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Editor’s Corner

Donna Edwards

Thank you for the warm invitation to serve as the editor for Perspectives. I truly appreciate the support of my colleagues in SIG 13, Swallowing and Swallowing Disorders (Dysphagia). To my delight, the Editorial Committee continues to offer their expertise through their diverse talents and rich knowledge base. The transition has been smooth and I know you join me in thanking Lori Davis for her many years of service and dedication.

As I learn my role, I have found it an honor to work with our various authors during the creative process. Each author willingly accepted the challenge to make this, the first issue of Perspectives on Swallowing and Swallowing Disorders (Dysphagia) for 2012, a cumulative effort focused on oral issues related to dysphagia, and it falls as a natural precursor to the later issues for this year.

John R. Ashford reviews oral care from pediatrics through geriatrics with special attention to medically complex patients. Heather M. Clark and Nancy Pearl Solomon discuss the general neurophysiological substructure of muscle tone and implications of sensory and motor treatments and offer a review of certain measurement tools to assess orofacial tone. Merete Bakke, Allan Bardow, and Eigild Møller explore a treatment option of botulinum toxin to the parotid and submandibular glands in patients with severe drooling in hopes of increasing the quality of life, reinforcing psychosocial interactions, and optimizing overall health. Donna Lundy and Paula Sullivan investigate the etiology and management of xerostomia and its impact upon dysphagia. Annette H. May, E. Danielle Hiner, and Elizabeth Feldman examine oral integrity after chemoradiation in order to optimize long-term function while minimizing side effects.

This issue would not have been possible without the support and reviews from the Editorial Committee: Carmin Bartow, Jill Senner, Caryn Easterling, Stephanie Daniels, Jo Puntill-Sheltman, Cindy DuBose, Sheryl Amaral, and Krisi Brackett. A special thank you to Marni Simon for assisting with peer reviews and to Todd Coleman, SIG 13’s CE Content Manager.

As always, we welcome suggestions for future topics. It is our hope to provide outstanding continuing education opportunities to SIG 13 on a timely basis. Feel free to e-mail me at edwardsd@childrensdayton.org.
Oral Care Across Ages: A Review

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Mouth cleaning is performed to prevent diseases such as dental caries, gingivitis, and periodontitis. Bacteria, present since birth, form complex biofilms that attach to oral surfaces. These flora—controlled with saliva, brushing, and the immune system—may contribute to systemic diseases, including aspiration pneumonia. This review examines oral properties, biofilms, potential disease associated with the oral flora, and oral care practices.

Mouth care begins early with parents teaching their children to clean their teeth daily “to prevent cavities.” The World Health Organization (2011) estimates show that dental caries affect 60–90% of school children and the majority of adults in industrialized nations. Periodontal disease affects up to 12% of American adults. With aging, tooth loss affects over a quarter of Americans age 65 and older (Center for Disease Control and Prevention, 2011). Oral disease, in young and old alike, is directly related to the types, population, and control of microorganisms in the oral cavity.

Oral Cavity Environment

Encapsulated by hard and soft surfaces, the oral cavity is covered by a protective mucous membrane, serous fluids, and mixtures of microorganisms, or flora, comprised of bacteria, viruses, and fungal species (Avila, Ojcius, & Yilmaz, 2009). Over 600 species of bacteria, either floating free in oral secretions or attached to surfaces as plaque, struggle for survival (Keijser et al., 2008). As the environment changes with maturity, or as a consequence of illness, bacteria composition also changes. Birth moves the infant from the sterile intrauterine environment to an extrauterine environment of continuous exposure to microorganisms (Crielaard et al., 2011). The infant’s first feeding introduces bacteria to the oral cavity from its mother. Streptococcus salivarius, present 8 hours after birth, makes up 98% of the infant’s oral flora until teeth appear at 6 to 9 months of age (Rotimi & Duerden, 1981; Todar, 2011). Hard, non-shedding tooth surfaces provide permanent locations for new microorganisms, particularly Streptococcus, with concentration levels reaching more than 1,011 microorganisms per cubic millimeter (Li, Kolltveit, Tronstad, & Olson, 2000). Deciduous teeth give way to larger-surfaced permanent teeth, providing more area for colonization (Durso, 2005).

Complex, but slimy, oral flora communities, or biofilms, attach and cover the surfaces of the oropharynx and dental restorations. These coatings benefit the oropharynx by stimulating the immune system to protect surfaces against colonization and infection from invading microbes and to stimulate certain nutritional and digestive functions (Todar, 2011). Bacteria within this film chemically communicate among themselves, altering densities, producing virulence factors, and protecting other antibiotic-sensitive bacteria (Drinka, 2010).
Dental plaque, a unique biofilm, contains bacteria and orally secreted glycoproteins that adhere in layers to teeth surfaces. Plaque, if not controlled with good oral care, will evolve into a gram-negative bacterial species that can develop into an oral infection known as periodontitis (Guthmiller & Novak, 2002). Findings by Alexander et al. and Saxton et al., as reported by Rowshani, Timmerman, and Van der Velden (2004), show that plaque recolonizes on tooth surfaces within 3 hours of cleaning and to original concentration levels in less than 24 hours in healthy persons. For individuals with periodontal disease, plaque may recolonize within 5 minutes of cleaning.

Tooth destruction and disease are directly related with poor oral cavity health. Tooth decay, a risk factor for children and adolescents, is a softening and degrading of the tooth enamel. Bacterial-laden plaque attaches to these surfaces, and, if not removed, produces acids that demineralize the enamel, leaving pits and fissures (Durso, 2005). Destructive bacteria, such as Streptococcus mutans, use a sticky sucrose-derived substance to attach to these pits and fissures, increasing tooth decay susceptibility (Shay, 2002). Gingivitis, a form of periodontal disease, is characterized by swollen, inflamed, and bleeding gums, and is a consequence of dental plaque irritating the gingival and adjacent mucosa. Other promoting factors may include mouth-breathing, orthodontic appliances, and misaligned teeth. Periodontitis, another form of periodontal disease, chronically inflames and destroys the periodontal ligament and alveolar bone that hold teeth in place (Chi, Neville, Krayer, & Gonsalves, 2010). Localized juvenile periodontitis is particularly destructive in adolescents and is associated with impaired immune response to oral bacteria in the plaque biofilm (Durso, 2005). For elderly persons wearing dentures, bacterial biofilms present unique difficulties. Coulthwaite and Verran (2007) report that acrylic and silicone materials used in denture and denture-lining construction provide ample surfaces for bacteria attachment. Many elderly people are unable to adequately clean their dentures, increasing the prevalence of stomatitis, or mouth inflammation. Denture biofilm is broadly similar to dental biofilm but has fewer types of gram-negative bacteria. Dentures that fit closely to mouth surfaces reduce salivary cleaning and encourage development of Candida abicans, a yeast-laden biofilm affecting 10% to 75% of denture wearers.

