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Correlations between EMG jaw muscle activity and facial morphology in complete denture wearers

A. TALLGREN, S. HOLDEN, B. R. LANG *and* M. M. ASH, JR *The University of Michigan Dental Research Institute, Ann Arbor, Michigan, and the Royal Dental College Copenhagen, Denmark*

Summary

In a sample of fifteen partially edentulous subjects assigned for immediate complete denture treatment, a correlation analysis was performed between pre-extraction facial morphology determined from lateral cephalograms, and EMG activity of the anterior temporal and masseter muscles in maximal clench and tapping of teeth. Marked correlations observed between vertical and sagittal jaw relations and mean voltages of the jaw-closing muscles indicated strong biting activity in subjects with a square facial type. No significant associations were observed between biting strength and the age of the subjects.

Correlations between facial morphological changes and changes in EMG biting activity after denture insertion and during 1 year of denture wear indicated that the anterior temporal muscles were extremely sensitive to sagittal changes in anterior occlusion. The masseter muscles were less sensitive, but responded in some instances to changes in vertical jaw relationship.

Introduction

A previous electromyographic study of subjects provided with immediate complete dentures revealed pronounced changes in biting activity of the anterior temporal and masseter muscles during 1 year of denture wear (Tallgren *et al.*, 1980b). Marked individual variations in muscle force, estimated by the mean voltage of the electromyograms, were observed at the different observation stages.

The relationship between form and function in the masticatory system was studied by Møller (1966) in an electromyographic investigation of young adults. He found that strong activity of the masseter and the anterior temporal muscles in maximal clench was associated with a facial type characterized by a small inclination of the mandible, marked mandibular prognathism and a small gonial angle, in other words with a square facial type. Conversely, in subjects with a retrognathic facial type the jaw muscle activity was found to be less marked. Similar observations were reported by Ingervall & Thilander (1974) in an electromyographic and cephalometric study of

Correspondence: Dr A. Tallgren, The Royal Dental College, Copenhagen, Jagtvej 160, DK-2100 Copenhagen Ø, Denmark, and Dr M. M. Ash, University of Michigan School of Dentistry, Ann Arbor Mich. 48109, U.S.A.

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children, and by Ringqvist (1973) and Ingervall & Helkimo (1978) in studies of bite force in relation to facial morphology. Furthermore, Ahlgren (1966) found an association between a small gonial angle and high EMG activity of the masseter muscles in chewing. Regarding complete denture wearers, long-term cephalometric investigations of alveolar ridge resorption by Tallgren (1970, 1972) have demonstrated relationships between the magnitude of anterior ridge reduction and facial morphologic characteristics, the most marked correlations being observed with the shape of the mandible.

The aim of the present study was to investigate the relationship between craniofacial morphology and jaw muscle activity in maximal clench and tapping of teeth in subjects assigned for immediate complete dentures, and to study the possible effect on the jaw muscle activity of changes in jaw and dental relationships due to insertion and wearing of the dentures.

Material and methods

The analysis was based on cephalometric and electromyographic (EMG) data obtained from a sample of partially edentulous subjects provided with immediate upper and lower complete dentures (Tallgren *et al.*, 1980a,b).

The original sample consisted of eighteen subjects, but since three persons did not attend the 1-year examination, the analysis was restricted to fifteen subjects, nine men and six women. The age range of the subjects was 27–69 years, the mean age 53·2 years. None of the subjects gave a history of functional disorders in the masticatory system or of any diagnosed disease, which might have affected the muscles of mastication. Prior to the first recording the subjects as a rule had had their molars and second premolars extracted; some subjects were also missing the first premolars.

The posterior teeth used for the complete dentures were zero degree 31 mm acrylic resin teeth. These were set to a flat occlusal plane without compensating curves and without protrusive balance and, consequently, the anterior teeth were set with a low incisal guidance. For details regarding the denture treatment, the reader is referred to Tallgren *et al.* (1980a).

The present analysis comprised the following observation stages: (a) before extraction of the residual anterior dentition, (b) approximately 3 weeks after denture insertion, when the patients felt comfortable with the dentures and did not complain of sore spots, (c) 6 months after denture insertion, and (d) 1 year after insertion.

Methods of analysis

A detailed account of the roentgencephalometric technique and method of measurement has been given elsewhere (Tallgren *et al.*, 1980a). The reference points and lines used for the cephalometric analysis are shown in Fig. 1. All measurements were obtained from cephalograms taken in centric occlusion, i.e. the habitual occlusal position.

Regarding measurements of anterior occlusion in the natural dentition and at the denture stages (Fig. 1), the vertical position of the upper incisal edge in relation to the maxilla (*is* vert. max.) was defined as the perpendicular distance from *is* to the reference line REF, and the horizontal position (*is* hor. max.) as the distance from *is* to a perpendicular to REF through the reference point maxillon (*ma*). The vertical position of the lower incisal edge to the mandibular base was defined as the perpendicular distance from point *ii* to ML, and the horizontal position as the distance from *ii*

