disheartening and embarrassing as everyone else contacted has so graciously agreed to assist us in this project. Please take some time to have a set of cephalograms taken on yourself and send them to us.

See you in Boston!

Sincerely,

Rolf G. Behrents, D.D.S., M.S.

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2123 ABINGTON ROAD
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CASE WESTERN RESERVE
UNIVERSITY
(216) 368-3469

Name
Address

Dear Dr.

Thank you so much for sending the cephalometric x-rays we requested. They will now be on file in the Bolton Study.

On behalf of the Bolton Study, the Department and myself --- we thank you.

Sincerely,

Rolf G. Behrents, D.D.S., M.S.
Director of Clinics
Department of Orthodontics

RGB:efm

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Name
Address

Dear

We would all like to take this opportunity to thank you for participating in our recent Recall Study. Your participation has provided us with invaluable long-term information on the health of the Bolton Study Subjects.

This information is presently being analyzed and we will keep you informed of the important developments. These records will also act as a legacy for future researchers in growth and development.

Please accept the enclosed as a small token of our personal appreciation for your continued support and interest.

Sincerely,

B. Holly Broadbent, Jr., D.D.S.
D. H. Enlow, Ph.D.
Rolf G. Behrents, D.D.S., M.S.

APPENDIX D

CEPHALOMETRICS

CEPHALOMETRIC PLANES

The following planes have been utilized:

1. SELLA-NASION PLANE: Sella-Nasion.
   S-N(46-54)

2. FRANKFORT PLANE: Porion-Orbitale.
   PO-OP(44-57)

3. PALATAL PLANE: Anterior Nasal Spine-Posterior Nasal Spine.
   ANS-PNS(59-12)

4. FUNCTIONAL OCCLUSAL PLANE: Premolar mesial contact point-upper molar distal cusp tip.
   PMC-UDT(18-28)

5. DOWNS OCCLUSAL PLANE: Anterior Downs point-posterior Downs point.
   ADP-PDP(7-24)

6. MANDIBULAR PLANE: Menton-gonial intersection.
   ME-GOI(1-32)

7. RAMAL PLANE: Articulare, posterior-gonial intersection.
   AR-GOI(41-32)

8. PM VERTICAL: Pterygo-maxillary fissure, inferior-ethmoid registration point.
   PTM-SE(47-68)

9. LOWER INCISOR AXIS: Lower incisor incisal edge-lower incisor root apex.
   LIE-LIA(6-16)

10. NASION PERPENDICULAR: A line through nasion, perpendicular to Frankfort plane.

11. UPPER INCISOR AXIS: Upper incisor incisal edge-upper incisor root apex.
    UIE-UIA(8-13)

12. FACIAL PLANE: Nasion-pogonoin
N-PG(54-3)

13. SOFT TISSUE PLANE: Soft tissue A point-soft tissue B point.
A'-B'(80-84)

LANDMARK DEFINITIONS

(after Riolo et al., 1974; Israel, 1973; Krogman and Sassouni, 1955)

NUMBER	CODE	DEFINITION
1	ME	MENTON: The most inferoir point on the symphyseal outline.
2	GN	GNATHION: The most anterior-inferior point on the contour of the bony chin symphysis. Determined by bisecting the angle formed by the mandibular plane and a line through pogonion and nasion.
3	PG	POGONION: The most anterior part on the contour of the bony chin. Determined by a tangent through nasion.
4	B	B POINT: The point most posterior to a line from infradentale to pogonoin on the anterior surface of the symphyseal outline of the mandible. B point should lie within the apical third of the incisor roots.
5	ID	INFRADENTALE: The anterior superior point on the mandible at its labial contact with the mandibular central incisor.
6	LIE	LOWER INCISOR INCISAL EDGE: The incisal tip of the mandibular central incisor.
7	ADP	ANTERIOR DOWNS POINT: The midpoint of the line connecting landmarks 6 and 8 (LIE and UID). This represents the anterior point through which Downs occlusal plane passes.
8	UIE	UPPER INCISOR INCISAL EDGE: The incisal tip of the maxillary central incisor.
9	UIL	LABIAL OF THE UPPER INCISOR: The most labial aspect of the upper incisor.
10	SD	SUPRADENTALE: The most anterior inferior point on the maxilla at its labial contact with the maxillary central incisor.

NUMBER	CODE	DEFINITION
11	A	A POINT: The most posterior point on the curve of the maxilla between the anterior nasal spine and supradentale.
12	ANS	ANTERIOR NASAL SPINE: The tip of the median, sharp bony process of the maxilla at the lower margin of the anterior nasal opening.
13	UIA	UPPER INCISOR APEX: The root tip of the maxillary central incisor.
14	UIB	UPPER INCISOR LINGUAL BONY CONTACT POINT: The lingual contact of alveolar bone with the maxillary central incisor. This point generally corresponds with the lingual cemento-enamel junction (CEJ).
15	LIB	LOWER INCISOR LINGUAL BONY CONTACT: The lingual contact of alveolar bone with the mandibular central incisor. Generally corresponds with the lingual CEJ.
16	LIA	LOWER INCISOR APEX: The root tip of the mandibular central incisor.
17	SYM	LINGUAL SYMPHYSEAL POINT: A constructed point used to determine symphyseal width at pogonion. The SYM point is located at the intersection of a construction line through pogonion and parallel with the posterior border of the mandibular symphysis.
18	PMC	PREMOLAR MESIAL CONTACT POINT: A point established by the intersection of a line along the occlusal contact of the upper and lower premolars and a perpendicular line to it through the averaged anterior contact of the first maxillary premolars with the maxillary cuspid.
19	PDC	PREMOLAR DISTAL CONTACT POINT: Established along the same premolar occlusion line as point 18 but at the point of a perpendicular line through the distal contact of the maxillary first premolar. The distance from PMC to PCD should be equal to the averaged mesial-distal distance of the first maxillary premolar.

NUMBER	CODE	DEFINITION
20	LMR	LOWER MOLAR ROOT APEX: The apex of the mesial root of the mandibular first molar.
21	LMJ	LOWER MOLAR MESIAL CEJ: The anterior cemento-enamel junction of the mandibular first molar at the bony crest.
22	LMC	LOWER MESIAL CONTACT: The mesial contact (height of contour) of the mandibular first molar relative to the FOP.
23	UMT	UPPER MESIAL CUSP TIP: The anterior cusp tip of the maxillary first molar.
24	PDP	POSTERIOR DOWNS POINT: The midpoint of the line connecting landmarks 23 and 25 (LMT and UMT). This represents the posterior point through which Downs occlusal plane passes.
25	LMT	LOWER MOLAR MESIAL CUSP TIP: The anterior cusp tip of the mandibular first molar.
26	UMJ	UPPER MOLAR MESIAL CEJ: The anterior cemento-enamel junction of the maxillary first molar at the bony crest.
27	UMR	UPPER MOLAR ROOT APEX: The mesiobuccal root apex of the maxillary first molar.
28	UDT	UPPER MOLAR DISTAL CUSP TIP: The posterior cusp tip of the maxillary first molar.
29	FPP	FUNCTIONAL OCCLUSAL PLANE POINT: This point is logically determined. It is used to define the posterior location of the functional occlusal plane and consequently its value is related to the presence (or absence) of molars. If second molars are present the point is marked at their distal contact points. If second molars are absent point 28 is used.
30	AB	ANTERIOR BORDER OF THE RAMUS: This is defined as the intersection of the FOP with the anterior border of the ramus.
31	GO	GONION: The midpoint of the angle of the mandible. Found by bisecting the angle formed by the mandibular plane and a plane through articulare, posterior and along the portion of the mandibular ramus inferior to it.

NUMBER	CODE	DEFINITION
32	GOI	GONIAL INTERSECTION: The intersection of the mandibular plane with a plane through articulare, posterior and along the portion of the mandiublar ramus inferior to it.
33	PB	POSTERIOR BORDER OF THE RAMUS: This is defined as the intersection of the FOP with the posterior border of the mandibular ramus.
34	PSE	POSTERIOR SKULL EXTERNAL: The most posterior aspect of the skull on the external surface determined by a line parallel to sella nasion through glabella.
35	PSI	POSTERIOR SKILL INTERNAL: Determined similarly to point 33 on the endocranial surface.
36	OCP	OCCIPITAL PROTUBERANCE: The highest point on the occipital protuberance.
37	I	INION: The highest point on the internal occipital protuberance.
38	OP	OPISTHION: The posterior midsagittal point on the posterior margin of foramen magnum.
39	BP	BOLTON POINT: The highest point in the retrocondylar fossa in the midline.
40	BA	BASION: The most inferior, posterior point on the anterior margin of foramen magnum.
41	AR	ARTICULARE POSTERIOR: The point of intersection of the inferior cranial base surface and the averaged posterior surfaces of the mandibular condyles.
42	AA	ARTICULARE, ANTERIOR: The point of intersection of the inferior surface of the cranial base and the averaged surfaces of the mandibular condyles.
43	CO	CONDYLION: The most posterior superior point on the curvature of the average of the right and left outlines of the condylar head. Determined as the point of tangency to a perpendicular construction line to the anterior and posterior borders of the condylar head. The

NUMBER	CODE	DEFINITION
		CO point, is therefore, located as the most superior axial point of the condylar head rather than as the most superior point on the condyle.
44	PO	PORION: The midpoint of the line connecting the most superior point of the radiopacity generated by each of the two ear rods of the cephalostat.
45	APO	ANATOMIC PORION: The midpoint of a line connecting the most superior point of anatomic porion.
46	S	SELLA TURCICA: The center of the pituitary fossa of the sphenoid bone. Determined by inspection.
47	SE	ETHMOID REGISTRATION POINT: Intersection of the sphenoidal plane with the averaged greater sphenoid wing.
48	GBI	GLABELLA INTERNAL: The inner curvature of the frontal bone corresponding to glabella.
49	GB	GLABELLA: The height of curvature of the bone overlying the frontal sinus. In cases where this point is not readily apparent, the overlying soft tissue is used to locate it.
50	FSS	FRONTAL SINUS SUPERIOR: The highest point in the frontal sinus.
51	SUP	SUPRAORBITALE: The highest point in the outline of the orbital ridge.
52	FSI	FRONTAL SINUS INFERIOR: The lowest point in the frontal sinus.
53	FMN	FRONTOMAXILLARY NASAL SUTURE: The junction of the frontal, maxillary and nasal bones.
54	N	NASION: The junction of the frontonasal suture at the most posterior point on the curve at the bridge of the nose.
55	NB	NASAL BONE: The tip of the nasal bone.