Oropharyngeal colonization of bacteria has been implicated directly with systemic diseases. Bacteremia, or bacteria circulating in the bloodstream, can result from dental work or simple tooth brushing, but usually does not affect healthy children or adults. For some, particularly those with periodontitis, the risk for developing or complicating systemic illnesses is significantly increased (Li et al., 2000). Diseases such as arthritis, osteomyelitis, and meningitis may result from serious infections associated with bacteremia originating from oral sources (Kuppermann, 1999). Other systemic diseases include atherosclerosis, myocardial infarction, endocarditis (Li et al., 2000), chronic obstructive pulmonary disease (Scannapieco, Bush, & Paju, 2003), pregnancy complications, and diabetes (Scannapieco, Dasanayake, & Chhun, 2010; Shay, 2002). Risk of developing pneumonia from aspiration in children or adults with dysphagia is of the utmost concern to the medical team. The causal relationships of oral microorganisms and dysphagia with pneumonia have not been well understood until recently. Studies have identified respiratory pathogens in oral secretions in persons with aspiration pneumonia (Scannapieco, 1999). Poor oral hygiene, profuse plaque development, and a compromised host immune system provide favorable conditions for pneumonia development when orally incubated pulmonary pathogens are aspirated (Li et al., 2000; Scannapieco et al., 2003; Scannapieco et al., 2010; Shay, 2002).

**Oral Care**

Maintaining ecological balance of the oral cavity is contingent upon constant and adequate rinsing of oral surfaces with saliva, thorough manual cleaning of the oral surfaces, and maintaining good overall systemic health. Saliva is the predominant lubricant and oral cavity defender. Because this serous fluid is rich in antimicrobial substances, such as
immunoglobulin A and enzymes, oral pathogens are prevented from attaching to and colonizing the oropharyngeal surfaces, thus preventing oral infections (Gibson & Barrett, 1992). Reduced salivary flow may result in surface dryness, or xerostomia, increasing the probability of bacteria colonization and stomatitis. Prescription medications are the most common cause of xerostomia, followed by Sjögren’s syndrome and head and neck radiation therapy (Cassolato & Turnbull, 2003; Vissink, Spijkervet, & Amerongen, 1996). Primary Sjögren’s syndrome is an autoimmune disease that destroys salivary glands cells and affects salivary flow rate and composition. As a secondary disease, it may accompany connective tissue diseases including rheumatoid arthritis, systemic lupus erythematosus, and scleroderma. Though predominately affecting middle-aged and elderly Caucasian women, it may occur in persons of all ages and ethnic backgrounds (Cassolato & Turnbull, 2003). Radiation to salivary tissues results in severe inflammation and significantly affects salivary flow (Cassolato & Turnbull, 2003).

Xerostomia treatment may include reducing medications and using artificial saliva, such as MouthKote spray or Salivart aerosol, or dentrifices, such as Biotene Dry Mouth toothpaste, mouthwash, or gum (Daniels & Wu, 2000; Rayman, Dincer, & Almas, 2010). Fehder (2008) suggests sipping water between and during meals, eating fibrous foods (apples and carrots) to stimulate saliva, chewing sugarless gum, using saliva substitutes, and using medications such as Evoxac and Salagen.

Manually cleaning the teeth and other oral structures is a common activity for most people. To maintain adequate oral health, the American Dental Association (ADA) recommends brushing twice daily (ADA, 2011). Oral cleaning should begin very soon after birth. The infant’s gums should be cleaned with wet gauze or a washcloth. After teeth begin to appear, using a small toothbrush with water is recommended (ADA, 2008). Tooth brushing is strongly supported over use of foam swabs with hospitalized and nursing care patients. Many published clinical studies confirm the ineffectiveness of swabs to clean teeth. Pearson and Hutton (2002) examined dental plaque removal with 34 volunteers and reported that toothbrushes were substantially better at removing plaque than foam swabs. Reports suggest oscillating/rotating/pulsating electric toothbrushes are significantly more effective than manual toothbrushes for removing plaque (Pizzo, Licata, Pizzo, & D’Angelo, 2010). However, a study by Pobo et al. (2009) reported that use of electric toothbrushes with ventilator patients was not effective in preventing ventilator-associated pneumonia. In a systematic review, Ames (2011) could not establish the effectiveness of toothbrush use with critically ill children and adults based on current clinical studies. Other studies report oral cleaning should occur every 2 to 4 hours (Day, 1993; Trenter & Creason, 1986). Some recommend every 8 hours (Fields, 2008) or every 12 hours for intubated patients, with oral moistening every 2 hours (Barnason et al., 1998). Suction toothbrushes are widely utilized with intensive care patients and nursing home residents, but no reports are available evaluating their effectiveness.

Oral care should include use of dentifrices and/or mouth rinses. Dentifrice is a powder or paste used as a cleaning agent. Toothpastes containing fluoride are recommended over non-fluoride dentifrices, particularly for children and adolescents. Marinho et al., as reported by Davies (2004), found a 24% reduction in caries when using fluoride toothpastes. However, frequency of use, fluoride concentration, and rinsing behavior are significant to the effectiveness of this agent. Triclosan, a broad-spectrum antibacterial agent used in some dentifrices, has been shown to effectively reduce plaque and gingivitis and is now included in many toothpaste products. Mouth rinses containing fluoride have been found to help reduce caries in children and adolescents by 26% (Davies, 2004). Also found in toothpastes and mouth rinses is chlorhexidine, a widely used broad spectrum, antimicrobial agent. A report from the Center for Disease Control and Prevention (2003) declined to recommend chlorhexidine oral rinse with surgical or other high-risk patients due to lack of strong supporting evidence. However, Houston et al. (2002) reported that oral rinses mixed with a 0.12% solution of chlorhexidine reduced the rate of pneumonia in heart surgery patients by 52%. Beraldo and de Andrade (2008) identified eight meta-analyses and randomized clinical trials examining
chlorhexidine effectiveness. Seven (87.5%) reported chlorhexidine diminished oropharynx pathogen colonization and reduced ventilator-associated pneumonia.

