SPECIAL ARTICLE

Geriatric Oral Health and Its Impact on Eating

Jonathan A. Ship, DMD,[*] Valerie Duffy, PhD,[†] Judith A. Jones, DDS, MPH,[‡] and Susan Langmore, PhD[§]

OBJECTIVE: Adequate food and fluid intake and nutritional health are requisites for sustaining life. The oral-pharyngeal region has evolved multiple, highly regulated processes to ensure that the intake, chewing, and swallowing of foods and beverages is maintained. The objective of this paper is to identify the independent and collective roles of oral health on eating in older people.

DESIGN: Research reports from peer-reviewed scientific journals. Hypothesis-driven research that objectively examined taste, smell, dental and oral mucosal health, dental prostheses, chewing, and swallowing in the context of aging.

DATA EXTRACTION AND SYNTHESIS: Data results were extracted independently by multiple observers. A qualitative synthesis of data results from independent studies was made in order to form conclusions regarding the role of oral health on eating in older people.

CONCLUSIONS: Many oral functions remain intact in healthy older adults. However, significant alterations arise from oral and systemic diseases and their treatments, and these may have a profound effect on eating, drinking, and the nutritional status of older individuals. The care of older persons with smell, taste, dental/alveolar, oral mucosal, chewing, and swallowing problems requires a multidisciplinary team of health care providers. Recognition of the interrelationship between oral, pharyngeal, and systemic physiological processes will help practitioners identify the etiology of these disorders and implement appropriate therapy. **J Am Geriatr Soc 44:456–464, 1996.**

From the [*]University of Michigan School of Dentistry, Ann Arbor, Michigan; [†]University of Connecticut School of Allied Health Professions, Storrs, Connecticut; [‡]Dental Service, Edith Nourse Rogers VA Medical Center, Bedford, Massachusetts; and [§]the Audiology and Speech Pathology Service, Ann Arbor VA Medical Center, Ann Arbor, Michigan.

Address correspondence to Jonathan A. Ship, DMD, Department of Oral Medicine, Pathology, Surgery, University of Michigan School of Dentistry, 1011 N. University, Room 2012, Ann Arbor, MI 48109-1078.

Critical functions of the oral cavity are the intake of foods and beverages, communication, and the protection of the host from noxious substances. Multiple head, neck, and oral tissues have evolved to carry out these vital functions: muscles of facial expression, mastication, and deglutition (including the tongue), oral mucosa, teeth and periodontal tissues, saliva, and taste and smell receptors. These tissues work together continually to keep an individual hydrated and nutritionally healthy, to provide chemosensory information about foods, beverages, and potentially dangerous substances, and to protect the upper aerodigestive tract. While many of these processes and tissues can remain remarkably intact throughout the aging process in healthy persons (Table 1), numerous systemic diseases and their treatment (medications, surgery, head and neck radiation) can cause significant impairments to oral health. These problems can subsequently lead to malnutrition. For example, a recent study examined 200 long-term care older patients, and found that the prevalence of undernutrition was close to 50%, which was associated significantly with eating and swallowing problems, many of them related directly to oral health.[1] Familiarity with oral/pharyngeal physiological processes in healthy older persons will assist health care providers in their treatment of older patients with multiple, food-related complaints: dehydration, weight loss, malnutrition, difficulty with mastication, dysphagia, impaired smell and taste, and a loss of interest in eating and drinking. This paper reviews taste and smell function, food selection, chewing, and swallowing in older people and discusses how these processes are integrated to protect the nutritional health of older persons.