NUMBER	CODE	DEFINITION
56	LO	LATERAL ORBIT: The most posterior aspects of the lateral aspect of the orbits.
57	OR	ORBITALE: The lowest point on the average of the right and left borders of the bony orbit.
58	IZ	INFERIOR ZYGOMA: The lowest point on the average of the right and left outlines of the zygoma.
59	PNS	POSTERIOR NASAL SPINE: The most posterior point at the sagittal plane on the bony hard palate.
60	PTM	PTERYGO-MAXILLARY FISSURE, INFERIOR: The most inferior point on the average of the right and left outlines of the pterygo-maxillary fissure.
61	CP	CORONOID PROCESS: The most superior point on the average of the right and left outlines of the coronoid process.
62	PTMS	PTERYGO-MAXILLARY FISSURE, SUPERIOR: The most superior point on the average of the right and left outlines of the pterygo-maxillary fissure.
63	3VS	3rd VERTICAL SUPERIOR: The highest periosteal surface of the body of the 3rd cervical vertebrae determined by visual inspection along the long axis.
64	3VA	3rd VERTEBRA ANTERIOR: The most anterior surface of the body.
65	3VI	3rd VERTEBRA INFERIOR: The inferior surface as in 63.
66	3VP	3rd VERTEBRA POSTERIOR: The anterior surface of the spinal canal.
67	3VC	3rd VERTEBRA CANAL: The posterior aspect of the spinal canal.
68	3VSP	3rd VERTEBRA SPINE: The most posterior aspect of the spine of the 3rd cervical vertebrae.

NUMBER	CODE	DEFINITION
69	4VS	4th VERTEBRA SUPERIOR: as in 63.
70	4VA	4th VERTEBRAE ANTERIOR: as in 64.
71	4VI	4th VERTEBRA INFERIOR: as in 65.
72	4VP	4th VERTEBRA POSTERIOR: as in 66.
73	4VC	4th VERTEBRA CANAL: as in 67.
74	4VSP	4th VERTEBRA SPINE: as in 68.
75	GI'	SOFT TISSUE GLABELLA: The height of the curvature on the soft tissue over glabella.
76	Na'	SOFT TISSUE NASION: The deepest point on the soft tissue over nasion.
77	NoA'	TIP OF NOSE-A: The most anterior surface over the nose.
78	NoB'	TIP OF NOSE-B: The most anterior and inferior point on the nose.
79	Sn'	SUBNASALE: The deepest point on the concavity between the tip of the nose and upper lip.
80	A'	SOFT TISSUE A POINT: The deepest point on the upper point on the upper lip corresponding to point A, not including the ridges of the philtrum.
81	UL'	UPPER LIP ANTERIOR: The most prominent point on the upper lip.
82	St'	STOMION: The contact point between the upper and lower lip at the mouth-slit.
83	LL'	LOWER LIP ANTERIOR: The most prominent point on the lower lip.
84	B'	MENTAL SULCUS (SOFT TISSUE B POINT): The deepest point on the soft tissue between the upper lip and the chin corresponding to B point.

NUMBER	CODE	DEFINITION
85	Pog'	SOFT TISSUE POGONION: The most anterior point on the soft tissue chin.
86	Gn'	SOFT TISSUE GNATHION: The most anterior and inferior point on the soft tissue chin.
87	Me'	SOFT TISSUE MENTON: The most inferior point on the soft tissue chin.

APPENDIX E

HEALTH INFORMATION

BOLTON STUDY

ADULT-AGING RECALL

Name Yes responses to the questions. Age_____ Sex_____
(Please Print or Type)
Address_____ Phone_____

Name of Physician_____ Name of Dentist_____
(Optional) (Optional)
Office Phone_____

HEALTH HISTORY

Please place checkmark under Yes or No in ALL spaces provided. If the answer is YES please describe on the reverse side of this sheet giving details such as dates, severity, resulting disability, and medications being taken now or taken in the past.

	Yes	No
1. Has your health been impaired?	19	
2. Are you under physicians care for other than routine check-ups?	14	
Have you had any of the following:		
3. Oral, facial or neck surgery?	46	
4. Tonsillectomy? Age___	109	
5. Adenoidectomy? Age___	81	
6. Other surgery?	99	
7. Is surgery planned?	4	
8. Heart Trouble?	5	
9. High blood pressure?	15	
10. Diabetes?	5	
11. Rheumatic fever?	3	
12. Tuberculosis?	5	
13. Arthritis?	22	
14. Thyroid disorder?	7	
15. Blood disorder?	2	
16. Bleeding tendency?	1	
17. Leukemia?	0	
18. Skin tumors?	12	
19. Cancer, other tumors?	11	
20. Joint problems?	30	

21. For Females: Age of onset of menses___ Menstrual problems: Yes 6 No_____
(Describe over)

22. Your ages at time of normal live-birth deliveries___ ___ ___

23. Your ages at time of still births or miscarriages___ ___ ___

24. Has menopause occurred? Yes 34 No___ If yes at what age?___

Signature:_____ Date:_____

(Continued on Reverse Side)

RESPONSES TO QUESTIONS

1. Has your health been impaired?
   - Herpes Zoster (1)
   - Allergies (1)
   - Spinal Degeneration (1)
   - Epilepsy (1)
   - Hepatitis (2)
   - Nephrosis (1)
   - Hip Degeneration (1)
   - Mastectomy (1)
   - Hernia (1)
   - Hypoglycemia (1)
   - Varicose Veins (1)

2. Are you under a physician's care for other than routine check-ups?
   - Hypertension (1)
   - Diabetes (1)
   - Costrochondritis (1)
   - Glaucoma (1)

3. Oral, facial or neck surgery.
   - Extraction of teeth (17)
   - Rhinoplasty (1)
   - Endodontics (2)
   - Gingival surgery (6)
   - Nevus removed (5)
   - Mastoidectomy (1)

4. Tonsillectomy?
   - Most at 5-6 years
   - ¼ as adults (greater than 16 years)

5. Adenoidectomy?
   - Most at 5-6 years
   - 1/10 as adults (greater than 16 years)

6. Other surgery?
   - Mastoidectomy (2)
   - Appendectomy (20)
   - Hemmorhoids (4)
   - Caesarian Section (2)
   - Kidney stones (3)

Prostectomy (1)
Female reproductive (11)
Fractures or joint surgery (21)
Cardiovascular (2)
Circumcision (2)
Lung surgery (1)
Vasectomy (2)
Cataracts (1)
Hernia repairs (13)
Tumor removal (9)
Varicose veins (2)
Breast (5)

7. Is surgery planned?
   Back fusion (1)
   Varicose veins (1)
   Hemmorhoids (1)

8. Heart trouble?
   Heart attack (2)

9. High blood pressure?
   9 reports (all on medication)

10. Diabetes
    4 reports, adult onset

11. Rheumatic fever?
    3 reports
    12 reports of permanent damage
    1 on medication

12. Tuberculosis?
    5 reports
    3 as adult
    all rehabilitated

13. Arthritis?
    15 reported as minor
    3 reported as degenerative
    areas reported:
        hands (3)
        neck (1)
        spine (1)
        knee (13)
        hips (1)
        shoulders (1)
        feet (1)
        ankles (1)

14. Thyroid disorder?
    - Continuing treatment (1)
    - Treated and no present problem (2)
    - Continuing, untreated (1)

15. Blood disorder?
    - Related to medication (1)
    - Related to pregnancy (1)

16. Bleeding tendency?
    - No reports

17. Leukemia?
    - None

18. Skin tumors?
    - Benign (2)
    - Basal cell carcinoma (2)
    - Squamous cell carcinoma (3)
    - Locations reported:
        - face (1)
        - nose (1)
        - stomach (1)

19. Cancer, other tumors?
    - Breast tumor (3)
    - Rectal cancer (1)

20. Joint problems?
    Locations:
    - Shoulders (2)
    - Ankle (1)
    - Back (3)
    - Wrist (3)
    - Elbow (2)
    - Hands (2)
    - Knee (6)
    - Feet (1)
    - Hip (1)
    - Sports related (3)
    - Fracture related (2)
    - Considered degenerative (2)
    - Surgerized (1)

21. Onset of menses?
    - Range 10-15 years
    - Ages:
        - 10 (3)
        - 11 (3)

12 (13)
13 (11)
14 (4)
15 (1)

Menstrual problems
Severe cramps (5)
Heavy flow (3)

22. Age at time of normal live-birth deliveries?
119 children from 34 mothers
Approximately a mean of 4 children
Range = 1-9 children
Range of maternal age at birth = 19-41
Most born in mother's 20's

23. Ages at time of still births or miscarriages?
20 from 12 mothers
Range of 1-3
Range of maternal age = 25-50
Most beyond 30 years of age

24. Has menopause occurred?
5 surgical
Age range of non-surgical 40-55 years

25. Other responses
Extreme weight loss (1)
Guilliam Barre syndrome
Mononucleosis
Ulcer
Asthma
Viral pneumonia
Polio
Bell's palsy
Gout

APPENDIX F

DEFINITIONS

APPENDIX F

DEFINITIONS

ADULT: As commonly thought as one who is "grown-up" or mature.

AGE CHANGES: Processes which tend to begin or accelerate at maturity, even though evidence of these changes may be present prior to maturity.

AGED CHANGES: As in age changes, but with the negative connotation of degeneration.

AGING: Used in the broadest sense of the word as the time period between conception and death and not limited to the period of senility. In this paper aging refers to the period post-adolescence (generally seventeen years on).

CONFORMATION: Act of forming or producing conformity; adaptation. Formation or fashioning of anything by symmetrical arrangement of its parts; shaping; a putting into form.

DEVELOPMENT: A concept not clearly divided from aging but commonly conceived as meaning processes which pass through and

exhibit eventful milestones by which the progress of maturity can be assessed.

DIMORPHISM: Difference of form or structure of a more or less permanent nature between members of the same species. In this case between male and female.

GROWTH: The progressive development of a living being or part of an organism from its earliest stage including increases in size and shape change.

MATURITY: A slowing or cessation of developmental processes.

SECULAR TREND: Changes in growth occurring among generations.

SENILITY: A portion of aging with the connotation of degeneration attached.