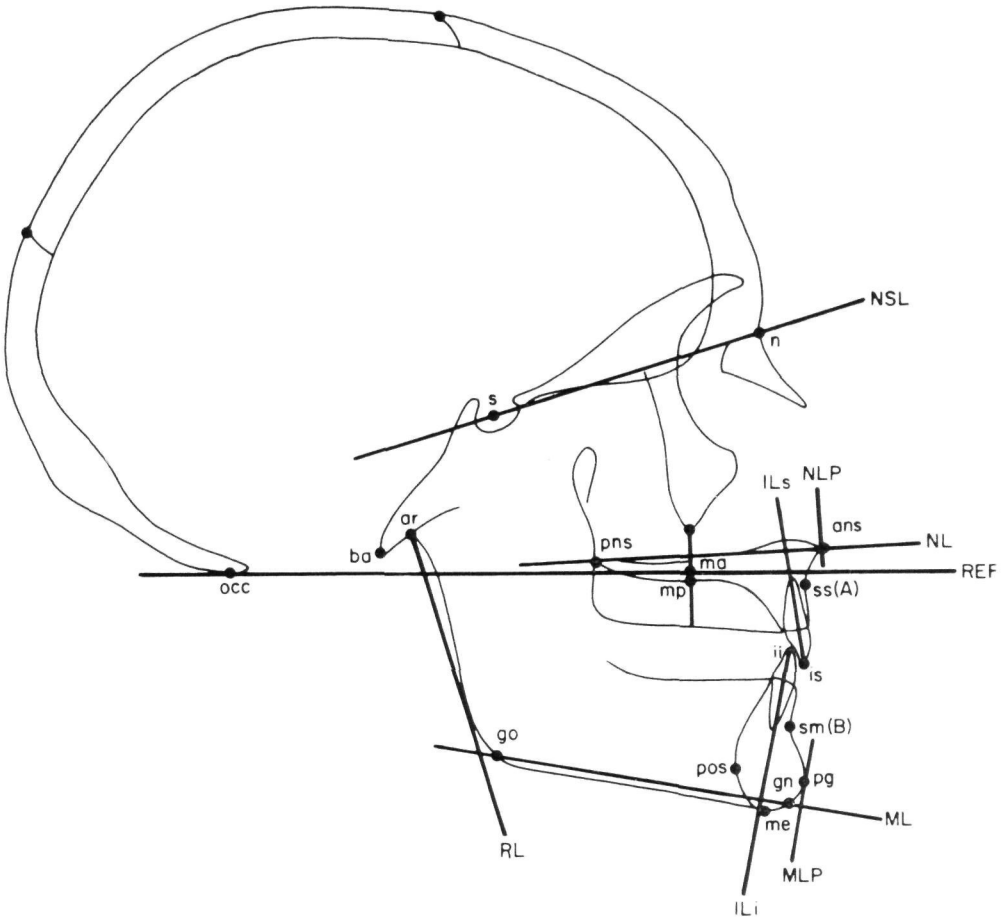

Fig. 1. Reference points and lines on the lateral cephalometric films.

to the mandibular line perpendicular, MLP. The overjet was determined as the horizontal distance *is–ii* parallel with REF, and the overbite as the vertical distance between these points parallel to a perpendicular to REF.

The EMG activity of the anterior temporal and masseter muscles in maximal clench and light tapping of teeth from postural position was recorded bilaterally. Bipolar surface electrodes with an interelectrode distance of 2 cm were taped by palpation of the muscles in the main direction of the fibres. Care was taken that for each individual the electrode placement was as close as possible the same at the different sessions.

All amplitude measurements were performed on the mean voltage traces. For maximal clench, the maximal (peak) and average levels of the mean voltage amplitudes were measured in relation to the baseline, and for each recorded sequence the muscle activity was based on the average of three clenches. For light tapping the peak of the mean voltage amplitudes was measured, and the muscle activity was assessed as the average of six taps (Tallgren *et al.*, 1980b).

The statistical analysis of the data was carried out using the Michigan Interactive Data Analysis System (MIDAS) (Fox & Guire, 1976). For the statistical description of the cephalometric and electromyographic variables and the differences between observation stages, the conventional statistical parameters were used. The normality of the cephalometric distributions was evaluated by the parameters of skewness and kurtosis. For the electromyographic variables the normality of the distributions was tested by using the Lilliefors procedure and histograms were computed as a graphic representation of the test.

In order to obtain information on the relationship between the pairs of variables, product–moment correlation coefficients were computed. A further examination of the two-dimensional distributions was performed graphically.

Results

The statistical description of the facial morphology at the pre-extraction stage is given in Table 1. Mean changes in jaw and dental relationships between stages of observation have been reported elsewhere (Tallgren *et al.*, 1980a).

Table 1. Facial morphology at the pre-extraction stage. The variables are given in mm and degrees

Variable	Min.	Max.	$\bar{x}$	s.d.
n–s–ba	124·3	135·8	129·64	3·52
s–ba–o	123·4	138·3	130·62	5·19
NSL/NL	4·1	13·8	8·41	3·15
NSL/ML	21·3	43·9	33·49	5·63
NL/ML	15·1	38·7	25·08	6·69
s–n–ss	72·8	89·3	80·31	4·28
s–n–sm	75·0	84·6	78·88	2·94
s–n–pg	75·9	85·5	80·01	2·95
ss–n–sm (A–n–B)	−5·8	9·3	1·43	3·57
ss–n–pg	−7·5	10·8	0·29	4·37
n–s–pns	66·8	82·9	72·63	4·35
pns–s–ba	45·6	64·5	57·02	5·14
ar–gn–go	13·9	29·4	20·54	3·47
RL/ML	108·5	142·2	126·12	7·86
n–ans	48·0	68·0	58·82	5·40
ans–me	62·3	88·5	74·11	7·92
n–me	112·8	147·0	131·65	10·91
s–pns	46·3	60·9	52·85	4·50
s–go	66·2	101·4	86·36	9·99
ar–go	42·5	62·7	54·59	7·05
n–s	70·3	84·0	76·29	4·21
s–ba	40·1	55·2	46·86	4·20
ans–pns	47·8	63·6	55·63	4·58
gn–ar	102·8	135·5	121·55	10·48
pg–go	69·1	90·1	81·72	6·87
ILs/NL	97·3	126·8	111·42	9·49
ILi/ML	72·8	110·7	93·33	11·53
Overbite	1·4	13·8	5·07	3·50
Overjet	1·8	10·8	4·57	2·38

Sample size = 15.