TASTE AND SMELL IN OLDER PEOPLE

The chemosensory functions of taste and smell play a vital role in human physiology. They determine the flavor and palatability of foods and beverages, the selection of nutrients essential for life, and the warning of fire, toxic vapors, and spoiled foodstuffs.[2] The hedonic role of chemosensation is experienced daily by everyone. Alterations in these pleasurable sensations have serious complications for the preservation of oral and systemic health, with dramatic effects on the quality of life.[3] For example, the inability to detect or distinguish among concentrations of sugar may make it difficult for older diabetic people to control sugar consumption.[4] Similarly, loss of ability to assess levels of salt accurately may lead hypertensive patients to violate a low-sodium diet.[4] Since smell and taste provide some of the first sensations during eating, chemosensory disorders can disrupt the mechanisms of eating and drinking, which could place an individual at risk for developing a nutritional imbalance.[5] Although smell

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Table 1. Oral-Pharyngeal Processes in Older People

Process	Healthy Older People	Medically Compromised
Taste	Unaffected	Diminished
Smell	Diminished	Diminished
Food enjoyment	Unaffected	Diminished
Salivary output	Unaffected	Diminished
Chewing efficiency	Slightly diminished	Diminished
Swallowing	Slightly diminished	Diminished

and taste disorders are relatively common in the general population,[6,7] they are most likely to exist in older individuals. Increased age per se accounts for some of these disorders, but they are affected more profoundly by numerous systemic diseases, environmental pollutants, and medical treatments including medications, surgery, chemotherapy, and head and neck radiation.

Gustation is subserved by taste buds in the mouth, pharynx, and larynx that are innervated by branches of the facial, glossopharyngeal, and vagus nerves. These taste buds are responsible for four primary sensations: bitter, sweet, salty, and sour. Nongustatory tactile and temperature sensations in the tongue arise from the lingual branch of the trigeminal nerve, and these perceptions interact with gustation and olfaction to discern flavor. Although elevated taste detection thresholds have been detected in older people for several of the primary tastants,[4,8] many studies have found that intensity perception is virtually age-stable.[8] Overall, most of the published data indicate that taste is remarkably robust with advancing age and do not support the expectation that most older persons will demonstrate profound taste disturbances.

Olfaction, unlike gustation, is subserved by only one cranial nerve (olfactory), and can detect and discriminate among thousands of different odorants. Mechanoreceptors, thermoreceptors, nociceptors, and proprioceptors from the trigeminal nerve in the mouth and nose provide multiple sensations that assist olfaction and gustation. Whereas the gustatory system is virtually age-stable, olfactory function undergoes significant changes with increasing age. The ability to detect and identify various odorants diminishes markedly across the human life span,[5,7-10] even in very healthy, nonmedicated subjects.[11]

In addition to the assessment of taste and smell, other studies have evaluated the more complicated problems of flavor perception,[12] food recognition,[5,13] and food preference.[5,14] Although results are not uniform, older individuals do less well when performance is assessed in these tasks. Since taste remains relatively age-stable while smell function declines,[15] the assessment of complex food stimuli may be impaired in older individuals as a result of olfactory dysfunction.

Medical problems and their treatments have a dramatic influence on taste and smell in older people (Tables 2 and 3). Gustation and olfaction can be altered by damage to peripheral nerves subserving taste and smell systems and central nervous system diseases,[16] as well as head trauma.[17] Numerous systemic conditions contribute to chemosensory dysfunction, including neurological, hepatic, renal, endocrine, and ear diseases, nutritional deficiencies, and infections.[2,18] Depression[19] and other psychiatric diseases[20] should also be considered in the differential diagnosis of chemosensory problems. The treatments of many systemic conditions have been implicated in both gustatory and olfactory dysfunction. Craniofacial and oral surgery,[2] chemotherapy,[21,22] and radiotherapy to the head and neck region[22-24] cause temporary and/or permanent taste and smell changes. Finally, multiple prescription and nonprescription medications can significantly impair taste and smell perception.[18,25]

Normal chemosensory function cannot operate independently of oral health. Numerous oral conditions can directly or indirectly affect smell and taste by altering the underlying biology of the taste or smell system or by introducing exogenous stimuli that produce abnormal taste or smell sensations in the mouth or nose.[26] Many oral conditions, including infections, lesions, salivary gland hypofunction, poorly fitting prostheses, and oral manifestations of systemic diseases can cause chemosensory dysfunction.[3] Therefore, the evaluation of the patient with smell and taste disorders may require a multidisciplinary approach, utilizing several health care providers, because of the complexity of factors affecting the chemical senses.