APPENDIX G

CALCULATION TABLES

UNTREATED SAMPLE-INITIAL TO FINAL

	gain	loss	Δ	Δ sd	Δ se	Max	Min	Δ %	t
001 SIMP 46-1	107	6	2.9	2.6	.24	16.1	-3.1	2.2	***
002 SIMP 46-2	106	7	2.8	2.4	.23	15.4	-.7	2.1	***
003 SIMP 46-3	110	3	3.0	2.5	.23	16.0	-.4	2.3	***
004 SIMP 46-4	95	18	2.0	2.2	.20	11.0	-2.0	1.8	***
005 SIMP 46-5	103	10	2.0	1.9	.18	10.9	-1.2	1.8	***
006 SIMP 46-6	98	15	2.0	1.9	.18	9.9	-1.4	1.9	***
007 SIMP 46-7	102	11	1.9	1.7	.16	9.4	-1.1	1.9	***
008 SIMP 46-8	105	8	1.9	1.5	.14	7.8	-.8	1.8	***
009 SIMP 46-9	104	9	2.5	1.9	.18	8.6	-2.5	2.4	***
010 SIMP 46-10	106	7	1.7	1.3	.13	6.7	-1.3	1.7	***
011 SIMP 46-11	91	22	1.3	1.4	.13	5.4	-2.3	1.4	***
012 SIMP 46-12	100	13	1.5	1.8	.17	9.1	-1.7	1.6	***
013 SIMP 46-13	105	8	2.5	1.8	.17	8.6	-1.3	2.9	***
014 SIMP 46-14	103	10	2.0	1.4	.14	7.6	-1.1	2.1	***
015 SIMP 46-15	102	11	2.0	1.8	.17	10.3	-2.6	1.9	***
016 SIMP 46-16	98	15	1.9	2.1	.19	11.8	-1.9	1.7	***
017 SIMP 46-17	101	12	2.5	2.4	.23	14.5	-2.8	2.2	***
018 SIMP 46-18	108	5	2.5	1.9	.17	8.7	-1.5	2.6	***
019 SIMP 46-19	102	11	2.4	2.1	.19	8.8	-2.3	2.6	***
020 SIMP 46-20	100	13	2.3	2.3	.22	11.7	-2.7	2.3	***
021 SIMP 46-21	107	6	2.7	2.2	.20	11.0	-1.0	2.9	***
022 SIMP 46-22	103	10	2.4	2.0	.19	10.2	-.8	2.8	***
023 SIMP 46-23	102	11	2.3	2.0	.19	8.4	-1.5	2.7	***
024 SIMP 46-24	104	9	2.4	2.0	.19	9.0	-.7	2.8	***
025 SIMP 46-25	102	11	2.4	2.1	.20	9.7	-.8	2.8	***
026 SIMP 46-26	106	7	2.1	1.9	.18	9.6	-2.4	2.7	***
027 SIMP 46-27	96	17	2.2	2.1	.18	9.7	-1.5	3.3	***
028 SIMP 46-28	108	5	2.6	1.9	.18	10.2	-.6	3.3	***
029 SIMP 46-29	106	7	2.7	2.2	.21	10.7	-.7	3.7	***
030 SIMP 46-30	85	28	1.8	2.3	.22	10.1	-2.5	2.7	***
031 SIMP 46-31	102	11	3.0	2.6	.24	14.8	-1.2	3.6	***
032 SIMP 46-32	103	10	3.1	2.7	.25	14.2	-1.0	3.6	***
033 SIMP 46-33	88	25	2.5	2.9	.27	11.5	-2.3	4.1	***
034 SIMP 46-38	62	51	.4	1.6	.15	5.5	-2.7	.5	*
035 SIMP 46-39	74	39	.5	1.5	.14	6.4	-2.9	.8	***
036 SIMP 46-40	80	33	.6	1.2	.11	4.4	-2.3	1.3	***
037 SIMP 46-41	69	44	.6	1.2	.11	4.8	-2.0	1.4	***
038 SIMP 46-42	70	43	.3	1.1	.10	3.6	-2.5	1.0	*
039 SIMP 46-43	56	57	.1	1.7	.16	7.0	-3.7	.7	-
040 SIMP 46-44	70	43	1.3	3.5	.33	9.8	-6.7	4.8	***
041 SIMP 46-45	52	61	-.3	2.5	.23	8.1	-10.4	-.6	-
042 SIMP 46-47	65	48	.1	.7	.06	2.7	-1.5	.4	-
043 SIMP 46-48	57	56	.2	1.6	.15	4.6	-6.1	.3	-
044 SIMP 46-49	100	13	1.5	1.4	.13	4.8	-2.5	1.9	***
045 SIMP 46-50	96	17	1.3	1.6	.15	7.5	-2.4	1.7	***
046 SIMP 46-51	90	23	1.2	1.5	.14	4.7	-2.0	1.7	***

	gain	loss	Δ	Δsd	Δse	Max	Min	Δ%	t
047 SIMP 46-52	72	41	.5	3.4	.32	10.6	-13.9	1.0	-
048 SIMP 46-53	89	24	1.5	1.8	.17	5.4	-3.2	2.1	***
049 SIMP 46-54	104	9	1.1	.8	.08	3.1	-.9	1.5	***
050 SIMP 46-55	105	8	1.3	1.2	.12	4.9	-3.7	1.5	***
051 SIMP 46-56	87	26	.7	.9	.08	3.2	-1.8	1.3	***
052 SIMP 46-57	99	14	1.1	1.2	.11	4.6	-3.5	1.8	***
053 SIMP 46-58	98	15	1.1	1.4	.13	6.6	-3.5	1.9	***
054 SIMP 46-59	90	23	.9	1.2	.11	3.9	-2.3	1.8	***
055 SIMP 46-60	65	48	.3	1.6	.16	5.4	-5.3	.9	*
056 SIMP 46-61	80	33	1.1	2.4	.22	6.6	-5.2	3.0	***
057 SIMP 46-62	60	53	-.1	.9	.08	2.7	-2.2	-.1	-
058 SIMP 46-75	93	20	1.6	1.8	.17	6.7	-2.7	1.8	***
059 SIMP 46-76	101	12	1.8	1.6	.15	6.6	-1.6	2.2	***
060 SIMP 46-77	110	3	2.9	2.2	.20	10.9	-.7	2.6	***
061 SIMP 46-78	103	10	2.7	2.2	.20	11.2	-1.1	2.4	***
062 SIMP 46-79	69	44	.5	1.8	.17	6.1	-4.7	.5	**
063 SIMP 46-80	94	19	2.3	2.2	.21	7.5	-2.4	2.1	***
064 SIMP 46-81	88	25	1.9	2.3	.21	9.1	-3.9	1.7	***
065 SIMP 46-82	101	12	2.6	2.3	.22	11.4	-2.1	2.3	***
066 SIMP 46-83	90	23	2.1	2.6	.25	11.7	-3.1	1.7	***
067 SIMP 46-84	108	5	3.9	2.7	.25	13.9	-1.5	3.2	***
068 SIMP 46-85	103	10	4.9	4.0	.37	17.5	-3.3	3.7	***
069 SIMP 46-86	107	6	4.9	3.7	.35	18.4	-2.3	3.5	***
070 SIMP 46-87	97	16	3.7	3.5	.33	18.3	-4.0	2.7	***
071 3PTA 54-46-1	62	51	.1	.8	.07	2.5	-2.9	.2	-
072 3PTA 54-46-2	70	43	.2	.8	.07	3.0	-2.2	.2	*
073 3PTA 54-46-3	72	41	.3	.8	.07	3.5	-1.5	.4	***
074 3PTA 54-46-4	72	41	.2	.9	.08	2.4	-2.5	.3	*
075 3PTA 54-46-5	66	47	.2	.7	.07	2.6	-1.7	.3	*
076 3PTA 54-46-6	64	49	.2	.6	.06	2.0	-1.7	.3	*
077 3PTA 54-46-7	63	50	.1	.7	.06	1.9	-2.1	.3	*
078 3PTA 54-46-8	60	53	.1	.7	.07	2.0	-2.6	.2	-
079 3PTA 54-46-9	87	26	.5	.7	.07	2.4	-1.1	1.0	***
080 3PTA 54-46-10	64	49	.1	.6	.05	1.5	-1.8	.3	*
081 3PTA 54-46-11	45	68	-.1	.7	.07	2.2	-2.3	-.3	-
082 3PTA 54-46-12	51	62	0	.6	.06	1.5	-2.2	-.1	-
083 3PTA 54-46-13	50	63	0	.8	.07	2.3	-1.6	0	-
084 3PTA 54-46-14	55	58	0	.6	.05	1.8	-1.8	0	-
085 3PTA 54-46-15	59	54	.1	.9	.08	2.3	-2.1	.1	-
086 3PTA 54-46-16	49	64	-.2	1.0	.10	3.1	-2.7	-.3	*
087 3PTA 54-46-17	62	51	.1	.8	.08	2.4	-2.2	.2	-
088 3PTA 54-46-18	57	56	0	.8	.08	2.7	-2.3	0	-
089 3PTA 54-46-19	54	59	0	.9	.09	2.6	-3.2	-.1	-
090 3PTA 54-46-20	32	81	-.7	1.0	.10	1.4	-3.8	-.9	***
091 3PTA 54-46-21	40	73	-.3	.9	.09	1.9	-3.4	-.5	***
092 3PTA 54-46-22	40	73	-.4	.9	.08	2.1	-2.9	-.6	***