Oral care practices across the lifespan differ little among most healthy individuals, regardless of age. With serious illnesses, typically requiring intensive care including ventilator support, oral care is recognized as a crucial part of a larger treatment regimen. However, standard protocols for oral care have not been widely or uniformly developed. Although tooth brushing and mouth rinsing are generally accepted as pathogen deterrents, more research is needed to incorporate these tools into a standard and cohesive care package.

References


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Muscle Tone and the Speech-Language Pathologist: Definitions, Neurophysiology, Assessment, and Interventions

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Abnormal muscle tone is presumed to underlie certain types of dysarthria and dysphagia. However, the speech-language pathologist rarely assesses orofacial muscle tone, presumably because of a lack of training and the unavailability of adequate tools. This article reviews the general mechanisms underlying muscle tone, explains sensory and motor therapeutic strategies that target muscle tone, and introduces new measurement tools.

Speech-language pathologists serving individuals with dysphagia and dysarthria typically address oral motor function, including strength, endurance, range, and coordination of relevant structures. Although muscle tone is frequently cited as relevant to speech motor control and oral swallowing function, it is often overlooked in the assessment and management of dysphagia and dysarthria. Contributing to this issue is the general lack of availability of clinical tools and procedures for assessing muscle tone. Furthermore, although textbooks and clinical resource books suggest interventions for addressing underlying abnormalities in muscle tone, little evidence exists to support their use to improve speech or swallowing. When therapeutic approaches have not been thoroughly studied, clinicians must rely on their understanding of the treatments and their mechanism of action when deciding whether to use them. In this article, we review pertinent information to help speech-language pathologists make clinical decisions about muscle tone.

Neurophysiology and the Muscle Spindle

Muscle tone is defined as the resistance offered by a resting muscle to passive stretch or palpation (Benarroch, Westmoreland, Daube, Reagan, & Sandok, 1999). Tissue elasticity and peripheral reflexes contribute to this resistance (Masi & Hannon, 2008). The central nervous system (CNS) contributes to tone regulation by modulating peripheral reflexes (Benarroch et al., 1999). The peripheral reflex of greatest interest to this discussion is the stretch reflex,
because it involves the muscle spindle and is the target of many interventions intended to normalize muscle tone.

When muscles are passively stretched, fibers lengthen and thereby stimulate muscle spindles. These sensory receptors have afferents that synapse directly with lower motor neurons (LMNs), causing the stretched muscle to contract, thus offering resistance to the passive stretch. At the same time, collateral synapses inhibit contraction in the antagonistic muscle. This peripheral reflex is regulated by descending tracts from the CNS. The indirect upper motor neuron (UMN) system has an inhibitory effect on the stretch reflex; UMN damage often causes spasticity, which reflects velocity-dependent hyper-responsiveness of the stretch reflex. Damage in the basal ganglia control circuit is commonly associated with rigidity, a type of non-velocity-dependent hypertonia that may also reflect increased gain of the muscle spindle reflex (McLellan, 1973). Damage to the cerebellar control circuit is typically associated with hypotonia, particularly in the context of cerebral palsy, but there is disagreement regarding whether the cerebellar control circuit regulates sensitivity of the stretch reflex or influences tone by some other mechanism (Fine, Ionita, & Lohr, 2002; Gorassini, Prochazka, & Taylor, 1993).

Disruptions in muscle tone are common in both developmental and acquired neuromotor disorders. Cerebral palsy may be accompanied by hypertonicity, hypotonicity, or variable tone. Stroke or head trauma often result in hypertonicity, although hypotonia may present initially (i.e., “spinal shock”) and may persist if there is also peripheral trauma. Progressive diseases may also alter tone: Parkinson’s disease is associated with rigidity (hypertonia), and amyotrophic lateral sclerosis may result in hyper- and/or hypotonia depending on contributions of the UMN and LMN systems, respectively. Muscle tone impairments that accompany neurologic disease have been assessed in the limb and trunk musculature using a variety of perceptual and instrumental methods.

**Assessment**

The most common perceptual method of assessing muscle tone is judging the level of resistance of a body structure to passive movement around a joint (Sloan, Sinclair, Thompson, Taylor, & Pentland, 1992). The Modified Ashworth Scale is a 6-point scale (range from 0 = normal tone to 4 = affected part(s) rigid in flexion or extension) that is commonly used to document the severity of hypertonia (Bohannon & Smith, 1987). Other informal scales include ratings for both decreased and increased muscle tone (e.g., -4 = severe hypotonia, 0 = normal tone, +4 = hypertonia). Examiners may also palpate a muscle, judging the degree to which the tissue resists deformation. Unfortunately, the agreement between clinical rating scales and physiologic measures of spasticity is not encouraging (Malhotra et al., 2008). Instrumental measures of muscle tone may be used to objectify the judgments made in these contexts. For example, torque motors quantify the resistance of structures around a joint. Electromyographic measures reveal the amount of muscle activity generated in response to passive movements. Instrumental measures are employed more frequently in research than clinical contexts, although emerging handheld technologies may make such measures more feasible for clinical use.

**Intervention**

Disruptions in muscle tone in the limbs are addressed a number of ways. Pharmacologic and surgical interventions are common treatments for hypertonia. For example, spasticity may be improved with the use of baclofen and botulinum toxin (Olvey, Armstrong, & Grizzle, 2010) or following rhizotomy (Lazorthes, Sol, Sallerin, & Verdie, 2002). Rigidity is often responsive to medications (e.g., dopamine agonists, anticholinergics) and selected neurosurgical procedures (e.g., pallidotomy, deep brain stimulation; Lyons, 2011). Promising
new pharmacologic treatments are available for managing orofacial hyperkinesias characterized by abnormal changes in muscle tone (Koshikawa, Fujita, & Adachi, 2011).