The complaint of a smell or taste problem may be indicative of a chemosensory disorder, or it could be the manifestation of an oral and/or systemic medical problem. For example, the sudden loss of either smell or taste may be a sign of a brain tumor. Older subjects are more likely to have chemosensory complaints. Unfortunately, these complaints are very poor predictors of olfactory dysfunction[11] and may be attributable instead to other sensory disturbances or to systemic and cognitive disorders.

In summary, smell and taste function are intricately involved in eating, drinking, nutritional health, and a person's quality of life; chemosensory dysfunction may be indicative of oral and/or systemic disorders; there are prominent age-related declines in olfaction, even in healthy adults; multiple medical conditions and their treatments adversely affect smell and taste; chemosensory dysfunction may increase the risk of malnutrition; and smell and taste complaints are relatively common in older people. Therefore, medical providers caring for older patients should inquire about chemosensory disorders and, when present, identify the cause.

CHEMOSENSORY CHANGES AND FOOD INTAKE IN OLDER PEOPLE

Taste and smell are important determinants of food selection, especially in older people.[27] Gustation helps select nutrients (i.e., to satisfy the need for salt or sugar)[28] whereas olfaction permits the exact identification of a substance[29] and may play a greater role in the type of foods selected and the pleasure of eating.[30] Olfactory sensation plays a dual role in the perception of food.[31] Food odors perceived through the nostrils (orthonasal perception) stimulate appetite and help initiate eating. Once in the mouth, taste, smell from the oral cavity (retronasal perception), and the trigeminal system interact in the perception of food flavor. Individuals are typically unable to separate and distinguish taste from smell in the sensory processing of food.[32]

As outlined above, olfactory perception is more vulnerable to loss with aging than is taste perception. Older people may suffer even greater loss of retronasal olfactory function.

Table 2. Oral Etiologies of Gustatory and Olfactory Dysfunction, Food Selection, Chewing, and Swallowing Problems

Etiology	Smell and Taste Problem	Food Selection and Chewing Problem	Swallowing Problem
Oral Trauma			
Burns, lacerations, chemical damage	X	X	X
Anesthetic, surgical	X	X	
Removable prosthodontic appliances	X	X	X
Oral Diseases & Problems			
Periodontal diseases	X	X	
Dental-alveolar and other infections	X	X	
Soft tissue lesions/oral tumors	X	X	X
Candidiasis, denture stomatitis	X	X	
Burning mouth syndrome	X	X	
Salivary dysfunction	X	X	X
Tooth loss		X	X
Diminished activity of muscles of mastication		X	X
Impaired chewing	X	X	X
Velopharyngeal incompetence			X
Oral pain		X	
Treatment of Oral and Systemic Diseases			
Oral mouth rinses, gels, & dentifrices	X		
Removable prosthodontic appliances	X	X	X
Drugs in saliva	X		
Dental material interactions, galvanism	X		
Poor dental restorations		X	
Chemosensory Problems			
Dysosmia	X	X	
Dysgeusia	X	X	
Halitosis	X	X	

For example, a direct comparison of orthonasal and retronasal olfaction[33,34] revealed that some older people tested normosmic on a standard olfactory dysfunction test, but had an elevated retronasal threshold. Active retronasal perception requires adequate manipulation of food to release and transport volatile substances to the olfactory cleft. One study suggested that retronasal perception may be disturbed by the presence of dentures because older women with maxillary dentures had a significantly higher retronasal threshold than those without dentures or with partial dentures only.[35] This denture effect was statistically independent of measured orthonasal olfaction.

Older persons may show some or a combination of two general nutritional risk patterns, indiscriminate eating and compensation eating, in response to an olfactory loss.