		gain	loss	Δ	Δ sd	Δ se	Max	Min	Δ %	t
093	3PTA 54-46-23	32	81	-.4	.9	.09	2.1	-3.3	-.6	***
094	3PTA 54-46-24	27	86	-.4	.9	.08	1.8	-4.0	-.7	***
095	3PTA 54-46-25	35	78	-.5	.9	.09	2.2	-3.7	-.7	***
096	3PTA 54-46-26	41	72	-.2	.9	.08	2.7	-3.0	-.4	**
097	3PTA 54-46-27	64	49	.2	1.3	.13	3.9	-3.0	.3	-
098	3PTA 54-46-28	32	81	-.6	.9	.09	1.5	-3.5	-.8	***
099	3PTA 54-46-29	42	71	-.4	1.1	.10	2.3	-5.4	-.5	***
100	3PTA 54-46-30	79	34	.7	1.3	.12	5.3	-2.8	1.0	***
101	3PTA 54-46-31	45	68	-.3	.9	.09	1.6	-3.5	-.3	**
102	3PTA 54-46-32	50	63	-.2	.9	.09	2.5	-4.3	-.2	-
103	3PTA 54-46-33	36	77	-.5	1.0	.10	2.2	-4.8	-.4	***
104	3PTA 54-46-38	40	73	-.4	1.0	.09	1.8	-3.0	-.2	***
105	3PTA 54-46-39	41	72	-.4	1.5	.14	5.0	-4.5	-.3	**
106	3PTA 54-46-40	54	59	-.1	1.4	.13	4.5	-4.9	-.1	-
107	3PTA 54-46-41	64	49	.3	1.5	.14	4.3	-3.0	.3	*
108	3PTA 54-46-42	40	73	-.7	2.8	.26	5.6	-17.2	-.6	**
109	3PTA 54-46-43	63	50	.6	2.5	.24	9.6	-6.0	.5	**
110	3PTA 54-46-44	49	64	-.9	6.8	.64	21.4	-16.2	-.6	-
111	3PTA 54-46-45	49	64	-.5	7.0	.66	19.0	-18.0	-.3	-
112	3PTA 54-46-47	55	58	0	1.0	.10	2.7	-2.9	NA	-
113	3PTA 54-46-48	58	55	.1	1.1	.10	3.4	-4.1	1.7	-
114	3PTA 54-46-49	40	73	-.3	1.1	.10	2.6	-5.3	-2.5	**
115	3PTA 54-46-50	95	18	1.7	1.9	.18	8.3	-2.3	11.4	***
116	3PTA 54-46-51	56	57	.1	.8	.07	2.7	-2.7	4.8	-
117	3PTA 54-46-52	72	41	.5	1.8	.17	6.4	-7.8	NA	**
118	3PTA 54-46-53	49	64	-.2	1.2	.12	2.8	-3.7	6.4	*
119	3PTA 54-46-55	41	72	-.1	.7	.07	4.1	-1.9	-.8	-
120	3PTA 54-46-56	43	70	-.7	1.9	.17	3.7	-5.3	-4.0	***
121	3PTA 54-46-57	54	59	0	.8	.07	2.3	-3.1	0	-
122	3PTA 54-46-58	43	70	-.2	1.0	.09	3.9	-2.4	-.4	*
123	3PTA 54-46-59	72	41	.5	1.7	.16	4.1	-4.0	.7	**
124	3PTA 54-46-60	71	42	.3	1.2	.11	3.5	-2.6	.5	**
125	3PTA 54-46-61	59	54	.3	2.6	.24	7.6	-6.3	.7	-
126	3PTA 54-46-62	28	85	-1.7	2.7	.26	4.7	-16.0	-3.7	***
127	3PTA 54-46-75	41	72	-.5	1.4	.13	2.5	-6.6	-4.8	***
128	3PTA 54-46-76	64	49	.4	1.8	.17	5.0	-4.3	NA	**
129	3PTA 54-46-77	98	15	1.1	.9	.09	3.1	-.8	4.3	***
130	3PTA 54-46-78	101	12	1.1	.9	.09	3.2	-.9	3.9	***
131	3PTA 54-46-79	100	13	1.1	.9	.09	3.0	-1.7	3.2	***
132	3PTA 54-46-80	108	5	1.8	1.2	.11	4.4	-.6	4.5	***
133	3PTA 54-46-81	109	4	2.2	1.4	.13	6.0	-.9	5.2	***
134	3PTA 54-46-82	99	14	1.2	1.2	.11	3.6	-1.4	2.6	***
135	3PTA 54-46-83	85	28	.8	1.2	.11	3.6	-2.5	1.6	***
136	3PTA 54-46-84	79	34	.5	1.0	.10	3.1	-2.6	.8	***
137	3PTA 54-46-85	78	35	.5	1.3	.12	3.3	-2.8	.9	***
138	3PTA 54-46-86	74	39	.5	1.2	.12	4.0	-2.1	.9	***
139	3PTA 54-46-87	73	40	.5	1.5	.14	5.2	-2.4	.8	***

	gain	loss	Δ	Δ sd	Δ se	Max	Min	Δ %	t
140 SIMP 43-3	108	5	3.0	2.6	.24	16.2	-1.5	2.5	***
141 SIMP 43-17	97	16	2.6	2.5	.24	15.1	-1.4	2.5	***
142 SIMP 43-31	99	14	3.1	3.1	.29	15.3	-2.2	5.2	***
143 SIMP 31-3	84	29	.9	1.2	.12	5.2	-1.7	1.1	***
144 PDIS 61/41-32	87	26	.9	1.8	.17	5.4	-5.0	2.2	***
145 SIMP 33-30	45	68	-.3	1.6	.15	3.7	-6.0	-1.0	*
146 SIMP 31-30	65	48	.2	1.3	.12	3.1	-3.7	.5	-
147 PDIS 30/3-5	85	28	1.2	1.8	.17	6.5	-2.7	2.5	***
148 PDIS 33/3-5	80	33	.8	1.4	.13	5.1	-3.2	1.0	***
149 PDIS 61/31-1	88	25	1.9	2.7	.25	9.0	-5.0	3.1	***
150 SIMP 17-3	83	30	.4	.6	.06	2.2	-1.1	2.3	***
151 PDIS 3/54-4	82	31	.2	.8	.07	1.9	-6.2	NA	**
152 PDIS 5/32-1	96	17	.9	1.1	.10	4.1	-2.3	2.7	***
153 PDIS 6/32-1	98	15	1.1	1.2	.11	5.0	-3.0	2.5	***
154 PDIS 15/32-1	89	24	1.1	1.6	.15	6.7	-3.6	3.4	***
155 PDIS 21/32-1	95	18	1.1	1.3	.13	5.4	-3.5	4.2	***
156 PDIS 25/32-1	102	11	1.6	1.4	.13	4.6	-2.2	4.6	***
157 PDIS 6/54-4	68	45	.1	1.9	.18	3.9	-16.0	NA	-
158 PDIS 6/11-3	63	50	0	1.2	.12	2.2	-8.4	NA	-
159 SIMP 60-11	89	24	1.2	1.5	.14	5.9	-2.9	2.0	***
160 PDIS 11/54-3	53	60	0	.9	.09	3.5	-3.6	NA	-
161 PDIS 44/54-46	70	43	1.2	4.2	.39	9.6	-9.7	8.5	**
162 SIMP 47-59	99	14	1.0	1.1	.10	5.4	-1.6	2.1	***
163 PDIS 59/54-46	98	15	1.0	1.0	.10	4.3	-1.6	2.1	***
164 PDIS 12/54-46	91	22	.9	1.2	.11	6.0	-1.7	1.6	***
165 PDIS 58/54-46	91	22	.7	1.3	.12	7.0	-3.2	1.6	***
166 PDIS 58/59-12	73	40	.3	1.1	.11	3.0	-3.6	NA	*
167 PDIS 57/54-46	84	29	.5	.8	.08	3.0	-2.0	1.8	***
168 PDIS 57/59-12	79	34	.5	1.1	.10	4.0	-2.6	1.9	***
169 PDIS 51/46-54	63	50	.2	1.0	.10	3.5	-3.7	NA	*
170 SIMP 51-57	82	31	.7	1.4	.14	5.0	-4.9	2.0	***
171 PDIS 10/12-59	69	44	.5	1.2	.12	3.8	-2.6	3.1	***
172 PDIS 8/12-59	77	36	.7	1.2	.11	4.5	-2.5	2.4	***
173 PDIS 14/12-59	80	33	.6	1.1	.11	4.5	-2.1	3.1	***
174 PDIS 26/12-59	76	37	.6	1.2	.12	3.6	-2.4	3.8	***
175 PDIS 23/12-59	83	30	.7	1.2	.12	3.6	-2.1	2.8	***
176 PDIS 8/11-3	61	52	0	1.5	.15	2.5	-13.1	NA	-
177 PDIS 9/NP45	57	56	-.1	2.2	.20	5.5	-11.6	NA	-
178 PDIS 9/NP44	56	57	-.3	3.9	.36	10.3	-10.9	NA	-
179 SIMP 39-54	89	24	1.4	1.8	.17	9.0	-2.7	1.1	***
180 SIMP 47-54	100	13	1.0	.9	.09	3.0	-1.6	2.1	***
181 PDIS 46/60-47	62	51	.1	.6	.06	2.8	-1.6	.3	-
182 PDIS 56/47-60	84	29	.5	.9	.09	2.6	-1.6	2.0	***
183 PDIS 54/47-60	95	18	.9	1.0	.09	3.1	-1.8	2.1	***
184 PDIS 11/47-60	93	20	1.2	1.4	.14	5.9	-2.5	2.1	***
185 PDIS 31/60-47	40	73	-.8	2.5	.23	6.3	-9.0	-4.6	**