The activity of the anterior temporal and masseter muscles in maximal clench and tapping of teeth at the pre-extraction stage, and the changes in mean voltage between observation stages have been accounted for in a previous publication (Tallgren *et al.*, 1980b).

Correlations between facial morphology and EMG activity at the pre-extraction stage

Correlation coefficients between craniofacial morphology and average mean voltages of the jaw closing muscles during maximal clench on the residual anterior dentition are given in Table 2.

The clench activity of the masseter muscles showed significant negative correlations ($P \leqslant 0{\cdot}01$) with the vertical jaw relation (NL–ML), and positive correlations ($P \leqslant 0{\cdot}05$) with the mandibular prognathism (*s–n–pg*). Positive correlations ($P \leqslant 0{\cdot}05$) were

Table 2. Pre-extraction stage. Correlations between facial morphologic variables and average mean voltage (μV) of right and left anterior temporal (RAT and LAT) and right and left masseter muscles (RM and LM) during maximal clench

		Maximal clench			
Craniofacial morphology		RAT	LAT	RM	LM
Cranial base flexion					
	*n–s–*ba	−0·51	−0·43	0·06	0·13
	s–ba–o	0·01	0·23	0·21	0·16
Inclination jaw bases					
Maxilla	NSL–NL	0·13	0·34	0·59*	0·55*
Mandible	NSL–ML	−0·22	−0·20	−0·28	−0·46
	NL–ML	−0·24	−0·33	−0·51	−0·65**
Facial prognathism					
Maxilla	*s–n–ss*	−0·21	−0·25	0·02	−0·19
Mandible	*s–n–sm*	0·39	0·25	0·26	0·25
	s–n–pg	0·48	0·42	0·55*	0·52*
Sagittal jaw relations					
	ss–n–sm (A–*n*–B)	−0·57*	−0·51	−0·19	−0·43
	ss–n–pg	−0·52*	−0·53*	−0·35	−0·54*
Nasopharyngeal space					
	n–s–pns	0·25	0·62*	0·11	0·28
	pns–s–ba	−0·56*	−0·81**	0·05	−0·14
Mandibular shape					
	ar–gn–go	0·00	0·10	0·04	0·35
	RL–ML	−0·02	−0·04	0·13	−0·15
Vertical dimensions					
Anterior	*n–ans*	0·28	0·65**	0·66**	0·53*
	ans–me	−0·04	0·03	−0·07	−0·26
	n–me	0·16	0·39	0·32	0·14
Posterior	*s–pns*	0·18	0·32	0·36	0·15
	s–go	0·23	0·42	0·40	0·35
	ar–go	0·18	0·34	0·50	0·56*
Antero-posterior dimensions					
Cranial base	*n–s*	0·15	0·37	0·39	0·25
	s–ba	−0·03	0·03	−0·16	−0·28
Maxilla	*ans–pns*	0·08	0·46	0·27	0·09
Mandible	*gn–ar*	0·29	0·41	0·57*	0·46
	pg–go	0·30	0·37	0·38	0·31
Dento-alveolar relations					
	ILs–NL	−0·09	−0·29	−0·22	0·07
	ILi–ML	0·45	0·52*	0·61·	0·32
	Overbite	0·13	−0·01	0·09	−0·12
	Overjet	0·37	0·06	0·01	−0·20
Age of the subjects		−0·16	−0·33	−0·07	−0·14

Sample size = 15.
*$P \leqslant 0{\cdot}05$.
**$P \leqslant 0{\cdot}01$.

observed also with the inclination of the maxilla to the anterior cranial base (NSL–NL). Similar but non-significant correlations were observed for the anterior temporal muscles. Moreover, significant negative correlations ($P \leqslant 0{\cdot}05$), particularly of the anterior temporals, were observed with sagittal jaw relations, *ss–n–sm* (A–n–B) and

Table 3. Pre-extraction stage. Correlations between facial morphologic variables and maximal mean voltage (μV) of right and left anterior temporal (RAT and LAT) and right and left masseter muscles (RM and LM) during tapping of teeth

		Tapping			
Craniofacial morphology		RAT	LAT	RM	LM
Cranial base flexion					
	n–s–ba	−0·28	−0·28	0·16	0·33
	s–ba–o	0·11	0·54*	−0·05	−0·06
Inclination jaw bases					
Maxilla	NSL–NL	−0·24	0·28	0·01	0·21
Mandible	NSL–ML	−0·16	−0·34	−0·11	−0·56*
	NL–ML	−0·02	−0·42	−0·09	−0·57*
Facial prognathism					
Maxilla	*s–n–ss*	0·28	0·19	0·28	−0·07
Mandible	*s–n–sm*	0·33	0·28	0·33	0·28
	s–n–pg	0·47	0·53*	0·34	0·38
Sagittal jaw relations					
	ss–n–sm (A–*n*–B)	0·09	0·00	0·07	−0·32
	ss–n–pg	−0·02	−0·17	0·04	−0·32
Nasopharyngeal space					
	n–s–pns	−0·32	0·19	−0·32	−0·10
	pns–s–ba	0·07	−0·35	0·38	0·31
Mandibular shape					
	ar–gn–go	−0·18	0·19	−0·11	0·66**
	RL–ML	0·20	−0·20	0·20	−0·48
Vertical facial dimensions					
Anterior	*n–ans*	0·06	0·54*	0·19	0·08
	ans–me	0·23	0·04	0·19	−0·35
	n–me	0·21	0·32	0·23	−0·18
Posterior	*s–pns*	0·33	0·38	0·35	0·02
	s–go	0·24	0·40	0·24	0·18
	ar–go	0·13	0·34	0·30	0·55*
Antero-posterior dimensions					
Cranial base	*n–s*	0·19	0·27	0·19	−0·14
	s–ba	0·05	−0·10	0·00	−0·30
Maxilla	*ans–pns*	0·09	0·34	0·14	−0·33
Mandible	*gn–ar*	0·30	0·42	0·39	0·22
	pg–go	0·29	0·48	0·23	0·08
Dento-alveolar relations					
	ILs–NL	−0·46	−0·33	−0·17	0·61*
	ILi–ML	0·47	0·33	0·43	−0·15
	Overbite	0·20	0·15	0·24	−0·01
	Overjet	0·26	0·21	0·38	0·07
Age of the subjects		−0·03	−0·08	0·28	0·15