Indiscriminate Eating

An older person's response to food may be one of indifference as a result of olfactory loss. Inability to perceive the aromas of food can diminish an external cue for eating. When food is perceived as "bland" in flavor, the drive to consume a diverse diet is decreased.[36] The older person may report a poor food intake, eventually resulting in weight loss or a low body mass index.

The literature provides some support for a pattern of indiscriminate eating in response to olfactory dysfunction. Most individuals who seek treatment for olfactory dysfunction report that food is less flavorful and less enjoyable.[37,38] In independent-living older people, reports of self-rated flavor loss are not consistent, however, and range from only a few older people who notice a loss[39] to more than 50% who claim that food has less "taste" than when they were younger.[40] The report of appetite changes and olfactory dysfunction also vary. One study reported that independent-living older women with olfactory dysfunction did not report a poor appetite or decreased enjoyment of food, but they did indicate less interest in food-related activities (e.g., enjoying cooking for self or others).[41] Older people with olfactory dysfunction are less discriminating and not as finicky about the foods that they eat.[42] Finally, it has been suggested that chemosensory losses play a role in the anorexia that is often observed in older people.[43] Anorexia in response to olfactory loss may be more common in institutionalized older people who may have this loss in combination with additional medical, physical, and psychological dysfunctions.

Compensation Eating

This can occur when an older person with olfactory dysfunction increases the use of nonolfactory sensory components (e.g., primary taste qualities, food textures) or relies on nonhedonic reasons for eating (e.g., health or social aspects of eating) to compensate for loss of olfactory flavor. Nutritional risks result if the individual compensates with high salt or high sugar foods that often provide excess calories from fat. In fact, persons with olfactory dysfunction often show a risk for obesity.[37,38]

There is data to support the use of compensation eating in response to losses in smell function. The majority of

Table 3. Systemic Etiologies of Gustatory and Olfactory Dysfunction, Food Selection, Chewing, and Swallowing Problems

Etiology	Smell and Taste Problem	Food Selection and Chewing Problem	Swallowing Problem
Upper Respiratory Tract Problems			
Lesions of the nose/airway	X		
Viral and bacterial infections	X		
Exposure to toxic airborne contaminants	X		
Peripheral or Central Nervous System Pathologies			
Head & neck trauma	X	X	X
Tumors, lesions	X		X
Neurological diseases (e.g., Alzheimer's)	X	X	X
Systemic Diseases			
Systemic Conditions			
Cerebrovascular diseases	X	X	X
Head & neck cancers	X	X	X
Arthritides		X	X
Psychiatric disorders	X	X	
Endocrinopathies (e.g. diabetes)	X	X	X
Pulmonary diseases			X
Gastrointestinal disorders	X	X	X
Swallowing disorders		X	X
Sjögren's syndrome	X	X	X
Treatment of Systemic Conditions			
Prescription & nonprescription drugs	X		X
Head & neck radiation	X	X	X
Chemotherapy	X	X	X
Head & neck surgery	X	X	X
Gastrointestinal surgery			X
Nutritional and Dietary Problems			
Inappropriately restricted diet		X	
Monotonous diet, poor texture & color		X	
Insufficient smell/taste cues to initiate eating		X	
Nutritional deficiencies	X	X	X
Psycho-social Problems			
Eating alone		X	
Perceived chewing/eating problems		X	
Low socio-economic status		X	
Others			
Aging	X	X	X
Circadian variation	X		
Menses and pregnancy	X		
Functional problems (ADL, IADL)		X	

individuals who seek treatment for olfactory dysfunction report using foods (e.g., primary tastants, spices, and trigeminal stimulants) and non-food related strategies (e.g., eating with others) to maintain food appreciation.[37] If smell function is altered, the primary taste component (sweet, sour, bitter, salty) may become more apparent because of the lack of modulation of tastes via olfaction. This can result in changes in food preference and food intake. Independent-living older women with diminished olfactory perception showed lower preference for foods with a strong sour/bitter taste (i.e., citrus fruits, Brassica vegetables), ingested sugars and high-fat sweets more frequently, and consumed a cardiac-risk nutrient intake (higher intake of saturated fatty acid calories, lower polyunsaturated to saturated fatty acid intake, higher total fat).[41]