		gain	loss	Δ	Δsd	Δse	Max	Min	Δ%	t
186	PDIS 4/47-60	77	36	1.2	2.5	.24	8.9	-5.3	2.2	***
187	PDIS 3/47-60	81	32	1.6	3.0	.28	10.3	-6.7	2.6	***
188	SIMP 41-54	97	16	1.6	1.4	.13	5.4	-1.5	1.6	***
189	SIMP 43-54	90	23	1.4	1.5	.14	5.4	-2.0	1.4	***
190	SIMP 43-11	97	16	1.6	1.5	.15	6.1	-.9	1.7	***
191	SIMP 43-2	105	8	2.9	2.6	.24	16.1	-1.2	2.4	***
192	SIMP 40-54	102	11	1.5	1.4	.13	5.2	-2.0	1.4	***
193	SIMP 40-11	94	19	1.4	1.4	.13	4.9	-1.9	1.4	***
194	SIMP 40-4	91	22	1.6	2.0	.19	10.0	-2.1	1.5	***
195	PDIS 11/NP44	57	56	.2	2.9	.27	7.2	-7.3	NA	-
196	PDIS 3/NP44	59	54	.3	5.2	.49	13.6	-12.9	NA	-
197	PDIS 11/NP45	49	64	-.7	3.2	.30	7.7	-10.1	NA	*
198	PDIS 3/NP45	46	67	-1.5	6.2	.58	14.7	-16.0	NA	**
199	SIMP 54-12	90	23	.9	1.2	.11	5.8	-1.7	1.6	***
200	SIMP 12-1	102	11	1.9	1.9	.18	7.4	-2.6	2.8	***
201	SIMP 54-1	104	9	2.8	2.3	.22	10.7	-.5	2.2	***
202	SIMP 59-31	87	26	1.5	1.9	.18	6.3	-2.8	3.2	***
203	PDIS 54/59-12	91	22	.9	1.0	.10	5.0	-1.4	1.6	***
204	PDIS 1/12-59	100	13	1.8	1.8	.17	7.9	-2.2	2.7	***
205	PDIS 46/59-12	96	17	1.1	1.2	.12	4.7	-1.7	2.5	***
206	PDIS 31/12-59	88	25	1.8	2.4	.23	10.4	-3.6	4.9	***
207	SIMP 62-2	107	6	3.2	2.6	.25	17.1	-.7	3.0	***
208	SIMP 31-58	99	14	2.1	1.8	.17	7.0	-1.9	3.2	***
209	SIMP 48-49	93	20	1.4	1.7	.16	7.5	-2.0	9.2	***
210	SIMP 50-52	99	14	3.5	4.3	.40	19.9	-5.6	30.8	***
211	SIMP 63-65	82	31	.6	1.0	.10	5.4	-1.7	4.8	***
212	SIMP 64-66	95	18	.7	.9	.08	3.5	-2.2	4.5	***
213	SIMP 38-40	47	66	-.2	1.9	.18	5.2	-4.3	-.3	-
214	SIMP 66-67	40	73	-.2	.8	.08	1.8	-3.1	-1.3	***
215	SIMP 64-68	103	10	1.4	1.2	.12	6.6	-1.3	2.9	***
216	PDIS 81/80-84	17	96	-1.2	1.3	.12	1.8	-4.0	-21.5	***
217	PDIS 83/80-84	28	85	-1.0	1.5	.14	2.3	-4.9	-15.2	***
218	PDIS 85/80-84	52	61	-.1	1.6	.15	4.6	-4.0	.4	-
219	PDIS 78/80-84	89	24	2.2	2.6	.25	9.8	-3.3	22.0	***
220	SIMP 93-92	76	37	1.0	2.7	.26	7.4	-6.1	3.4	***
221	SIMP 92-91	57	56	.1	2.3	.22	6.0	-6.2	.1	-
222	SIMP 12-82	107	6	2.6	2.1	.19	8.7	-1.4	9.6	***
223	SIMP 54-78	109	4	3.1	2.0	.19	10.7	-.7	5.1	***
224	SIMP 6-8	56	57	-.03	1.2	.11	3.2	-2.9	0	-
225	3PTA 46-54-4	52	61	-.1	.9	.08	3.7	-3.0	-.1	-
226	3PTA 46-54-11	56	57	0	.8	.08	2.3	-1.9	0	-
227	3PTA 39-54-3	53	60	-.1	1.0	.09	3.2	-2.8	-.1	-
228	3PTA 40-54-11	52	61	0	.8	.08	1.9	-2.9	0	-
229	4PTA 46-54/44-57	53	60	-.3	2.7	.26	6.7	-6.2	NA	-
230	4PTA 39-54/44-57	49	64	-.5	3.0	.28	7.8	-8.7	-1.6	-
231	4PTA 46-54/59-12	42	71	-.3	1.1	.10	2.7	-3.6	-4.4	**

		gain	loss	Δ	Δsd	Δse	Max	Min	Δ%	t
232	4PTA 46-54/29-18	43	70	-.7	2.2	.21	3.6	-8.1	-4.0	***
233	4PTA 46-54/24-7	54	59	0	2.2	.21	6.1	-7.1	.9	-
234	4PTA 46-54/31-2	43	70	-.5	1.4	.13	3.9	-5.3	-1.8	***
235	4PTA 46-54/32-1	44	69	-.6	1.5	.14	4.0	-5.2	-2.3	***
236	4PTA 46-54/41-32	64	49	0	1.5	.14	4.2	-4.6	.1	-
237	4PTA 46-54/47-60	62	51	.1	1.4	.13	5.0	-3.2	.1	-
238	4PTA 57-44/54-3	48	65	-.6	3.0	.28	7.2	-7.4	-.7	*
239	4PTA 44-57/29-18	51	62	-.1	3.6	.34	7.9	-8.4	NA	-
240	4PTA 44-57/24-7	61	52	.6	3.1	.29	7.3	-6.7	NA	*
241	4PTA 44-57/32-1	57	56	0	3.2	.30	6.7	-7.1	.7	-
242	4PTA 44-57/41-32	67	46	.7	3.4	.32	7.9	-7.8	.9	*
243	4PTA 44-57/46-2	68	45	.8	3.0	.29	8.0	-7.1	1.4	**
244	4PTA 40-54/46-2	64	49	.2	1.0	.09	2.5	-2.3	.2	-
245	4PTA 40-54/62-2	77	36	.4	1.2	.11	3.2	-2.5	.4	***
246	4PTA 59-12/29-18	51	62	-.4	2.3	.22	4.2	-9.0	NA	-
247	4PTA 59-12/32-1	47	66	-.3	1.7	.16	3.4	-5.0	-1.7	*
248	4PTA 60-47/59-12	46	67	-.4	1.7	.16	4.3	-5.5	-.5	*
249	4PTA 60-47/29-18	44	69	-.8	2.8	.26	5.2	-10.2	-.9	**
250	4PTA 60-47/32-1	39	74	-.7	2.2	.21	4.4	-6.4	-.7	***
251	4PTA 3-54/1-32	80	33	.6	1.0	.10	4.6	-1.4	.8	***
252	3PTA 41-32-1	34	79	-.7	1.6	.15	3.4	-5.6	-.6	***
253	3PTA 61-31-1	53	60	.1	1.9	.18	5.0	-5.6	.1	-
254	4PTA 3-54/4-11	56	57	.1	1.4	.13	4.1	-4.6	NA	-
255	3PTA 54-11-3	61	52	-.1	1.7	.16	7.1	-6.5	-.1	-
256	4PTA 54-46/13-8	37	76	-1.6	3.9	.37	11.4	-13.6	-1.5	***
257	4PTA 12-59/13-8	33	80	-1.9	4.0	.37	10.6	-13.6	-1.7	***
258	4PTA 1-32/8-13	79	34	2.2	3.8	.36	14.1	-7.5	4.7	***
259	4PTA 54-11/13-8	39	74	-1.5	4.0	.37	11.0	-14.3	-2.0	***
260	4PTA 59-12/27-23	43	70	-.8	4.6	.44	18.5	-10.6	-.7	-
261	4PTA 8-13/6-16	67	46	1.7	5.6	.53	21.9	-9.2	1.4	***
262	4PTA 54-46/6-16	58	55	.1	3.5	.33	9.8	-8.5	.4	-
263	4PTA 57-44/6-16	53	60	-.5	4.6	.43	11.6	-11.6	-.7	-
264	4PTA 12-59/6-16	54	59	-.2	3.7	.35	9.2	-9.1	-.2	-
265	4PTA 7-24/6-16	56	57	.1	4.0	.37	11.3	-8.7	.2	-
266	4PTA 1-32/16-6	64	49	.5	3.1	.29	8.7	-7.9	.5	-
267	4PTA 3-11/16-6	60	53	-.1	2.9	.28	7.6	-9.1	.2	-
268	4PTA 4-54/16-6	59	54	-.2	3.2	.30	7.2	-8.4	-.4	-
269	4PTA 32-1/25-20	62	51	.4	4.5	.42	14.6	-13.2	.7	-
270	3PTA 46-54-55	70	43	.2	2.3	.22	4.6	-12.0	.2	-
271	3PTA 75-76-77	66	47	1.7	8.1	.76	23.6	-26.7	1.5	*
272	3PTA 76-77-79	17	96	-4.7	4.2	.40	5.0	-16.3	-4.8	***
273	3PTA 76-78-79	15	98	-5.0	4.2	.39	5.6	-15.3	-5.4	***
274	3PTA 78-79-81	35	78	-4.3	7.0	.66	8.7	-28.5	-3.6	***
275	3PTA 83-84-85	87	26	6.4	9.4	.89	33.5	-22.8	5.4	***
276	4PTA 57-44/83-85	84	29	3.7	5.5	.52	20.4	-12.6	5.2	***
277	4PTA 57-44/80-84	72	41	2.0	4.3	.41	15.0	-8.5	2.9	***

	FEMALE				MALE			
	Δ	Δsd	Δse	t	Δ	Δsd	Δse	t
001 SIMP 46-1	2.06	1.65	.28	***	3.21	2.79	.31	***
002 SIMP 46-2	1.98	1.33	.23	***	3.12	2.66	.30	***
003 SIMP 46-3	2.30	1.65	.28	***	3.26	2.74	.31	***
004 SIMP 46-4	1.37	1.30	.22	***	2.31	2.38	.27	***
005 SIMP 46-5	1.42	1.08	.19	***	2.21	2.10	.24	***
006 SIMP 46-6	1.55	1.37	.24	***	2.13	2.12	.24	***
007 SIMP 46-7	1.62	1.17	.20	**	2.08	1.89	.21	***
008 SIMP 46-8	1.65	.98	.17	***	1.99	1.65	.19	***
009 SIMP 46-9	2.31	1.30	.22	***	2.60	2.07	.23	***
010 SIMP 46-10	1.63	.93	.16	***	1.72	1.49	.17	***
011 SIMP 46-11	.96	1.22	.21	***	1.40	1.46	.16	***
012 SIMP 46-12	1.08	1.39	.24	***	1.67	1.91	.21	***
013 SIMP 46-13	2.02	1.59	.27	***	2.70	1.90	.21	***
014 SIMP 46-14	1.63	1.16	.20	***	2.10	1.53	.17	***
015 SIMP 46-15	1.26	1.26	.22	***	2.27	1.95	.22	***
016 SIMP 46-16	.94	1.20	.21	***	2.31	2.22	.25	***
017 SIMP 46-17	1.68	1.64	.28	***	2.81	2.58	.29	***
018 SIMP 46-18	2.10	1.69	.29	***	2.60	1.91	.22	***
019 SIMP 46-19	1.80	1.72	.30	***	2.60	2.16	.24	***
020 SIMP 46-20	1.92	1.60	.27	***	2.44	2.54	.29	***
021 SIMP 46-21	2.01	1.39	.24	***	2.98	2.36	.27	***
022 SIMP 46-22	1.84	1.55	.27	***	2.71	2.16	.24	***
023 SIMP 46-23	1.80	1.64	.28	***	2.50	2.08	.23	***
024 SIMP 46-24	1.82	1.65	.28	***	2.60	2.06	.23	***
025 SIMP 46-25	1.81	1.56	.27	***	2.66	2.26	.25	***
026 SIMP 46-26	1.74	1.72	.30	***	2.30	1.93	.22	***
027 SIMP 46-27	2.08	2.09	.36	***	2.30	2.13	.24	***
028 SIMP 46-28	2.27	1.35	.23	***	2.74	2.14	.24	***
029 SIMP 46-29	2.28	2.11	.36	***	2.84	2.26	.25	***
030 SIMP 46-30	1.10	2.09	.36	**	2.15	2.33	.26	***
031 SIMP 46-31	1.52	1.32	.23	***	3.59	2.75	.31	***
032 SIMP 46-32	1.53	1.31	.22	***	3.76	2.83	.32	***
033 SIMP 46-33	1.79	3.00	.51	***	2.79	2.77	.31	***
034 SIMP 46-38	.61	1.89	.33	-	.26	1.39	.16	-
035 SIMP 46-39	.52	1.18	.20	*	.50	1.59	.18	**
036 SIMP 46-40	.37	1.26	.22	-	.72	1.13	.13	***
037 SIMP 46-41	.21	.97	.17	-	.70	1.23	.14	***
038 SIMP 46-42	.35	.97	.17	*	.22	1.12	.13	-
039 SIMP 46-43	.23	1.89	.32	-	.08	1.63	.18	-
040 SIMP 46-44	1.05	3.48	.60	-	1.45	3.47	.39	***
041 SIMP 46-45	-.20	2.70	.46	***	-.38	2.40	.27	-
042 SIMP 46-47	-.08	.69	.12	-	.19	.66	.07	*
043 SIMP 46-48	0	1.57	.27	-	.23	1.66	.19	-
044 SIMP 46-49	.70	1.12	.19	***	1.85	1.36	.15	***
045 SIMP 46-50	.89	1.40	.24	***	1.54	1.64	.18	***
046 SIMP 46-51	.77	1.10	.19	***	1.41	1.58	.18	***