Aside from these medical-surgical treatments, a number of behavioral interventions have been developed to ameliorate disruptions in muscle tone by targeting muscle spindles specifically or neuromuscular function more generally (Logan, 2011). Interventions targeting muscle spindles aim to enhance or inhibit the responsiveness of the muscle spindle receptors. Passive stretching can either decrease or increase tone, depending on the speed of the stretch. Muscle fibers stretched quickly normally elicit a brisk stretch reflex, thus increasing tone. Slow stretching, in contrast, causes an inhibition of the stretch reflex and may decrease tone. Although the therapeutic mechanism of passive stretching is well understood, evidence is lacking to demonstrate significant improvements in muscle tone and/or functional movements following these treatments (e.g., Ashworth, Satkunam, & Deforge, 2004). Vibration stimulates the muscle spindle and is employed to increase tone of the stimulated muscle and decrease tone of the antagonist (Bishop, 1975). Initial evidence suggests this modality may reduce spasticity (Noma, Matsumoto, Etoh, Shimodozono, & Kawahira, 2009). Tapping of the muscle body is thought to have the same therapeutic mechanism as vibration, but evidence for its benefit is lacking.

Although the muscle spindle as the sensory receptor plays an important role in the stretch reflex, the integrity of axonal afferents and motor efferents also influence the role of the stretch reflex in modulating muscle tone. Icing is a therapeutic modality intended to decrease both nerve conduction velocity and muscle contraction speed, thus resulting in an overall decrease in tone (Gracies, 2001; Katz, 1988; Michlovitz, 1986). Although treatment evidence related to icing for spasticity is robust (Annaswamy, Mallempati, Allison, & Abraham, 2007; Gracies, 2001; Price, Lehmann, Boswell-Bessette, Burleigh, & deLateur, 1993), the effects appear to be short-lasting.

**Muscle Tone in the Orofacial System**

Muscle tone has been studied to some extent in the limb/trunk musculature in terms of its modulation, effects on movement control, and assessment and treatment strategies. Although similar data are largely lacking for the speech and swallowing musculature, disruptions of tone have been proposed as contributing to dysarthria (Duffy, 2005) and dysphagia (Bahr, 2001). Nonetheless, given unique physiology, particularly with respect to muscle spindles, there is reason to believe that tone disruptions may manifest differently in the orofacial musculature compared to the limbs. Only one muscle group in the orofacial system has a high density of muscle spindles and exhibits clear stretch reflexes: the jaw-closing musculature. The muscles of the face and lips generally lack spindles and do not demonstrate stretch reflexes. Although muscle spindles are present in the lingual musculature, typical stretch reflexes have not been observed (Neilson, Andrews, Guitar, & Quinn, 1979). The presence and density of muscle spindles varies across the palatal, pharyngeal, and laryngeal muscles, and attempts to elicit stretch reflexes in the larynx have been unsuccessful (Ludlow, 2005).

The lack of orofacial stretch reflexes in all but the jaw-closing musculature has implications for the regulation of tone and the manifestation of tone impairments in dysarthria and dysphagia. In fact, evidence suggests that although spasticity is prominent in the jaw musculature (dos Santos & de Oliveira, 2004), it is not detectable in the lingual musculature of patients with spastic dysarthria. Nonetheless, reduced muscle stiffness in the facial musculature may accompany flaccid dysarthria (Solomon & Clark, 2010), and increased stiffness may reflect rigidity of the perioral muscles in patients with Parkinson’s disease (Chu, Barlow, Kieweg, & Lee, 2010). Even when disruptions of muscle tone can be detected, strategies for alleviating these disruptions are unlikely to be effective if the treatments target absent physiologic mechanisms. For example, interventions intended to stimulate stretch...
reflexes (e.g., fast stretch, vibration, tapping) would be expected to be ineffective for facial and lingual muscles.

Our understanding of the regulation of muscle tone in the orofacial musculature is admittedly limited. To address this problem, valid and reliable measures of muscle tone are needed, yet few are available. Perceptual ratings are based on stretching (Dworkin & Culatta, 1996) and palpation (Beckman, 1988), although psychometric properties and normative data are lacking for these methods. Moreover, these methods are applicable only to accessible muscle groups (i.e., face, lips, jaw, tongue).

**Preliminary Studies**

Muscle tone in the orofacial system has not been the subject of widespread study. Only one study, to our knowledge, has directly examined tone of the jaw, lips, and tongue by utilizing electromyography to demonstrate the absence of stretch reflexes (Neilson et al., 1979). More recent studies have considered tissue stiffness as an indirect measure of muscle rigidity. The OroSTIFF (Chu et al., 2010; Seibel & Barlow, 2007) uses a lever system to stretch the corners of the relaxed mouth laterally and calculates dynamic stiffness as the change in force as the corners are stretched farther apart. Although preliminary data support the reliability and validity of this method, the instrumentation is quite complex and not yet feasible in clinical settings.

In preliminary experiments, we used two devices designed for limb and trunk muscles to assess tone in the orofacial musculature. The first tool was the Myotonometer™ (Neurogenic Technologies, Missoula, MT), which involves positioning a small flat probe on the skin overlying the muscle of interest. It measures tissue compliance by recording tissue displacement at each of eight incremental forces (Leonard et al., 2003). Tissue compliance at rest reflects muscle tone and nonmuscular tissue stiffness.

The second instrument we investigated was the Myoton-3 (V6.7, 2005; Myoton AS, Estonia, EU), which delivers a brief pulse perturbation with a thin probe to the skin’s surface. An accelerometer then senses the resulting tissue perturbation. Versions of this device have been used to study stiffness and elasticity of the tongue and soft palate in adults with sleep apnea (Veldi, Vasar, Vain, & Kull, 2004). Our study explored the utility of the Myoton for assessing orofacial muscle tone of the tongue and cheeks in healthy and neurologically impaired participants. The test-retest reliability of the Myoton appears to be greater than that of the Myotonometer™ (Clark & Solomon, 2010; Solomon & Clark, 2010). Moreover, the Myoton was judged to be more versatile in that the probe can be applied effectively to more muscle groups.

Using these instruments, our initial studies revealed that careful review and application of these devices to the orofacial system are required before they can be recommended for general use. In the preliminary study exploring the utility of the Myoton for assessing orofacial muscle tone in participants with UMN or LMN lesions, we predicted increased and decreased tone, respectively. The results generally supported the prediction of reduced stiffness/decreased tone in the LMN impairments but failed to identify changes in stiffness associated with UMN lesions (Solomon & Clark, 2010). We subsequently expanded our study of the Myoton to include jaw and lip muscles; we have also recruited participants with a wide variety of neuropathologies. We are hopeful that these additional data will enlighten our judgments regarding the usefulness of the Myoton in the quantitative assessment of orofacial and masticatory muscle tone.