Older institutionalized individuals with olfactory dysfunction may be at the greatest risk of developing nutritional problems. They may be on restricted diets, prohibiting them from using the primary tastes to compensate for olfactory changes. In addition, chewing difficulties can limit textural diversity, a food attribute highly valued by individuals with congenital anosmia.[44] Many caregivers use creative methods to enhance the visual display of texture-modified foods. Schiffman and Warwick[45] advocated the use of flavor enhancers to counteract taste and smell deficits and to maintain nutritional status. Older persons provided higher preference ratings for moderately amplified foods than did younger persons.[45] Although older people may not recognize the olfactory decline, they are capable of recognizing flavor improvement caused by odor fortification. Finally, eating in a social atmosphere can draw a person's attention away from food flavor and enhance the enjoyment of the meal.

In summary, the nutritional risks associated with chemosensory and eating problems are not uniform and, therefore,

require individualized oral and medical evaluations and counseling to restore nutritional health and food enjoyment. The perception of a nutritional and/or a chemosensory disorder may aid clinicians in determining the course of treatment. For example, perceived chewing difficulty with a dental prosthesis was a larger determinant of food acceptance than measured function.[46] In a group of patients who sought treatment for chemosensory dysfunction, there was greater nutritional risk in individuals who claimed that the disorder changed their interest in eating or felt that eating exacerbated the disorder.[47] The perception of olfactory problems may increase the risk of nutritional problems even in the absence of objectively measured dysfunction.[35] Therefore, a comprehensive stomatological[3] and physical examination,[48,49] which includes smell function tests,[50] in patients with eating complaints may help determine if the etiology is physiological or the manifestation of behavioral and/or psychosocial factors.

Treatment of smell dysfunction and eating disorders should be directed toward the identified cause (Tables 2,3) if the cause can be determined. In addition, strategies should be implemented that capitalize on nonolfactory components of food flavor (altering food texture, primary taste qualities, temperature, and color) to help maintain food enjoyment. Foods and beverages that are salty, sweet, or that stimulate the trigeminal nerve (e.g., black or red pepper, carbonation) may provide another dimension to the eating experience. Enhancing the olfactory component of food flavor can also improve food intake in patients with olfactory dysfunction. These compensatory strategies may help improve dietary choices and maintain both food enjoyment and nutritional health.

CHEWING IN OLDER PEOPLE

Effective mastication requires the use of many specialized tissues of the oro-facial region, including the muscles of mastication and the tongue, as well as teeth, periodontium, saliva, healthy oral mucosa, and intact neuromuscular coordination.[51] There are three major issues affecting chewing in older people and its impact on dietary choices: (1) the relationships between age, dentition status, and masticatory efficiency; (2) the connection between objectively measured chewing function, perceived ease of chewing, and food preferences; and (3) the affect of age and changes in dentition status on nutrition, morbidity, and mortality.

National data demonstrate that older people are more likely than any other age group to have lost some or all of their teeth.[52–54] At the same time, the concept that tooth loss is not a consequence of normal aging has gained acceptance among health professionals.[55] Currently, tooth loss is viewed as the result of an accumulation of insults to the teeth and periodontium. Over the course of a human life span, older persons have been exposed to more trauma and diseases involving the dento-alveolar complex than persons in other age groups just by virtue of their longevity. Therefore, older persons are more likely to be totally or partially edentulous than other age groups.[52,54,56]

A substantial body of evidence indicates that tooth loss affects objective measures of masticatory performance.[57–61] Investigations in the 1950s and 1960s suggested that masticatory efficiency in wearers of complete dentures was approximately 75% lower compared to an intact natural dentition.[62–65] More recent work indicates that the diminished masticatory efficiency caused by tooth loss may be 30 to 40%.[66,67] However, these discrepancies may be partially related to differences in test foods, research methodologies, and subject populations.