	FEMALE				MALE			
	Δ	Δsd	Δse	t	Δ	Δsd	Δse	t
047 SIMP 46-52	.56	2.25	.39	-	.53	3.82	.43	-
048 SIMP 46-53	1.43	1.46	.25	***	1.47	1.90	.21	***
049 SIMP 46-54	1.22	.76	.13	***	1.08	.84	.10	***
050 SIMP 46-55	1.08	1.36	.23	***	1.35	1.17	.13	***
051 SIMP 46-56	.42	.61	.10	***	.76	.95	.11	***
052 SIMP 46-57	1.14	1.09	.19	***	1.05	1.19	.13	***
053 SIMP 46-58	1.12	1.18	.20	***	1.16	1.48	.17	***
054 SIMP 46-59	.67	1.12	.19	***	.99	1.21	.14	***
055 SIMP 46-60	.04	1.59	.27	-	.46	1.67	.19	*
056 SIMP 46-61	1.15	2.30	.39	**	1.06	2.42	.27	***
057 SIMP 46-62	.08	1.06	.18	-	-.10	.80	.09	-
058 SIMP 46-75	.76	1.52	.26	**	1.97	1.79	.20	***
059 SIMP 46-76	1.67	1.53	.26	***	1.81	1.64	.18	***
060 SIMP 46-77	2.12	1.43	.24	***	3.23	2.35	.26	***
061 SIMP 46-78	1.73	1.33	.23	***	3.10	2.32	.26	***
062 SIMP 46-79	-.24	1.23	.21	-	.84	1.88	.21	***
063 SIMP 46-80	.88	1.74	.30	**	2.87	2.10	.24	***
064 SIMP 46-81	.96	1.80	.31	**	2.32	2.33	.26	***
065 SIMP 46-82	1.54	1.83	.31	***	3.10	2.37	.27	***
066 SIMP 46-83	.95	1.82	.31	**	2.56	2.76	.31	***
067 SIMP 46-84	2.54	1.98	.34	***	4.50	2.72	.31	***
068 SIMP 46-85	3.14	2.91	.50	***	5.73	4.11	.46	***
069 SIMP 46-86	3.16	2.92	.50	***	5.62	3.75	.42	***
070 SIMP 46-87	2.01	2.65	.45	***	4.43	3.63	.41	***
071 3PTA 54-46-1	.48	.70	.12	***	-.04	.76	.09	-
072 3PTA 54-46-2	.50	.66	.11	***	.01	.78	.09	-
073 3PTA 54-46-3	.63	.76	.13	***	.14	.71	.08	-
074 3PTA 54-46-4	.60	.83	.14	***	.02	.85	.10	-
075 3PTA 54-46-5	.34	.72	.12	**	.10	.75	.08	-
076 3PTA 54-46-6	.23	.60	.10	*	.12	.67	.08	-
077 3PTA 54-46-7	.19	.62	.11	-	.11	.67	.08	-
078 3PTA 54-46-8	.07	.67	.12	-	.08	.73	.08	-
079 3PTA 54-46-9	.51	.69	.12	***	.50	.74	.08	***
080 3PTA 54-46-10	.20	.57	.10	*	.08	.54	.06	-
081 3PTA 54-46-11	-.15	.76	.13	-	-.12	.72	.08	-
082 3PTA 54-46-12	-.07	.66	.11	-	-.01	.54	.06	-
083 3PTA 54-46-13	-.03	.82	.14	-	-.01	.75	.09	-
084 3PTA 54-46-14	.02	.58	.10	-	-.02	.55	.06	-
085 3PTA 54-46-15	.15	.84	.14	-	.02	.87	.10	-
086 3PTA 54-46-16	-.06	1.14	.20	-	-.25	.98	.11	*
087 3PTA 54-46-17	.47	.89	.15	**	.01	.75	.09	-
088 3PTA 54-46-18	-.12	.92	.16	-	.02	.78	.09	-
089 3PTA 54-46-19	-.02	1.03	.18	-	-.05	.85	.10	-
090 3PTA 54-46-20	-.68	1.07	.18	***	-.66	1.05	.12	***
091 3PTA 54-46-21	-.31	.94	.16	-	-.33	.90	.10	**
092 3PTA 54-46-22	-.33	.91	.16	*	-.40	.84	.09	***

	FEMALE				MALE			
	Δ	Δsd	Δse	t	Δ	Δsd	Δse	t
093 3PTA 54-46-23	-.53	1.03	.18	**	-.37	.91	.10	***
094 3PTA 54-46-24	-.51	1.11	.19	**	-.39	.79	.09	***
095 3PTA 54-46-25	-.44	.98	.17	**	-.47	.89	.10	***
096 3PTA 54-46-26	-.40	1.03	.18	*	-.14	.77	.09	-
097 3PTA 54-46-27	-.21	1.28	.22	-	.32	1.33	.15	*
098 3PTA 54-46-28	-.80	.93	.16	***	-.47	.89	.10	***
099 3PTA 54-46-29	-.67	1.12	.19	***	-.25	1.03	.12	*
100 3PTA 54-46-30	.77	1.69	.29	**	.71	1.04	.12	***
101 3PTA 54-46-31	.39	.62	.11	***	-.55	.89	.10	***
102 3PTA 54-46-32	.41	.79	.14	**	-.41	.87	.10	***
103 3PTA 54-46-33	-.02	1.02	.17	-	-.65	1.01	.11	***
104 3PTA 54-46-38	-.30	1.01	.17	-	-.39	.94	.11	***
105 3PTA 54-46-39	-.33	1.69	.29	-	-.41	1.43	.16	**
106 3PTA 54-46-40	-.29	1.58	.27	-	-.06	1.29	.15	-
107 3PTA 54-46-41	.73	1.76	.30	*	.17	1.39	.16	-
108 3PTA 54-46-42	.24	2.56	.44	-	-1.14	2.79	.31	***
109 3PTA 54-46-43	1.20	3.05	.52	*	.37	2.27	.26	-
110 3PTA 54-46-44	.57	6.10	1.05	-	-1.53	7.01	.79	-
111 3PTA 54-46-45	.98	8.43	1.45	-	-1.16	6.30	.71	-
112 3PTA 54-46-47	.21	1.09	.19	-	-.06	1.01	.11	-
113 3PTA 54-46-48	-.24	1.31	.23	-	.25	.97	.11	*
114 3PTA 54-46-49	-.59	1.39	.24	*	-.16	.93	.10	-
115 3PTA 54-46-50	1.41	1.48	.25	***	1.77	2.05	.23	***
116 3PTA 54-46-51	.10	.73	.13	-	.06	.81	.09	-
117 3PTA 54-46-52	.44	1.05	.18	*	.56	2.06	.23	*
118 3PTA 54-46-53	-.37	1.13	.19	-	-.20	1.30	.15	-
119 3PTA 54-46-55	-.08	.68	.12	-	-.15	.73	.08	-
120 3PTA 54-46-56	-.76	2.18	.37	*	-.64	1.71	.19	***
121 3PTA 54-46-57	-.02	.96	.16	-	.01	.70	.08	-
122 3PTA 54-46-58	-.04	1.20	.21	-	-.29	.84	.10	**
123 3PTA 54-46-59	.78	1.99	.34	*	.38	1.56	.18	*
124 3PTA 54-46-60	.19	1.23	.21	-	.33	1.19	.13	*
125 3PTA 54-46-61	.30	2.25	.39	-	.36	2.75	.31	-
126 3PTA 54-46-62	-1.69	2.42	.42	***	-1.64	2.87	.32	***
127 3PTA 54-46-75	-.62	1.72	.30	*	-.46	1.21	.14	***
128 3PTA 54-46-76	.69	1.89	.32	*	.33	1.75	.20	-
129 3PTA 54-46-77	1.03	.93	.16	***	1.12	.95	.11	***
130 3PTA 54-46-78	1.15	.96	.17	***	1.12	.93	.11	***
131 3PTA 54-46-79	1.23	1.01	.17	***	1.09	.88	.10	***
132 3PTA 54-46-80	1.66	.97	.17	***	1.87	1.25	.14	***
133 3PTA 54-46-81	1.95	1.17	.20	***	2.31	1.46	.16	***
134 3PTA 54-46-82	1.34	1.01	.17	***	1.18	1.16	.13	***
135 3PTA 54-46-83	1.07	1.02	.18	***	.65	1.22	.14	***
136 3PTA 54-46-84	.68	.87	.15	***	.38	1.11	.13	**
137 3PTA 54-46-85	.85	1.17	.20	***	.38	1.31	.15	**
138 3PTA 54-46-86	1.00	1.31	.23	***	.33	1.17	.13	**
139 3PTA 54-46-87	1.01	1.75	.30	**	.35	1.30	.15	*