Sample size = 15.
* $P \leqslant 0{\cdot}05$.
** $P \leqslant 0{\cdot}01$.

ss–n–pg. The anterior temporal muscles further showed correlations significant at the 1 and 5% levels with the size of the nasopharyngeal space, positive correlations being observed with *n–s–pns*, and negative with *pns–s–ba*.

Correlations with linear craniofacial dimensions revealed for both muscles significant positive associations ($P \leqslant 0{\cdot}01$) with the anterior upper facial height (*n–ans*). The masseter clench activity further showed positive correlations ($P \leqslant 0{\cdot}05$) with the mandibular height (*ar–go*) and length (*gn–ar*).

Regarding dento-alveolar variables, positive correlations were observed with the inclination of the lower incisors, ILi–ML (LAT, RM, $P \leqslant 0.05$).

No significant associations were observed between jaw muscle activity in maximal clench and the age of the subjects.

Analysis of relationships between facial morphology and maximal (peak) mean voltages of the jaw closing muscles in tapping from postural position showed in many instances similar correlations as in maximal clench, although mostly weaker and with unilateral significance (Table 3). Negative correlations (LM, $P \leqslant 0{\cdot}05$) were observed with the inclination of the mandible to the jaw bases (NSL–ML, NL–ML) and positive correlations (LAT, $P \leqslant 0{\cdot}05$) with mandibular prognathism (*s–n–pg*). Single marked positive correlations (LM, $P \leqslant 0{\cdot}01$ and $0{\cdot}05$) were seen with the mandibular base bend (*ar–gn–go*), the ramus height (*ar–go*) and the inclination of the upper incisors (ILs–NL); and furthermore (LAT, $P \leqslant 0{\cdot}05$) with the inclination of the posterior cranial base (*s–ba–o*) and upper facial height (*n–ans*). As for maximal clench, no significant associations were observed with the age of the subjects.

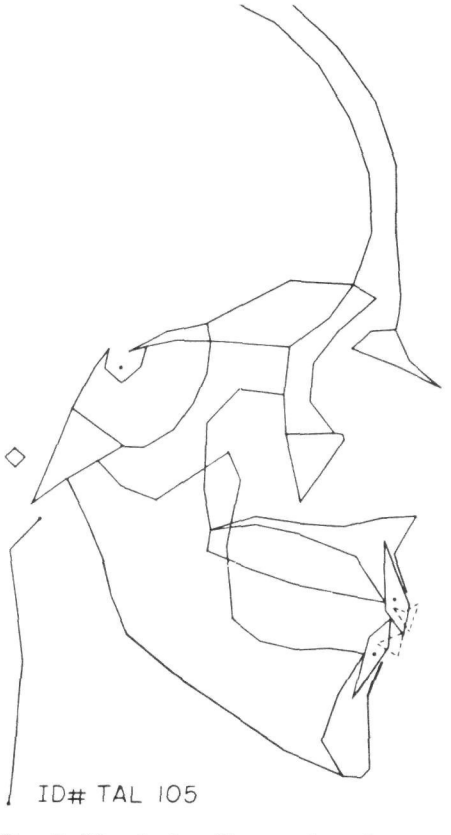

Fig. 2. Head plot illustrating changes in anterior occlusion due to complete denture construction. The broken line illustrates position of the artificial incisors after denture insertion, as compared to the natural teeth (solid line).

Morphological and electromyographic changes after denture insertion

In construction of the dentures, marked changes in position of the anterior teeth had been made in comparison with the natural dentition (Tallgren *et al.*, 1980a). The upper denture incisors generally were positioned more upward and outward than

Table 4. Correlations between alterations in jaw and dental relationships 3 weeks after denture insertion and changes in average mean voltage (μV) of right and left anterior temporal (RAT and LAT) and right and left masseter muscles (RM and LM) in maximal clench

	Maximal clench			
Variables	RAT	LAT	RM	LM
NSL/ML	−0·14	−0·24	−0·38	−0·11
NL/ML	−0·14	−0·25	−0·40	−0·14
s–n–pg	0·36	0·47	0·59*	0·42
ans–me	−0·40	−0·41	−0·63*	−0·31
n–me	−0·39	−0·41	−0·63*	−0·30
is vert. max.	−0·28	−0·16	−0·51	−0·34
ii ML	0·11	−0·22	−0·43	−0·17
is hor. max.	−0·25	−0·53*	−0·62*	−0·18
ii MLP	0·43	0·31	0·12	0·19
Overjet	0·61*	0·22	0·02	0·05
Overbite	0·23	0·08	−0·19	−0·03

Sample size = 15.
$*P \leqq 0{\cdot}05$.
$**P \leqq 0{\cdot}01$.