The influence of age on masticatory efficiency is less clearly understood. Studies conducted by the Boston VA Dental Longitudinal Study (DLS) demonstrated that when raw carrots were used as a test food, dentition status (denture wearers vs persons with intact natural dentition) rather than age was the primary determinant of masticatory ability.[68–70] In addition, older subjects, regardless of dentition status, chewed their food longer and with more strokes than younger individuals. A longitudinal assessment of masticatory efficiency in DLS subjects showed that there were clinically small but statistically significant age-related changes in swallowing threshold indexes among persons with natural teeth but not among denture wearers.[71] In contrast, a cross-sectional study using almonds as a test food showed that both dentition status and age affected chewing performance as well as swallowing threshold tests.[67] In addition to age and dentition effects on mastication, oral motor performance is affected to a modest degree by aging,[72] which could have deleterious consequences to chewing performance in older people. Finally, a recent investigation reported that anterior masseter muscle size was significantly greater in dentate individuals compared with edentulous individuals; this relationship was independent of the age of the individual.[73]

While it is difficult to generalize about total chewing capacity based on these limited findings, they suggest that dentition, not age per se, has a direct influence on mastication. As discussed previously, dentition status is related to age not because of the aging process but rather as a result of the increased length of time during which insults to the dentition accumulate. Dentition status is subsequently related to chewing performance, as measured by masticatory efficiency and swallowing threshold. Persons with intact natural dentition perform more efficiently than those with compromised natural dentition, partial dentures, and complete dentures. Further, age influences how long a person chews, measured both in time and number of strokes. However, there are wide variations according to dentition status, and the relationship between age and masticatory efficiency may vary with the type of food consumed.

Masticatory ability clearly affects food preferences, perceived ease of chewing, taste and texture acceptability, and frequency of ingestion of hard to chew items (e.g., carrots and other crunchy raw vegetables, crunchy breads).[57,68,69,71,74–76] Furthermore, denture wearers are more likely to have a poorer quality diet than persons with natural teeth.[77] It is not clear, however, how these diet alterations affect nutrition adequacy as measured by anthropometric, biochemical, and clinical measures of nutrition. Sullivan et al.[78] demonstrated recently that the number of oral problems was the single most important predictor of weight loss in a group of frail older people. In addition, denture wearers perceive their dentures as interfering with chewing ability.[79,80]

A key relationship that requires investigation is that of tooth loss, nutrition, and general health. While oral diseases can exacerbate systemic conditions (e.g., diabetes), it is not known to what extent tooth loss and dental disease by themselves can adversely affect the nutritional health of an older person. Furthermore, poor nutritional status can have a deleterious effect on oral health.[81] It has been established that

edentulism may profoundly affect food selection and nutritional status, but it is not clear if these alterations are sufficient to cause significant morbidity and mortality. Edentulism may predispose a person to difficulties chewing, yet good nutrition is quite possible in the absence of teeth given the wide variety of dietary supplements available today.

It is possible that good oral health status, including an intact natural dentition, is a marker for successful aging. However, one study utilizing ambulatory, generally healthy adults found no overall oral health differences between nonmedicated subjects not being treated for medical problems and individuals taking medications and being treated for medical problems.[82] Nevertheless, preventive health habits probably contribute to sustained good overall health.

Finally, decrements in chewing can limit the variety and pleasure associated with eating. For these reasons, the effects of tooth loss may be more measurable from a quality of life perspective rather than through the use of physiologic measures. This is particularly important in the care of an older person, when quality of life issues may have greater significance than quantity of years yet to live. Future research in this area should endeavor to assess the impact of dentition status in a multidimensional fashion, including objective measures of dental and oral health and markers of patients' perceived quality of life.