	FEMALE				MALE			
	Δ	Δsd	Δse	t	Δ	Δsd	Δse	t
140 SIMP 43-3	2.49	1.71	.29	***	3.25	2.87	.32	***
141 SIMP 43-17	1.92	1.82	.31	***	2.86	2.71	.31	***
142 SIMP 43-31	1.61	2.01	.34	***	3.75	3.23	.36	***
143 SIMP 31-3	1.15	1.09	.19	***	.74	1.26	.14	***
144 PDIS 61/41-32	.88	1.61	.28	**	.87	1.84	.21	***
145 SIMP 33-30	-.21	1.98	.34	-	-.41	1.41	.16	**
146 SIMP 31-30	.27	1.55	.27	-	.15	1.14	.13	-
147 PDIS 30/3-5	1.04	2.12	.36	**	1.24	1.67	.19	***
148 PDIS 33/3-5	.85	1.14	.20	***	.85	1.52	.17	***
149 PDIS 61/31-1	1.00	1.94	.33	**	2.31	2.86	.32	***
150 SIMP 17-3	.43	.60	.10	***	.36	.66	.07	***
151 PDIS 3/54-4	.48	.56	.10	***	.11	.83	.09	-
152 PDIS 5/32-1	.90	.68	.12	***	.86	1.22	.14	***
153 PDIS 6/32-1	1.17	1.10	.19	***	1.06	1.26	.14	***
154 PDIS 15/32-1	1.25	1.69	.29	***	1.04	1.52	.17	***
155 PDIS 21/32-1	1.18	1.25	.21	***	1.09	1.39	.16	***
156 PDIS 25/32-1	1.47	1.24	.21	***	1.60	1.42	.16	***
157 PDIS 6/54-4	.69	1.06	.18	***	-.16	2.07	.23	-
158 PDIS 6/11-3	.19	.82	.14	-	-.09	1.37	.15	-
159 SIMP 60-11	1.02	1.56	.27	***	1.21	1.43	.16	***
160 PDIS 11/54-3	.27	.85	.15	-	-.10	.94	.11	-
161 PDIS 44/54-46	.33	4.14	.71	-	1.62	4.13	.47	***
162 SIMP 47-59	1.05	1.01	.17	***	1.03	1.12	.13	***
163 PDIS 59/54-46	.81	.97	.17	***	1.05	1.02	.12	***
164 PDIS 12/54-46	.56	1.06	.18	**	1.01	1.18	.13	***
165 PDIS 58/54-46	.82	1.36	.23	***	.70	1.23	.14	***
166 PDIS 58/59-12	-.05	1.33	.23	-	.39	1.04	.12	***
167 PDIS 57/54-46	.49	.91	.16	**	.47	.80	.09	***
168 PDIS 57/59-12	.22	.96	.16	-	.58	1.10	.12	***
169 PDIS 51/46-54	.21	.87	.15	-	.21	1.07	.12	-
170 SIMP 51-57	.51	1.03	.18	**	.82	1.58	.18	***
171 PDIS 10/12-59	.83	1.19	.20	***	.36	1.25	.14	**
172 PDIS 8/12-59	.81	1.20	.21	***	.67	1.22	.14	***
173 PDIS 14/12-59	.63	1.30	.22	**	.54	1.07	.12	***
174 PDIS 26/12-59	.34	1.06	.18	-	.73	1.29	.15	***
175 PDIS 23/12-59	.42	1.17	.20	*	.80	1.23	.14	***
176 PDIS 8/11-3	.48	.96	.16	**	.67	1.22	.14	-
177 PDIS 9/NP45	-.22	2.93	.50	-	-.02	1.74	.20	-
178 PDIS 9/NP44	.01	3.75	.64	-	-.43	3.94	.44	-
179 SIMP 39-54	1.52	1.29	.22	***	1.35	2.02	.23	***
180 SIMP 47-54	1.32	1.04	.18	***	.89	.81	.09	***
181 PDIS 46/60-47	-.13	.61	.11	-	.17	.59	.07	**
182 PDIS 56/47-60	.47	.84	.15	**	.54	.94	.11	***
183 PDIS 54/47-60	1.29	1.13	.19	***	.79	.90	.10	***
184 PDIS 11/47-60	.99	1.53	.26	***	1.27	1.39	.16	***
185 PDIS 31/60-47	.39	2.28	.39	-	-1.24	2.43	.27	***

	FEMALE				MALE			
	Δ	Δ sd	Δ se	t	Δ	Δ sd	Δ se	t
186 PDIS 4/47-60	.17	2.38	.41	-	1.67	2.43	.27	***
187 PDIS 3/47-60	.52	2.80	.48	-	2.06	2.92	.33	***
188 SIMP 41-54	1.58	1.30	.22	***	1.63	1.45	.16	***
189 SIMP 43-54	1.65	1.43	.25	***	1.22	1.54	.17	***
190 SIMP 43-11	1.57	1.46	.25	***	1.58	1.59	.18	***
191 SIMP 43-2	2.23	1.78	.31	***	3.19	2.82	.32	***
192 SIMP 40-54	1.33	1.45	.25	***	1.59	1.31	.15	***
193 SIMP 40-11	.89	1.39	.24	***	1.55	1.36	.15	***
194 SIMP 40-4	.54	1.24	.21	*	2.05	2.11	.24	***
195 PDIS 11/NP44	.29	3.64	.63	-	.13	2.52	.28	-
196 PDIS 3/NP44	.15	6.23	1.07	-	.42	4.73	.53	-
197 PDIS 11/NP45	-.36	3.13	.54	-	-.91	3.25	.37	*
198 PDIS 3/NP45	-1.29	5.66	.97	-	-1.61	6.39	.72	-
199 SIMP 54-12	.57	1.10	.19	**	1.02	1.18	.13	***
200 SIMP 12-1	2.07	1.54	.26	***	1.86	2.01	.23	***
201 SIMP 54-1	2.59	1.81	.31	***	2.86	2.49	.28	***
202 SIMP 59-31	.69	1.76	.30	*	1.89	1.81	.20	***
203 PDIS 54/59-12	.61	.96	.17	***	.98	1.04	.12	***
204 PDIS 1/12-59	1.77	1.44	.25	***	1.86	2.00	.23	***
205 PDIS 46/59-12	.98	1.28	.22	***	1.14	1.21	.14	***
206 PDIS 31/12-59	.43	1.82	.31	-	2.44	2.38	.27	***
207 SIMP 62-2	2.40	1.70	.29	***	3.57	2.88	.32	***
208 SIMP 31-58	1.64	1.64	.28	***	2.31	1.87	.21	***
209 SIMP 48-49	.80	1.22	.21	***	1.72	1.78	.20	***
210 SIMP 50-52	1.98	2.59	.44	***	4.18	4.67	.53	***
211 SIMP 63-65	.45	.96	.17	**	.68	1.06	.12	***
212 SIMP 64-66	.36	.76	.13	**	.89	.85	.10	***
213 SIMP 38-40	.33	2.19	.38	-	-.40	1.75	.20	*
214 SIMP 66-67	-.12	.87	.15	-	-.30	.76	.09	***
215 SIMP 64-68	.93	1.13	.19	***	1.54	1.23	.14	***
216 PDIS 81/80-84	-.70	.82	.14	***	-1.47	1.36	.15	***
217 PDIS 83/80-84	-.96	.99	.17	***	-.95	1.64	.19	***
218 PDIS 85/80-84	-.55	1.43	.24	*	.15	1.65	.19	-
219 PDIS 78/80-84	2.27	2.04	.35	***	2.17	2.87	.32	***
220 SIMP 93-92	.76	2.69	.46	-	1.09	2.78	.31	***
221 SIMP 92-91	-.04	2.22	.38	-	.14	2.34	.26	-
222 SIMP 12-82	2.19	1.82	.31	***	2.80	2.14	.24	***
223 SIMP 54-78	2.25	1.51	.26	***	3.42	2.11	.24	***
224 SIMP 6-8	.15	1.03	.18	-	-.11	1.24	.14	-
225 3PTA 46-54-4	-.70	.78	.13	***	.22	.80	.09	*
226 3PTA 46-54-11	-.28	.90	.15	-	.15	.75	.08	-
227 3PTA 39-54-3	-.57	1.04	.18	**	.13	.88	.10	-
228 3PTA 40-54-11	-.26	.77	.13	-	.13	.86	.10	-
229 4PTA 46-54/44-57	0	3.04	.52	-	-.47	2.58	.29	-
230 4PTA 39-54/44-57	.01	3.27	.56	*	-.76	2.87	.32	-
231 4PTA 46-54/59-12	-.50	2.45	.42	-	-.25	1.01	.11	*