We employed the Myotonometer™ to measure submental tissue compliance before and after therapeutic interventions (Clark & Solomon, 2010). The experiment involved healthy participants who were administered 2 minutes of icing (intending to decrease muscle tone/increase tissue compliance) or vibration (intending to increase muscle tone/decrease disuse compliance) during two separate assessment sessions. Neither intervention resulted in
systematic changes in submental tissue compliance. These preliminary data suggest that the interventions either had no effect on muscle tone or that the changes were too small for the sensitivity of the Myotonimeter™.

What is clear from this review is that much more research is needed to improve orofacial muscle tone assessment, inform our understanding of how orofacial tone is regulated and how disruptions in muscle tone may be manifest in dysphagia and dysarthria. We must continue to seek valid and reliable methods for assessing orofacial tone and documenting potential benefits of tone-altering interventions.

References


Severe Drooling and Treatment With Botulinum Toxin

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Severe drooling is associated with discomfort and psychosocial problems and may constitute a health risk. A variety of different surgical and non-surgical treatments have been used to diminish drooling, some of them with little or uncertain effect and others more effective but irreversible or with side effects. Based on clinical evidence, injection with botulinum toxin (BTX) into the parotid and submandibular glands is a useful treatment option, because it is local, reversible, and with few side effects, although it has to be repeated. The mechanism of BTX is a local inhibition of acetylcholine release, which diminishes receptor-coupled secretion and results in a flow rate reduction of 25–50% for 2–7 months.

Salivary Secretion

Saliva lubricates the oral tissues, facilitating speaking, chewing, and swallowing, and reduces the risk of infection in the oral mucosa and the salivary glands themselves. It protects teeth from decay by removing oral bacteria and their substrate and by repairing acid-induced softening of dental hard tissue by remineralization. Under normal physiological conditions, the resting or unstimulated saliva is produced continuously to the mouth at a flow of 0.20–0.50 ml/min during daytime, much less during night when asleep (Heintze, Birkhed, & Björn, 1983; Meurman & Rantonen, 1994; Sreebny, 2000). In humans, saliva secretion amounts to a daily volume between 0.5–1.5 liters, slightly higher for men than women and children. Normally, saliva is swallowed unconsciously throughout the day with about one swallow per minute and more often during eating and drinking. The saliva flow is lower in patients with systemic conditions like Sjögren’s syndrome and patients medicated with anticholinergic and psychotropic drugs. A saliva flow below 0.20 ml/min is considered subnormal. A flow below 0.10 ml/min is hyposalivation, which is diagnosed as pathologically reduced secretion (ICD-10
K11.7). In contrast, resting flow rates above 0.70 ml/min are considered to be hypersalivation and may require more frequent swallowing than normal.

The largest salivary gland, the strict serous parotid, weighing 14–28 g, and the mixed, also mainly serous submandibular gland, weighing 10–15 g, produce most saliva present in the mouth. The secretion from the mixed, mainly mucous sublingual gland and the small glands lining the oral mucosa contribute much less to the volume but may be important for protection of mucosal surfaces. In the unstimulated state, the submandibular gland secretes most saliva, whereas the parotid and submandibular glands are about equal contributors in the stimulated state. Here, depending on the stimulus, the flow rate can be increased to about 1.5 ml/min by chewing tasteless gum (Navazesh & Kumar, 2008) and up to about 7.0 ml/min by sour taste (Watanabe & Dawes, 1988).

The salivary glands are controlled by the autonomic nervous system. Stimulation from parasympathetic nerves fibers by release of acetylcholine from postganglionic nerve endings results in plentiful, thin saliva, and stimulation from sympathetic fibers by release of noradrenaline results in less and more viscous saliva. Prior to entering the mouth, saliva is nearly sterile and transparent, containing water, salts, and proteins including enzymes (Bardow, Lagerlof, Nauntofte & Tenovuo, 2008). In the oral cavity, saliva becomes contaminated with vast amounts of bacteria and epithelial cell debris, making it grayish and cloudy. The saliva composition mirrors the flow rate, with increased protein concentration at high-flow rates and flow-dependent changes in some inorganic components (Dawes, 1974).

Salivation and Drooling

Anterior drooling with saliva present beyond the lip margin after age 5 years is unusual, as the ability to control saliva develops with the oral motor and feeding control. Drooling caused by excessive secretion of saliva is defined as primary sialorrhoea and has been associated with conditions such as teething, gastroesophageal reflux, and pregnancy, and as side effects of pharmacologic treatment. Hence, the antipsychotic medicine clozapine, which is an agonist of the cholinergic receptor subtype in salivary glands, is often associated with troublesome drooling during the day and possible aspiration of saliva during nighttime (Godoy, Riva, & Ekström, 2011). Primary sialorrhoea may also occur from treatment with pilocarpine, ketamine, potassium chlorate, and risperidone and, in extreme cases, from exposure to toxic compounds like mercury, arsenic, insecticides, and chemical gases.

Drooling that is caused by decreased clearance (swallowing) of saliva, resulting in an increased amount of saliva in the mouth, is called secondary sialorrhoea. Generally, this type of drooling is more often associated with disorders in the coordinated activity of orofacial and palatolingual muscles than in the excessive secretion of saliva (Meningaud, Pitak-Arnnop, Chikhani, & Bertrand, 2006). Often patients with subnormal or even hyposalivation can suffer from secondary sialorrhoea when impaired swallowing leads to pooling of saliva in the oral cavity. Insufficient lip closure or reduced oral sensation can also lead to overflow and loss of saliva from the mouth or aspiration. Therefore, correct classification of drooling requires that the saliva flow rate is determined for each patient.