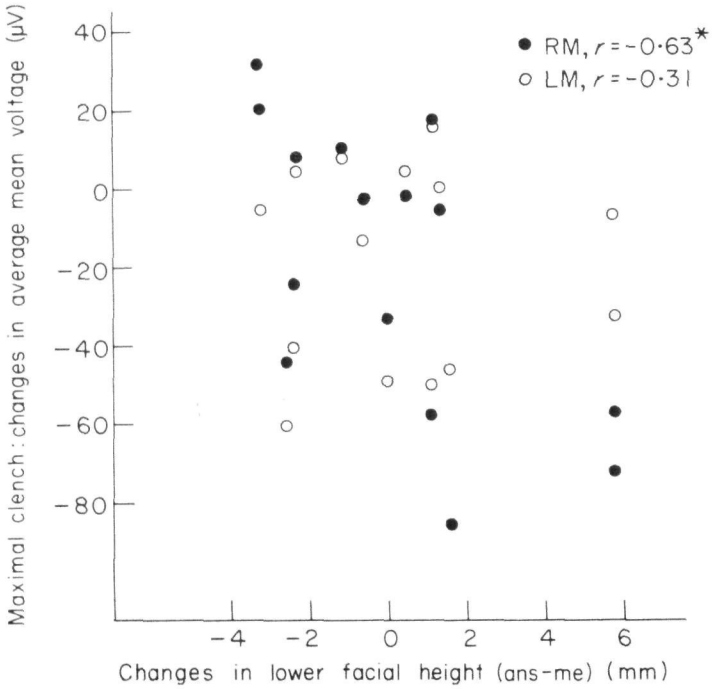

Fig. 3. Diagram illustrating the relationship between changes in occlusal vertical dimension (*ans–me*) due to insertion of complete dentures, and changes in average mean voltage of the right and left masseter muscles in maximal clench (RM, $r = -0{\cdot}63*$, LM $= -0{\cdot}31$). One outlier (LM, $x = -3{\cdot}3$ mm, $y = 284$ μV) omitted from the diagram.

the natural teeth, and the lower incisors more downward and outward (Fig. 2). The overjet was reduced by a mean of 1·6 mm and the overbite by a mean of 4 mm. Regarding changes in vertical jaw relation, eight subjects showed an increase in occlusal vertical dimension (*ans–me*), as compared with the pre-extraction dimension, and seven subjects a decrease.

The EMG activity of the jaw closing muscles in maximal clench 3 weeks after insertion of the immediate complete dentures showed a general decrease in mean voltage, as compared with the pre-extraction activity (Tallgren *et al.*, 1980b).

Correlations between post-insertion changes

Correlation coefficients between the alterations in jaw and dental relationships due to denture construction and the post-insertion changes in average mean voltage of the jaw-closing muscles in maximal clench are shown in Table 4. The changes in masseter activity showed some significant negative correlations (RM, $P=0{\cdot}05$) with the alterations in occlusal vertical dimension, *ans–me*, *n–me*, and positive with the changes in mandibular prognathism (*s–n–pg*). The plot (Fig. 3) shows that an increase in occlusal vertical dimension in most subjects was associated with a decrease in masseter clench activity. The changes in anterior temporal activity were more closely associated with the sagittal changes in anterior occlusion due to a more forward positioning of the denture incisors (Table 4). As further shown in Fig. 4, the decrease in overjet due to denture construction, observed in fourteen of the fifteen subjects, in most cases was associated with a decrease in clench activity of the anterior temporal muscles (RAT, $P \leqslant 0{\cdot}05$).

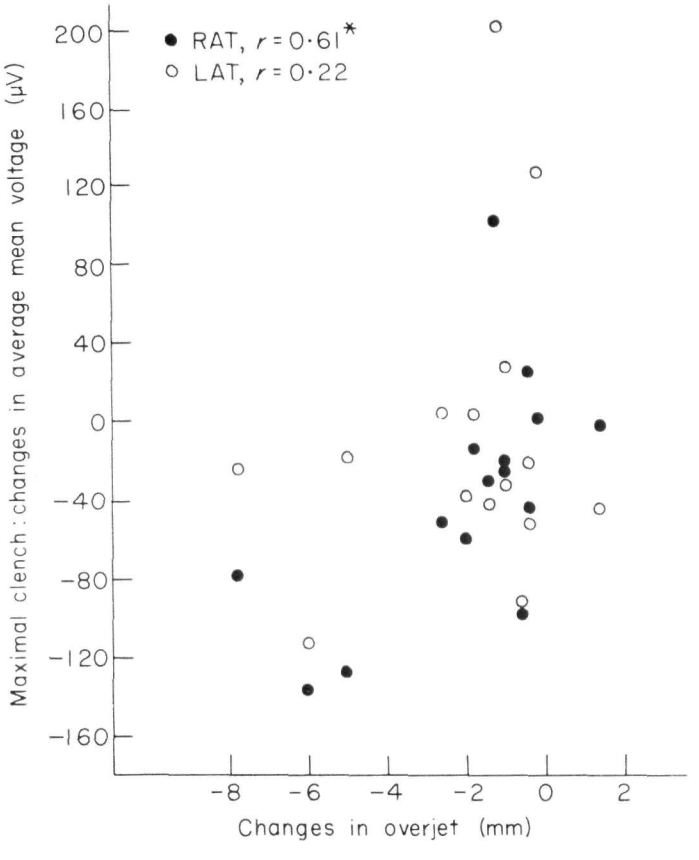

Fig. 4. Diagram illustrating the relationship between changes in anterior overjet due to complete denture construction, and changes in average mean voltage of the right and left anterior temporal muscles in maximal clench after insertion of the dentures (RAT, $r=0{\cdot}61$*, LAT, $r=0{\cdot}22$).

The post-insertion changes in tapping activity of the jaw-closing muscles showed individual variations of decreases and increases. Significant correlations ($P \leqslant 0{\cdot}05$) were observed only with the horizontal changes in position of the lower denture incisors in relation to the jaw bases, *ii* MLP (RAT, LM, $r = 0{\cdot}63$) and *ii* hor. max. (RAT, $r = -0{\cdot}54$).