		FEMALE				MALE			
		Δ	Δsd	Δse	t	Δ	Δsd	Δse	t
232	4PTA 46-54/29-18	-.50	2.45	.42	-	-.85	2.08	.23	***
233	4PTA 46-54/24-7	.66	2.10	.36	-	-.33	2.16	.24	-
234	4PTA 46-54/31-2	.34	1.00	.17	*	-.87	1.34	.15	***
235	4PTA 46-54/32-1	.38	1.14	.20	-	-1.05	1.42	.16	***
236	4PTA 46-54/41-32	.55	1.58	.27	*	-.18	1.44	.16	-
237	4PTA 46-54/47-60	-.07	1.51	.26	-	.16	1.36	.15	-
238	4PTA 57-44/54-3	-.56	2.93	.50	-	-.62	3.05	.34	-
239	4PTA 44-57/29-18	-.38	3.57	.61	-	.05	3.58	.40	-
240	4PTA 44-57/24-7	.82	3.22	.55	-	.53	3.02	.34	-
241	4PTA 44-57/32-1	.45	2.92	.50	-	-.16	3.34	.38	-
242	4PTA 44-57/41-32	.62	3.45	.59	-	.71	3.41	.38	-
243	4PTA 44-57/46-2	.57	3.00	.52	-	.90	3.05	.34	**
244	4PTA 40-54/46-2	.49	.89	.15	**	.04	.95	.11	-
245	4PTA 40-54/62-2	.86	1.04	.18	***	.19	1.15	.13	-
246	4PTA 59-12/29-18	-.07	2.69	.46	-	-.49	2.12	.24	*
247	4PTA 59-12/32-1	.80	1.33	.23	***	-.81	1.59	.18	***
248	4PTA 60-47/59-12	-.35	2.00	.34	-	-.40	1.56	.18	*
249	4PTA 60-47/29-18	-.42	3.05	.52	-	-1.01	2.62	.29	***
250	4PTA 60-47/32-1	.45	2.09	.36	-	-1.21	2.03	.23	***
251	4PTA 3-54/1-32	.11	.86	.15	-	.79	1.00	.11	***
252	3PTA 41-32-1	-.17	1.73	.30	-	-.87	1.43	.16	***
253	3PTA 61-31-1	-.39	2.23	.38	-	.26	1.70	.19	-
254	4PTA 3-54/4-11	.80	1.24	.21	***	-.14	1.38	.16	-
255	3PTA 54-11-3	-.34	1.67	.29	-	-.01	1.65	.19	-
256	4PTA 54-46/13-8	-1.28	3.33	.57	*	-1.73	4.19	.47	***
257	4PTA 12-59/13-8	-1.71	3.46	.59	**	-1.97	4.17	.47	***
258	4PTA 1-32/8-13	.90	3.18	.55	-	2.78	3.96	.45	***
259	4PTA 54-11/13-8	-1.08	3.42	.59	-	-1.63	4.18	.47	***
260	4PTA 59-12/27-23	.44	5.12	.88	-	-1.29	4.33	.49	**
261	4PTA 8-13/6-16	.03	4.67	.80	-	2.48	5.87	.66	***
262	4PTA 54-46/6-16	-1.25	3.10	.53	*	.75	3.53	.40	-
263	4PTA 57-44/6-16	-1.32	4.06	.70	-	-.14	4.79	.54	-
264	4PTA 12-59/6-16	-1.68	2.73	.47	***	.51	3.87	.44	-
265	4PTA 7-24/6-16	-.59	3.69	.63	-	.41	4.06	.46	-
266	4PTA 1-32/16-6	.87	2.73	.47	-	.30	3.23	.36	-
267	4PTA 3-11/16-6	.53	2.41	.41	-	-.33	3.09	.35	-
268	4PTA 4-54/16-6	.55	2.74	.47	-	-.53	3.33	.38	-
269	4PTA 32-1/25-20	-1.11	4.20	.72	-	1.09	4.50	.51	*
270	3PTA 46-54-55	-.52	2.76	.47	-	.49	2.02	.23	*
271	3PTA 75-76-77	4.46	7.33	1.26	***	.56	8.12	.91	-
272	3PTA 76-77-79	-4.61	4.46	.76	***	-4.77	4.13	.47	***
273	3PTA 76-78-79	-4.23	4.14	.71	***	-5.31	4.18	.47	***
274	3PTA 78-79-81	-5.19	6.45	1.11	***	-3.87	7.19	.81	***
275	3PTA 83-84-85	8.07	7.96	1.37	***	5.75	9.92	1.12	***
276	4PTA 57-44/83-85	3.44	4.29	.74	***	3.77	5.98	.67	***
277	4PTA 57-44/80-84	2.41	4.03	.69	***	1.89	4.49	.51	***

APPENDIX H

AGE SPAN SUMMARY

AGE SPAN SUMMARY

(UNTREATED-INITIAL TO FINAL)

Number	Sex	Entry Age	Final Age	Span
1	M	17	25	8
2	M	17	25	8
3	M	17	25	8
4	M	17	25	8
5	M	17	26	9
6	M	17	26	9
7	M	17	27	10
8	M	17	27	10
9	M	17	27	10
10	M	17	27	10
11	M	17	28	11
12	M	17	28	11
13	M	17	28	11
14	F	17	29	12
15	M	17	30	13
16	M	17	30	13
17	F	17	33	16
18	M	17	34	17
19	F	17	35	18
20	F	17	36	19
21	F	17	37	20
22	F	17	38	21
23	M	17	39	22
24	M	17	41	24
25	F	17	44	27
26	F	17	46	29
27	F	17	47	30
28	F	17	49	32
29	M	17	49	32
30	M	17	49	32
31	M	17	49	32
32	M	17	49	32
33	M	17	49	32
34	M	17	50	33
35	M	17	51	34
36	M	17	51	34
37	F	17	51	34
38	F	17	51	34
39	F	17	51	34
40	F	17	52	35
41	M	17	52	35
42	F	17	53	36
43	M	17	53	36
44	M	17	53	36
45	F	17	54	37

Number	Sex	Entry Age	Final Age	Span
46	M	17	54	37
47	M	17	54	37
48	M	17	54	37
49	F	17	55	38
50	F	17	56	39
51	M	17	56	39
52	M	17	56	39
53	M	17	56	39
54	M	17	56	39
55	M	17	56	39
56	F	17	57	40
57	F	17	57	40
58	M	17	57	40
59	M	17	57	40
60	M	17	58	41
61	M	17	58	41
62	M	17	58	41
63	M	17	58	41
64	M	17	58	41
65	F	17	58	41
66	F	17	58	41
67	M	17	59	42
68	M	17	59	42
69	M	17	59	42
70	M	17	59	42
71	M	17	59	42
72	F	17	60	43
73	M	17	61	44
74	M	18	25	7
75	F	18	25	7
76	F	18	27	9
77	M	18	42	24
78	F	18	46	28
79	M	18	50	32
80	F	19	25	6
81	M	19	51	32
82	M	19	53	34
83	M	19	56	37
84	M	20	25	5
85	F	20	26	6
86	M	20	44	24
87	M	20	70	50
88	M	21	33	12
89	M	21	52	31
90	M	21	52	31
91	M	21	63	42
92	F	22	32	10
93	M	22	47	25
94	M	23	67	44
95	M	25	36	11

Number	Sex	Entry Age	Final Age	Span
96	M	25	37	12
97	M	26	35	9
98	M	27	40	13
99	M	27	46	19
100	M	27	50	23
101	M	28	52	34
102	M	28	79	51
103	M	29	40	11
104	M	30	40	10
105	F	31	38	7
106	F	31	71	40
107	F	32	36	4
108	F	33	50	17
109	M	34	41	7
110	M	34	54	20
111	F	34	83	49
112	M	36	49	13
113	M	36	77	41

AGE SPAN SUMMARY

(TREATED-INITIAL TO FINAL)

Number	Sex	Entry Age	Final Age	Span
1	F	17	26	9
2	M	17	27	10
3	M	17	27	10
4	M	17	28	11
5	M	17	28	11
6	M	17	47	30
7	M	17	51	34
8	M	17	51	34
9	M	17	55	38
10	M	17	56	39
11	M	17	59	42
12	F	18	26	8
13	F	18	27	9
14	F	18	33	15
15	F	18	48	30
16	F	18	56	38
17	F	19	25	6
18	F	19	26	7
19	M	19	26	7
20	F	19	27	8
21	F	19	29	10
22	M	20	26	6
23	F	20	55	35
24	F	20	64	44
25	F	21	25	4
26	M	21	60	39
27	M	22	50	28
28	M	28	39	11

AGE SPAN SUMMARY

(DENTAL-INITIAL TO FINAL)

Number	Sex	Entry Age	Final Age	Span
1	F	17	51	34
2	F	17	57	40
3	F	17	58	41
4	M	17	61	44
5	F	17	64	47
6	M	17	65	48
7	F	18	56	38
8	M	21	72	51
9	F	30	72	42
10	M	31	81	50
11	M	38	64	26
12	F	64	68	4

AGE SPAN SUMMARY

(UNTREATED-SPECIFIED INITIAL AGES)

Number	Sex	Entry Age	Final Age	Span
1	F	25	32	7
2	F	25	35	10
3	M	25	36	11
4	M	25	37	12
5	M	25	51	26
6	M	25	56	31
7	M	25	56	31
8	M	25	56	31
9	M	25	58	33
10	M	25	59	34
11	M	26	35	9
12	M	26	58	12
13	M	26	58	31
14	M	27	33	6
15	F	27	35	8
16	F	27	37	10
17	M	27	40	13
18	M	27	46	19
19	M	27	50	23
20	M	27	59	32
21	M	27	59	32
22	M	27	59	32
23	M	27	67	40
24	F	28	37	9
25	M	28	42	14
26	M	28	51	23
27	M	28	52	24
28	M	28	79	51
29	M	29	40	11
30	M	30	40	10
31	M	31	33	2
32	F	31	35	4
33	F	31	37	6
34	F	31	38	7
35	F	31	38	7
36	F	31	71	40
37	F	32	35	3
38	F	32	36	4
39	M	32	39	7
40	M	32	79	47
41	F	33	36	3
42	F	33	50	17
43	F	34	36	2
44	M	34	41	7
45	M	34	54	20

Number	Sex	Entry Age	Final Age	Span
46	F	34	83	49
47	F	35	50	15
48	M	35	79	44
49	M	36	49	13
50	M	36	52	16
51	M	36	77	41
52	F	36	83	47
53	M	41	51	10
54	M	41	77	36
55	M	46	77	31
56	M	73	77	4

APPENDIX I

ABSTRACT

ABSTRACT

A TREATISE ON THE CONTINUUM OF GROWTH IN THE AGING CRANIOFACIAL SKELETON

by
Rolf Gordon Behrents

Chairman: Robert E. Moyers

From the records of the Bolton-Brush Studies, which comprise extensive longitudinal growth data collected in the 1930's and 1940's, some 113 of the original 6000 participants were recalled for new data collection. One hundred sixty three cases spanning ages 17-83 years (524 lateral cephalograms) were then utilized.

The purpose was to determine the nature and extent of any adult craniofacial alterations which occurred. Cephalometric examinations revealed continuing growth of the craniofacial complex throughout all age levels, similar to typical adolescent alterations but of lesser magnitude and rates. Both size and shape changes were noted. Certain facial regions altered differentially with a considerable extent of enlargement. Lesser but consistent changes were noted for many other areas.

In young adulthood, directions of growth were specific to an individual's growth pattern and sex. In later adulthood, vertical dimensional changes appeared to be a common alteration. Some

soft tissue alterations were dramatic, more so than among most skeletal alterations. These involved primarily elongation of the nose and relative flattening of the lips.

Definite differences in the nature and extent of some changes were found between males and females. Typically, females grew less, and their growth was more vertical. Forward rotation of the mandible in the male and a converse direction in females were common. Sexual dimorphic features were especially prominent in the orbital region. Data suggest that females undergo a generalized growth deceleration in their teens but with re-acceleration in the twenties.

Orthodontically treated cases and individuals with multiple tooth loss demonstrated continuous adult changes, but the nature and amount were different. These involved midfacial and mandibular size and position.

Recall studies are continuing as there are many implications for medicine and dentistry involved in a craniofacial complex that undergoes known and predictable adult changes.