Typical Conditions With Secondary Sialorrhoea

Neurological disorders, such as cerebral palsy (CP; i.e. spastic paresis from brain damage during pregnancy), and neurodegenerative diseases affecting the swallowing centers in the medulla and pontine area, the motor neurons, or the cortical and subcortical centers initiating or regulating swallowing, such as Parkinson’s disease (PD) and amyotrophic lateral sclerosis (ALS), often cause secondary sialorrhoea. ALS is a rare but severe neuromuscular disease with progressive paresis of the striated muscles in the bulbar, truncal, and/or extremity regions. PD is one of the most common neurological diseases (120:100,000 population) with resting tremor, rigidity, and bradykinesia as cardinal symptoms. The
prevalence of CP is even higher (200–400:100,000 population), with CP patients often having deviating facial morphology and open mouth posture, and with 10–40% suffering from drooling (Enfors & Lundberg, 1968; van De Heyning, Marquet, & Creten, 1980). However, drooling is more frequent in neurodegenerative diseases, with up to 50–80% of ALS patients and 30–80% of PD patients having severe drooling conditions (Hyson, Johnson, & Jog, 2002; Kalf, Smit, Bloem, Zwarts, & Munneke, 2007; Neppelberg, Haugen, Thorsen, & Tysnes, 2007; Stone & O’Leary, 2009). The drooling is typically caused by a combination of pooling of saliva in the mouth due to dysphagia and decreased swallowing frequency, diminished closure of the lips, and deviating head posture.

**Consequences of Drooling**

Physically, anterior drooling may lead to skin irritation around the mouth, redness of the chin and neck, and soaking of clothes. A great number of napkins, bibs, scarfs, handkerchiefs, and paper towels are needed to wipe away saliva from the mouth and chin and to keep clothes dry. Posterior drooling with excess saliva pooled in the pharynx may lead to aspiration pneumonia or even cause choking (Stone & O’Leary, 2009; Tumilasci et al., 2006; Verma & Steele, 2006). Socially, drooling is distressful for patient, family, and caregivers. Drooling may reduce the quality of life; constitute a health risk; and is psychosocially disabling, causing reduced social activity and embarrassment.

**Treatment Methods of Drooling**

A variety of different surgical and non-surgical treatments has been used to treat drooling (e.g., Meningaud et al., 2006; Molloy, 2007), some with little or uncertain effect and others more effective but irreversible or with side effects (Table 1). In children and young patients, the several methods that have been advised are removal of adenoid and tonsillar hypertrophies, oral motor exercises, palatal training appliances, anticholinergics, intraglandular BTX injections, and surgical rerouting or ligation of ducts from the parotid or submandibular glands, as well as glandular excision (Fairhurst & Cockerill, 2011). However, the effect of most methods has not been sufficiently documented. In adults with neurodegenerative diseases, the methods may be more invasive, also including radiotherapy (Table 1).
Table 1. Different Types of Treatment for Severe Drooling

<table>
<thead>
<tr>
<th>Type of Treatment</th>
<th>Effect</th>
<th>Effectiveness</th>
<th>Side Effects</th>
<th>Duration of Effect</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anticholinergic medication</td>
<td>Systemic</td>
<td>Effective with some side effects</td>
<td>Dry mouth and accelerated tooth decay, urinary retention, constipation</td>
<td>Short term</td>
<td>Treatment has to be repeated at daily intervals</td>
</tr>
<tr>
<td>Scopolamine patches</td>
<td>Systemic</td>
<td>Effective with some side effects</td>
<td>Allergic skin reactions, drowsiness, disorientation, difficulty urinating</td>
<td>Short term</td>
<td>Treatment has to be repeated twice at weeks</td>
</tr>
<tr>
<td>Botulinum toxin injections</td>
<td>Local</td>
<td>Effective with minor side effects</td>
<td>Temporary pain at injection site with occasionally swallowing difficulties up to 3 weeks after injections</td>
<td>2–7 months</td>
<td>Treatment has to be repeated depending on the effect duration, but with intervals of at least 3 months</td>
</tr>
<tr>
<td>Oral motor training</td>
<td>Local</td>
<td>Unknown</td>
<td>Little evidence present</td>
<td>Unknown</td>
<td>Possibly some effect in children, but time consuming and depends on patient cooperation</td>
</tr>
<tr>
<td>Radiotherapy</td>
<td>Local</td>
<td>Effective with possible major side effects</td>
<td>Exposure to irradiation with risk of osteoradionecrosis, dry mouth and accelerated tooth decay</td>
<td>Permanent</td>
<td>Primarily for patients with neurodegenerative diseases such as amyotrophic sclerosis</td>
</tr>
<tr>
<td>Salivary duct ligations or gland extirpations</td>
<td>Local</td>
<td>Effective with possible major side effects</td>
<td>Risk of salivary gland cyst, dry mouth and accelerated tooth decay</td>
<td>Semi-permanent or permanent</td>
<td>Ligations may be reversed</td>
</tr>
</tbody>
</table>

Systematic reviews show that most evidence regarding surgical management of sialorrhea is heterogeneous and of low quality (Reed, Mans & Brietzke, 2009; Stone & O’Leary, 2009). A Cochrane review of randomized and quasi-randomized controlled studies on any intervention for sialorrhea—including medications, BTX, radiotherapy, and surgery—concluded that only BTX injections into salivary glands for treatment of sialorrhoea was effective with no significant adverse effects (Young, Ellis, Johnson, Sathasivam, & Pih, 2011). Thus, injection with BTX seems a useful treatment option for severe drooling; it is local and reversible, but has to be repeated (Lim, Mace, Nouraei, & Sandhu, 2006; Stone & O’Leary, 2009; Møller et al., 2011; Molloy, 2007; Tan, 2006).

**Effect of BTX on Salivary Glands**

BTX inhibits the release of acetylcholine from nerve endings (Dolly, 2003). Consequently, fewer salivary muscarinic receptors are activated. Intraglandular BTX in the rat results in diminished saliva flow and atrophy of acini, together with reduced intracellular expression of amylase (Teymoortash et al., 2007). Treatment of humans has indicated that the primary effect of intraglandular treatment with BTX is reduced release of acetylcholine from
postganglionic parasympathetic fibers in combination with unchanged release of norepinephrine from postganglionic sympathetic nerve endings, both within the gland (Møller et al., 2011). Randomized controlled trials have demonstrated the effectiveness of BTX in the management of sialorrhoea with duration of 2–7 months (Bhidayasiri & Truong, 2005; Lim et al., 2006). Two to six weeks after BTX injection, the saliva secretion is reduced 25–50% in terms of flow rate or gland scintigraphy (Dogu, Apaydin, Sevim, Talas, & Aral, 2004; Ellies, Gottstein, Rohrbach-Volland, Arglebe, & Laskawi, 2004; Giess et al., 2000; Lagalla, Millevolte, Capecchi, Provinciali, & Ceravolo, 2006; Lipp, Trottenberg, Schink, Kupsch, & Arnold, 2003; Møller et al., 2011; Pal, Calne, Calne, & Tsui, 2000; Verma & Steele, 2006). In muscles, BTX induces nerve sprouting and outgrowth with the ability to form transitory functional synapses, but they are eliminated with the start of recovery of normal transmission after 2.5–3.0 months (Coffield & Yan, 2009; Meunier, Schiavo, & Molgo, 2002). The study by Møller et al. (2011) showed a temporary recovery of saliva flow 2–4 weeks after BTX injections into the parotid and submandibular glands, which may reflect similar sprouting.