Morphological and electromyographic changes during continued use of the dentures

The changes in jaw and occlusal relationships related to resorption of the alveolar ridges and settling of the dentures were characterized by a forward-upward rotation of the mandible with a resultant decrease in occlusal vertical dimension and increase in mandibular prognathism (Fig. 5). The changes in sagittal jaw relationship and the positional changes in forward direction of the dentures led to a further decrease in overjet. The changes in jaw and dental relations were specially marked during the first half year of denture wear.

The EMG activity of the anterior temporal muscles in maximal clench during the first half year of denture wear showed a further decrease in mean voltage. The masseter activity, on the other hand, showed tendencies to increase towards or to above the

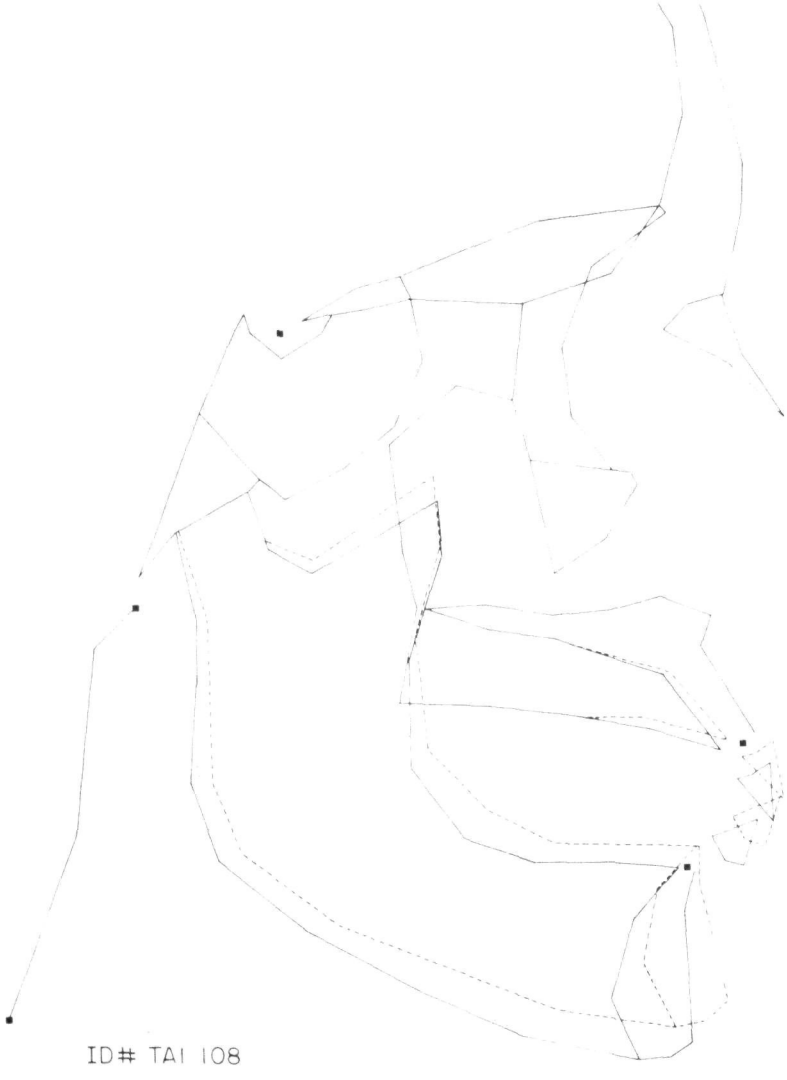

Fig. 5. Serial head plot from the stage of denture insertion (——) and after 1 year of denture wear (– – –) derived electronically by superimpostion of the structures of the skull and maxilla. The resorption of the alveolar ridges and settling of the dentures led to a marked forward-upward rotation of the mandible and decrease in anterior overjet.

pre-extraction level (Tallgren *et al.*, 1980b). At the 1 year stage, the temporal activity in maximal clench for most of the subjects still was lower or about the same as the pre-extraction activity. For the masseter muscles, on the other hand, an increase in mean voltage from the pre-extraction stage was noted for about a third of the subjects.

In tapping of teeth from postural position the peak mean voltage of the jaw-closing muscles showed a general increase during the continued use of the dentures, the increase being especially marked for the masseter muscles.

Correlations between changes during continued use of dentures

Correlation coefficients between changes in jaw and dental relationships during half year of denture wear and the changes in clench activity of the jaw-closing muscles are shown in Table 5. The changes in anterior temporal activity displayed a series of marked correlations with changes in dental and jaw relationships. Negative correlations (RAT, $P \leqslant 0{\cdot}05$) were observed with the changes in forward direction of the maxillary incisors (*is* hor. max.). Furthermore, negative correlations (LAT, $P \leqslant 0{\cdot}05$) were seen with changes of the upper and lower incisors in the direction of the jaw

Table 5. Correlations between changes in jaw and dental relationships after half year of denture wear and changes in average mean voltage (μV) of right and left anterior temporal (RAT and LAT) and right and left masseter muscles (RM and LM) in maximal clench

	Maximal clench			
Variables	RAT	LAT	RM	LM
NSL/ML	−0·29	−0·54*	−0·11	0·20
NL/ML	−0·28	−0·53*	−0·09	0·20
s–n–pg	0·22	0·59*	0·24	0·00
ans–me	−0·49	−0·63*	−0·10	0·19
n–me	−0·47	−0·62*	−0·11	0·20
is vert. max.	−0·41	−0·52*	−0·16	0·02
ii ML	−0·08	−0·57*	−0·27	0·10
is hor. max.	−0·58*	−0·40	−0·32	−0·03
ii MLP	0·24	−0·31	0·14	0·03
Overjet	0·46	−0·13	−0·37	−0·20
Overbite	−0·02	−0·45	0·02	−0·31

Sample size = 15.
* $P \leqslant 0{\cdot}05$.
** $P \leqslant 0{\cdot}01$.

bases due to settling of the dentures (*is* vert. max. and *ii* ML) and with the resultant decrease in vertical jaw relations (NSL/ML, NL/ML, *ans–me*, *n–me*); and positive correlations with the increase in mandibular prognathism (*s–n–pg*). The changes in masseter clench activity during half year of denture wear showed no significant correlations with the changes in jaw and dental relationships.