SWALLOWING IN OLDER PEOPLE

Once food is selected, put in the mouth, tasted, and chewed, the act of swallowing completes the process. Although the conscious awareness of ingestion stops at chewing, the neurological system continues to direct the process whereby the bolus moves from the mouth, through the throat and esophagus, terminating at the stomach. Swallowing occurs in three stages: the oral stage, the pharyngeal stage, and the esophageal stage. Each of these must work adequately to ensure a safe and efficient swallow.

The oral stage consists of two components: the preparatory phase, where food or liquid is manipulated in the oral cavity, and the initiation phase, where the bolus is thrust into the pharynx to initiate the swallow. During the preparatory stage, multiple factors are necessary to facilitate mastication and posturing of the bolus: adequate dentition, masticatory muscle strength, labial and buccal mucosal tone and strength, tongue coordination and mobility, saliva, and intact taste, thermal and tactile sensations. The bolus must be contained within the oral cavity while it is manipulated, chewed, and then transported to the back of the tongue for the swallow.

The transition from the oral preparatory stage to the initiation phase has not been well characterized. A recent report suggested that the consistency of the food bolus in the mouth determines when swallowing will begin and concluded that sensory input from oral cavity receptors may be critical for triggering the swallow reflex.[83] A portion of chewed food is transported into the oropharynx during mastication, after which a swallow is initiated. Swallowing foods always occurs during the phase in mastication where the teeth are closest together, whereas liquids are swallowed without an intervening transport cycle.

The most critical oral structure for initiating a brisk and effective swallow is the tongue. Just before thrusting the bolus into the pharynx, the tongue moves the bolus into position by means of a 'tipper' or 'dipper' movement.[84] The most common pattern is the tipper, where the tip of the tongue presses against the incisors and the bolus is held against the palate. A second pattern, more prevalent in older subjects, is the dipper pattern, where part of the bolus is held beneath the tongue initially, and the tongue tip must dip beneath the bolus to carry it to the supralingual position seen in the tipper pattern. Once the entire bolus is positioned above the tongue, the tongue elevates and rolls posteriorly to deliver the bolus to the pharynx.

The pharyngeal stage of the swallow technically begins when the bolus passes over the tongue and enters the pharynx. However, there is considerable overlap of pharyngeal/laryngeal movements with oral movements. When the bolus is still in the mouth, the larynx begins to elevate and move anteriorly to make room for the bolus, and the airway begins to close to prevent aspiration. The pharyngeal stage is more programmed than the oral stage. Regardless of the size or consistency of the bolus, an invariant order of events occurs, including airway closure, velar elevation, laryngeal elevation, pharyngeal shortening, opening of the upper esophageal sphincter, and pharyngeal contraction. Respiration ceases during the swallow.

As the bolus is propelled through the pharynx and into the esophagus, the last stage in swallowing begins. The bolus falls through the esophagus by gravity and is assisted by a strong peristaltic wave. While it takes only about 1 second for the bolus to pass from the anterior faucial pillars through the cricopharyngeus into the esophagus, the bolus requires approximately 10 seconds to traverse the entire esophagus. The lower esophageal sphincter relaxes as the bolus approaches it to allow passage into the stomach.

Normal aging has been reported to have some minor adverse effects on swallowing, although in the healthy older person, advanced age per se does not appear to cause any clinical dysfunction.[85,86] The changes are caused by sensory, muscular, and neurological deterioration that occur with age and are manifest throughout the body.

Two studies have reported age differences that relate to tongue force and pressure exerted at the initiation of the swallow. Robbins et al.[87] found that maximum tongue force was reduced in older persons, but the force utilized during swallowing was not different from younger persons. Conversely, Perlmann et al.[88] demonstrated that older subjects generated higher oropharyngeal pressures during swallowing and held the pressure longer than did the younger subjects. Methodological differences may account for these discrepant findings.

Older subjects often have a delayed initiation of the swallow: the swallow does not begin until after the bolus passes a key trigger point in the oropharynx.[85,86,89] Robbins et al.[85] reported an increase in laryngeal penetration in older subjects (the material entered the laryngeal vestibule), but Tracy et al.[86] reported no difference among the age groups in this regard. Significantly, the occurrence of aspiration (passage of the bolus below the vocal folds into the trachea) has not been documented in healthy older persons.