**Percutaneous Intraglandular Injections With BTX**

A thorough history and quantification of the drooling is important to identify the background for the problem. The evaluation should include self-reported intensity and frequency of drooling on the scale by Thomas-Stonell and Greenberg (1988) or on a visual-analog scale. The number of napkins, bibs, scarves, handkerchiefs, or paper towels used per day should be noted, and the unstimulated whole saliva flow rate should be determined (Møller et al., 2011). We recommend that more than one method for saliva flow rate measurement is available to the clinician (Navazesh & Kumar, 2008), because patients suffering from drooling display different levels of cooperation. The evaluations should be repeated to assess the treatment effect and to decide the need for repeated BTX treatment. The intervals between injections should be minimum 3 months to avoid formation of antibodies making BTX ineffective.

The treatment with BTX injections into the parotid and submandibular glands should be guided with ultrasonography to improve efficacy and safety (Tan, 2006) and reduce complications and side effects (Møller et al., 2011). Because the injections are associated with temporary local discomfort, light anesthesia or sedation may be needed, especially in children. Most clinical reports are performed with commercially available preparations of BTX type A, such as Botox® and Xeomin®, with 20–40 units to each parotid gland and 10–20 units to each submandibular gland, but preparations of type B are also used for drooling.

**Conclusion**

Based on clinical evidence, treatment with BTX injections into the parotid and submandibular glands is considered a useful treatment for drooling, because it is local, reversible, and with few side effects, but treatments have to be repeated.

**References**


Xerostomia

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Xerostomia, dry mouth, is a common and chronic problem that not only impacts a patient’s comfort but can adversely affect swallowing and vocal abilities. There are many potential etiologies for dry mouth, ranging from the most common, side effects of other medications, to side effects from treatments like radiation for other disorders, to symptoms of other autoimmune disorders like Sjogren’s disease. This article will highlight evaluation methods for xerostomia along with potential treatments.

Xerostomia comes from the Greek stoma, meaning mouth, and xeros, arid or dry. Dry mouth arises from reduced or absent salivary flow and frequently is associated with other conditions or diseases. Xerostomia rarely occurs in isolation.

Saliva is produced by the salivary glands including the parotid, submandibular, and sublingual. Its composition is 99% water and includes proteins and electrolytes. Saliva contributes to irrigation of the oral cavity and dilution of the contents of the mouth. The proteins aid in lubrication of the mucosa, inhibit growth of microorganisms, and may help with remineralization of tooth enamel. Saliva is innervated by the parasympathetic and sympathetic nervous systems; the parasympathetic producing more watery secretions, and the sympathetic yielding less quantity and more viscous flow (Dubnar, Sessle, & Storey, 1978). This may explain the sudden dryness that occurs during a flight/fright or anxiety-provoking situation.

Symptoms of xerostomia range from dry mouth, sore throat, burning, and hoarseness, to difficulties speaking and swallowing, depending on the severity and etiology (Guggenheimer & Moore, 2003).

Etiology

Etiologies for dry mouth range from side effects of medications, dehydration, and systemic diseases, to peripheral damage to the mucosa and/or the actual salivary glands. The perception of dry mouth may be secondary to dental conditions including caries and oral infections like candidiasis. Additional, more common sources for symptoms of dry mouth may arise from mouth breathing, smoking, alcohol intake, and tobacco usage, as well as excessive consumption of caffeinated products.

Medications

Side effects from medications are the most common etiology of xerostomia (Guggenheimer & Moore, 2003). These may include antihistamines, anticholinergics, anorexiant, antihypertensives, anti-Parkinson agents, diuretics, sedatives, antiemetics,
antidepressants, antipsychotics, and anti-anxiety medications (Sreebny & Valdini, 1987). The drying effect from medications is typically temporary. The risk of xerostomia from medications increases with the number of medications taken, placing older individuals at greater risk due to their propensity for polypharmacy (Gerdin, Einarson, Jonsson, Aronsson, & Johansson, 2005).

**Systemic Diseases**

Systemic diseases are a relatively common cause of xerostomia, with Sjogren’s being the most frequently seen. Primary Sjogren’s disorder, 40% of cases, includes dry mouth and eyes, whereas the secondary form also includes autoimmune or connective tissue disease (Neville, Damm, Allen, & Bouguot, 2002). It is more common in women and occurs more often after the 4th decade of life. Xerostomia associated with Sjogren’s is felt to be attributed to progressive lymphocytic infiltration that destroys the secretory acini of the major and minor salivary glands over time (Neville et al., 2002).

Other systemic disorders causing xerostomia include fibromyalgia, scleroderma, sarcoidosis, amyloidosis, and HIV disease.

**Radiation Therapy**

Damage to the actual salivary glands is more often seen following radiation therapy and leads to atrophy of the secretory components. This further impairs the nerves supplying sensation to the mouth and the normal function of the remaining saliva. Amosson and colleagues (2003) looked at the relationship between the dosage to the parotids and development of xerostomia in individuals with head and neck cancer and found increased radiation doses to the parotids resulted in more subjective complaints.

The duration of xerostomia following radiation therapy is not completely known and is one of the most long-standing complaints. Dirix, Nuys, Vander Poorten, Delaere, and Van den Bogaert (2008) looked at the impact on quality of life in 75 individuals following radiation therapy for head and neck cancer more than 6 months previous. They found that 93% complained of dry mouth with 65% noting moderate to severe xerostomia (grade 2–3), 65% complained of dysphagia, and 63% noted a taste loss. The overall impact on quality of life was related to tumor staging, radiation dosage, and concomitant chemotherapy and was independent of the amount of time that had elapsed since completion of radiation. This is consistent with findings by Keereweer and colleagues (2011), who reported persistent xerostomia more than 3 years following chemoradiation therapy for advanced hypopharyngeal cancer.