In tapping of teeth from postural position, a marked increase in masseter activity during half year of denture wear showed single significant correlations ($P \leqslant 0{\cdot}05$) with the decrease in mandibular inclination, NSL/ML, NL/ML, (RM, $r = -0{\cdot}51$) and the increase in mandibular prognathism, *s–n–pg* (RM, $r = 0{\cdot}51$).

At the 1-year stage, similar but less marked associations for the changes in clench and tapping activity were observed.

Discussion

The correlations between electromyographic variables and facial morphology observed in the present sample at the partially edentulous stage indicated that individual variations in biting activity of the anterior temporal and masseter muscles bore a relationship to facial morphologic characteristics.

Strong activity of the jaw-closing muscles during maximal clench on the residual anterior dentition was seen in subjects with a facial type characterized by a small inclination of the mandible, marked mandibular prognathism and a small sagittal jaw relationship, in other words, a rather square facial type. The biting activity of the masseter muscles showed marked associations with vertical jaw relations and the size and shape of the mandible, while the anterior temporal activity was more closely related to sagittal jaw relations and dimensions. Conversely, in subjects with a retrognathic facial type the jaw muscle activity was found to be less marked. No significant correlations were observed between the biting strength of the jaw-closing muscles and the age of the subjects, which ranged from 27 to 69 years.

The correlations between facial morphology and the clench activity of the jaw-closing muscles, observed at the pre-extraction stage, are largely in accordance with findings by Møller (1966) in young male adults with a complete natural dentition, and by Ingervall & Thilander (1974) in a sample of children. Analogous findings have been reported by Ringqvist (1973) and Ingervall & Helkimo (1978) in studies of bite force and facial morphology in young adults. The present study thus extends findings by the above-mentioned authors to comprise older and partially edentulous subjects and indicates that neither increasing age, nor loss of posterior teeth will markedly affect the relationship between facial shape and the biting strength of jaw-closing muscles, characteristic for the individual.

However, in the present sample of partially edentulous subjects, the average mean voltages of the anterior temporal and masseter muscles in maximal clench, generally, were lower than those reported by Møller (1966) and Sheikholeslam, Møller & Lous (1980) in individuals with a complete dentition. This finding may in part be related to the absence of occluding posterior teeth, and in part to a weak health status of the residual anterior dentition, as was discussed in a previous publication (Tallgren *et al.*, 1980b).

Correlations after insertion and use of the dentures

Post-insertion changes. The changes in jaw and dental relationships due to construction of the complete dentures seemed to have a certain effect on the biting activity of the jaw-closing muscles. The changes in masseter clench activity observed at the post-insertion stage showed some close associations with the alterations in vertical jaw relation, an increase in occlusal vertical dimension being associated with a decrease in mean voltage of the masseter muscles. Analogous findings of decrease in masseter clench activity associated with an increased vertical dimension by use of onlays have been reported both at small changes (0·05–0·20 mm) by Bakke & Møller (1980), and at large changes (6–8 mm) by Rasmussen & Møller (1975) and Møller (1975).

The post-insertion changes in anterior temporal activity were found to be more closely associated with horizontal changes in anterior occlusion due to the denture construction. A decrease in mean voltage of the anterior temporals during maximal clench at the post-insertion stage was associated with a reduction in overjet and a more forward positioning of the denture incisors, as compared with the anterior occlusion in the natural dentition. In this connection it is interesting to note that studies of dentate subjects, among others by Møller (1966) and by Tallgren, Melsen & Hansen (1979) have shown a pronounced reduction of the anterior temporal activity during protrusive clench on the incisors.

A general lowering of the mean voltages for the jaw-closing muscles in maximal clench at the post-insertion state probably in part was related to the recent extractions and apprehension to bite hard with the new dentures (Tallgren *et al.*, 1980b). It was assured, however, that the patients had no more sore spots at the stage of recording.

Correlations during continued use of dentures. Comparison between changes in jaw and dental relationships during continued use of the dentures and changes in biting activity of the jaw-closing muscles again revealed some marked associations. The correlations were particularly marked during the first half year, when the morphological changes due to the rapid rate of ridge resorption were most pronounced. Differences in magnitude of correlation coefficients for the right and left side muscles were probably related to occlusal differences between the two sides owing to variations in degree of resorption.

A continuing decrease in clench activity of the anterior temporal muscles during the first half year of denture wear showed some marked associations with positional changes in forward direction of the denture incisors due to ridge resorption (Fig. 6).