Esophageal motility also declines with aging, resulting in longer transit time and less efficient peristalsis.[90] In addition, gastroesophageal reflux disease is more prevalent in older people.[91,92] As with the pharyngeal stage of swallowing, these changes are generally reported to be minor, and have not been clinically associated with dysphagia.[93]

The most common causes of oropharyngeal dysphagia in older people (Tables 2,3) are cerebrovascular and neurolog-

ical diseases (e.g., Parkinson's disease, multiple sclerosis, motor neuron disease, and Alzheimer's disease) that affect the muscles used in swallowing. Head and neck cancer has a dramatic affect on swallowing attributable to surgical resection of vital structures and/or radiation therapy that destroys salivary glands and causes laryngeal and pharyngeal fibrosis. Other systemic diseases, including arthritis, diabetes, and pulmonary disease, may also cause dysphagia.

The effect of these diseases on the oral and pharyngeal stages of swallowing are multiple and complex. Diseases that affect strength, speed, and/or coordination of cranial nerve musculature often result in a slow and weak swallow. In such cases, the tongue cannot manipulate the bolus efficiently, mastication is inadequate, and the initiation of the swallow is delayed and weak. As a result, much of the bolus is not cleared out of the mouth during the swallow and is also left as residue in the pharynx. If laryngeal airway closure is weak or slow, or if the residue is substantial, aspiration may occur, with the bolus falling below the larynx into the trachea and lungs.

The adverse effect of impaired dental health on swallowing in older people is probably most apparent when considering chewing (see previous discussion). However, poor oral/dental health may also affect swallowing. Dentures have a significant impact on oral sensation, oral stereognosis, and taste.[94–97] The change in sensation caused by an oral prosthesis may affect the initiation of the swallow because sensory input from the periphery is known to be an important factor in "priming" the swallowing center in the brainstem for a swallow response.[83,94] One study has provided some support for this hypothesis. Tallgren and Tryde found that edentulous patients who were provided with a complete upper denture manifested changes in swallowing duration 2 years after first use of the prosthesis.[94] The clinical significance of this finding remains to be studied.

Although salivary gland function appears to be relatively unimpaired in healthy older persons,[98–100] multiple medical problems and their treatments (medications, head and neck radiation) cause salivary gland dysfunction and the complaint of a dry mouth (xerostomia) in older people.[101] Diminished salivary secretions have an adverse effect on many oral functions, including chewing, tasting, and swallowing. For example, Sjogren's syndrome, an autoimmune exocrinopathy affecting primarily postmenopausal females, causes the destruction of salivary glands, and there is a consequent delay in the initiation of swallowing.[102,103] Older patients with salivary gland disorders and xerostomia attributable to multiple medications are more likely to complain of dysphagia[104] and may be at risk for developing aspiration pneumonia.[105]

Treatment for dysphagia can be medical, surgical, or behavioral in nature. Primary providers are usually physicians, speech-language pathologists, dentists, nurses, dieticians, and occupational therapists. The complications of this problem are serious, including aspiration pneumonia, malnutrition, dehydration, and the possible extension of diseases such as esophageal cancer. Therefore, early identification, and appropriate diagnosis and management are critical for patients with dysphagia.

SUMMARY

Adequate food intake and nutritional health are requisites for sustaining life. The oral-pharyngeal region has evolved multiple, highly regulated processes to ensure that the intake, chewing, and swallowing of foods and beverages is maintained. Many of these functions remain intact in healthy older adults; however, significant alterations may have a profound effect in older, medically compromised individuals. The care of older persons with smell, taste, oral, chewing, and swallowing problems requires a multidisciplinary team of health care providers. Recognition of the interrelationship between oral, pharyngeal, and systemic physiological processes will help practitioners identify the etiology of these disorders and implement appropriate therapy.

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