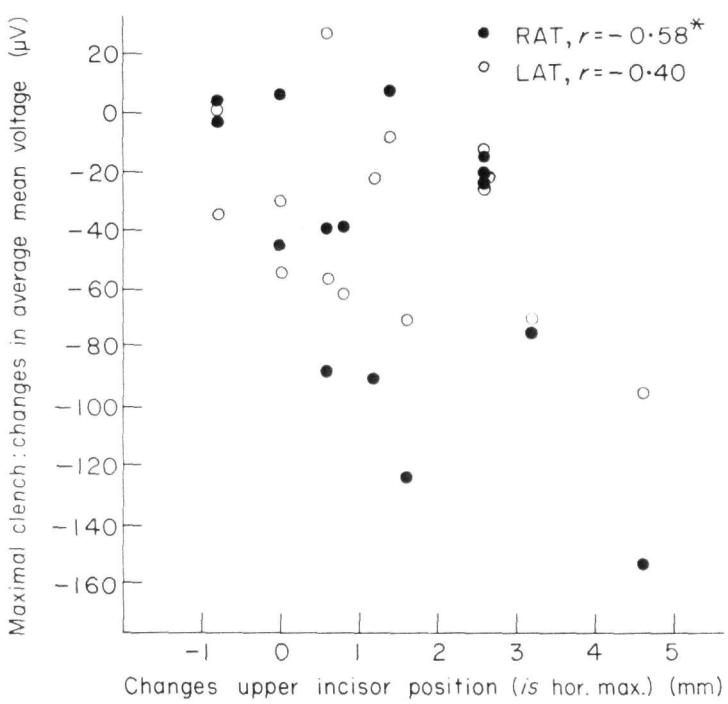

Fig. 6. Diagram illustrating the relationship between changes in horizontal position of the upper incisors (*is* hor. max.) after half a year of denture wear, and changes in average mean voltage of the right and left anterior temporal muscles in maximal clench (RAT, $r = -0{\cdot}58$*, LAT, $r = -0{\cdot}40$). Positive values of *is* hor. max. indicate a change in anterior direction of the upper incisors.

On the contrary, pronounced vertical changes towards the jaw bases of the upper and lower incisors due to settling of the dentures, and a marked reduction in vertical jaw relationship (*ans–me*) seemed to cause only less marked decrease in temporal clench activity or, even tendencies to increase (Fig.7).

The activity of the masseter muscles in maximal clench during continued use of the dentures showed tendencies to increase, but the changes were not significantly associated with the changes in jaw and occlusal relationships. In tapping of teeth from

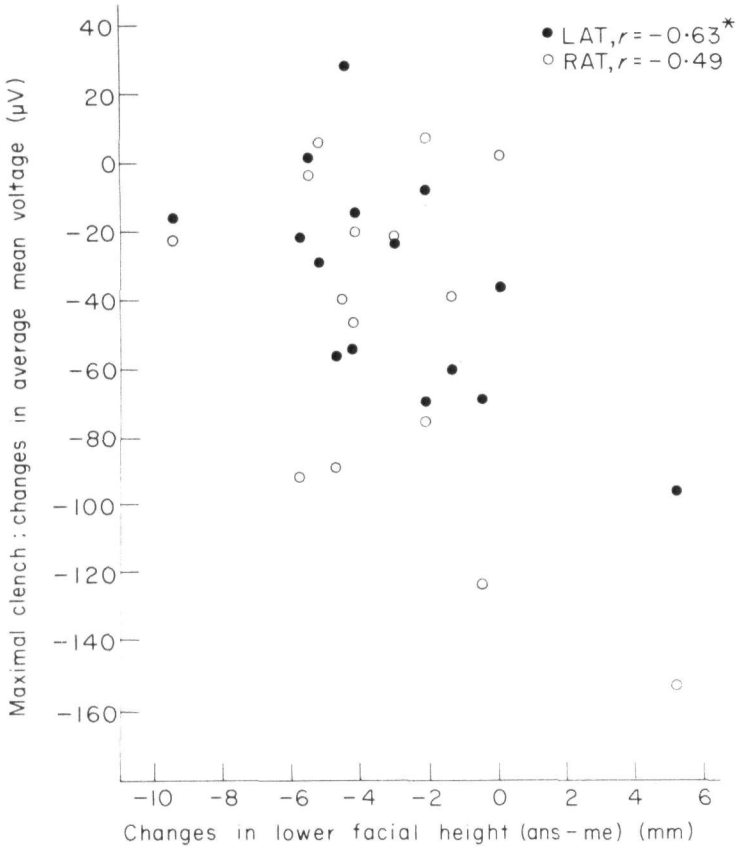

Fig. 7. Diagram illustrating the relationship between decrease in occlusal vertical dimension after half a year of denture wear (*ans–me*) and changes in average mean voltage of the left and right anterior temporal muscles in maximal clench (LAT, $r = -0{\cdot}63$*, RAT, $r = -0{\cdot}49$).

the postural position, however, a marked increase in masseter activity during a half year of denture wear was found to be associated with the decrease in vertical jaw relationship. This finding may be related to the fact, that the jaw motion during tapping from postural position to initial tooth contact occurred merely as a rotational movement, and did not involve the marked forward-upward change in mandibular position with resultant occlusal changes, which occurred in the maximal clench. A need for more muscle activity to move the mandible through a large free-way space may also be considered.

The findings in the present sample of great sensitivity of the anterior temporal muscles to changes in occlusal relations, but only less marked response of the masseter muscles, are in accordance with observations by other authors in various studies of dentate subjects and denture wearers (Jarabak, 1957; Kawamura, Tsuru & Funakoshi, 1960; Ramfjord, 1961; Tallgren, 1961, 1963; Møller, 1966).

Conclusions

The observations at the pre-extraction stage of strong biting activity of the anterior temporal and masseter muscles in individuals with a square facial type, and less marked activity in individuals with a retrognathic facial type, extend findings by other authors to comprise older and partially edentulous subjects.

The analysis of changes in facial morphology and biting activity of the jaw-closing muscles after insertion and use of immediate complete dentures showed that the anterior temporal muscles were extremely sensitive to sagittal changes in anterior occlusion. The masseter muscles were less sensitive to changes in jaw and dental relationships.

Acknowledgments

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