The direct impact of dry mouth on overall comfort level and adequate lubrication for solid and dryer foods is significant and must be weighed in the face of the higher incidence of dysphagia. Logemann and colleagues (2003) prospectively evaluated the relationship between salivary weight, dysphagia, and perception of difficulties in 36 individuals with oropharyngeal cancer treated with chemoradiation therapy. They found that, while salivary weight significantly decreased during treatment and patients complained of dysphagia, dry mouth, a need to use water to wash food down, and food sticking in their mouth, it was not related to findings on videofluoroscopic swallowing study. Specifically, transit times and/or residue post-swallow, which might be expected deficits from dry mouth, were not associated with the degree of the patient’s complaint. This may represent a perceptual mismatch, but it is also important to note that drier, crunchy type foods were not assessed.

**Diagnosis**

Imaging studies like sialography and scintigraphy may be useful to obtain more visual evidence of xerostomia. Sialography involves injecting a radio-opaque media directly into the salivary glands while the rate and density of uptake and time to excrete in the mouth is measured. This yields a picture of the salivary system, much like barium works to depict the upper or lower digestive system. Scintigraphy is a nuclear study where a contrast agent is
injected intravenously, and areas of increased activity light up on a scan. Neither method is
used commonly for the diagnosis of xerostomia but rather to delineate contributing factors like
a stone in the ductal system.

Sialometry measures actual salivary flow. Collection devices are placed over parotid,
submandibular, and sublingual gland orifices. The amount of saliva is then measured both
unstimulated and following stimulation with citric acid. Normative data for unstimulated flow
is 0.3–0.5 ml/minute and 1–2 ml/minute for stimulated saliva (Greenspan, 1996). Levels less
than 0.1 ml/min are diagnostic.

The Saxon Test quantifies the amount of whole mouth saliva by weighing a sterile 10 x
10 cm sponge before and after holding in the mouth and chewing for 2 minutes (Kohler &
Winter, 1985). Controls produce more than 2.75 grams of saliva in 2 minutes.

Quality of life is frequently impacted due to the symptoms and side effects of
xerostomia. The XQ scale is a patient-rated measure from the University of Michigan devoted to
xerostomia and includes eight statements—four about dryness while eating and four about
dryness when not eating—and is rated on a 10-point scale. The University of Washington
Quality of Life Questionnaire (UW-QOL v4, 1999) is a measure of 12 domains related to overall
quality of life, with one section devoted to saliva. The RTOG/EORTC late xerostomia grade
(Eisbruch et al., 2003) is a scale that rates the degree of dry mouth on a 4-point scale from 0 to
3.

According to Dawes (1987), patients do not perceive symptoms of dry mouth until at
least a 50% reduction in normal salivary flow is present. And, regardless of the results of
objective tests results, symptoms of xerostomia may warrant treatment.

Treatment

Preventative Measures

Oral hygiene is essential to prevent dental complications from xerostomia. Meticulous
attention, including regular flossing and rinsing with normal saline or other alcohol-free
mouthwashes, strict adherence to a noncarcinogenic diet, and regular dental care, is critical.
Antibacterial mouthwashes bind to oral surfaces and play a role in reducing the bacterial load,
inhibiting the development of dental plaque, and preventing gingivitis.

Symptomatic or Palliative Management

Traditionally, treatment of xerostomia has focused on palliative or symptomatic
measures with salivary substitutes serving to improve lubrication and hydration of oral tissues.
Saliva is a complex substance and difficult to replicate.

Topical, palliative therapies for xerostomia include sugar-free gum or candies,
lubricating gels, mouthwashes, lozenges, and toothpaste. Commercially available saliva
substitutes are also commonly prescribed to supplement the reduced production of both
mucus and serous secretions and are based on either mucin or carboxymethylcellulose.
Salivary stimulant pastilles and mucin sprays may also be useful. Rhodus and Bereuter (2000)
demonstrated that a topical oral moisturizer provided significant subjective and objective
improvement in individuals with xerostomia due to either Sjogren’s disease or radiation
therapy for head and neck cancer.

Continuous sipping of bottled water and use of ice chips is equally or more useful than
salivary substitutes in relieving symptoms of xerostomia. Olsson and Axell (1991) conducted a
double-blind trial demonstrating the mean duration of subjective improvement was 12–18
minutes, whereas objective improvement, as measured through mucosal friction tests, was
5.5–11.5 minutes. These values were about half of those obtained with artificial saliva
substitutes, particularly mucin-based products.

Milk may also play a role in relieving symptoms of xerostomia by providing moisture
and helping to buffer oral acids. It has the added benefit of providing nutritional benefits.
Humidification via cool or warm water vaporizers may be used on a nightstand to provide moist air to breathe while sleeping. In contrast, hyperthermic, supersaturated humidification through a nasal cannula appears to provide minimal relief.

**Nutritional Management**

Xerostomia may adversely influence oral intake and overall nutritional status by inhibiting swallowing and limiting dry, sticky, or crunchy food choices. Intensive counseling may be beneficial to assist patients to normalize their diet in combination with compensatory strategies. Increasing fluid intake before and during meals; choosing citric beverages, juice bars, and sherbets; and using sauces, gravies, and salad dressings may all be helpful. Selection of foods that require chewing may help to stimulate salivation and reduce taste abnormalities. Using an atomizer to apply a spray of cooking oil may provide additional lubrication. Foods and fluids containing sugar are better consumed with meals and not in between, and teeth should be cleaned afterward. Patients should substitute mucosal-drying caffeinated beverages and alcohol for decaffeinated choices.

**Local or Topical Treatments**

Chewing gum enhances salivary flow routes. Warde and colleagues (2000) demonstrated that a combination of mouthwash, toothpaste, and chewing gum reduced many symptoms of radiation-induced xerostomia. Davies (2000) found that chewing gum may be more effective than artificial saliva in symptomatic management of xerostomia. Chewing sugar-free gum both between and after meals can help to raise pH, thus aiding in the prevention of dental caries.

**Systemic Treatments**

Cholinergic agents may stimulate acetylcholine receptors in the major salivary glands. Patients vary widely in their response and ability to tolerate parasympathetic drugs; potential side effects of sweating, increased urination, and nausea may limit their efficacy.

The cholinergic drug with the most extensive clinical experience is pilocarpine. LeVeque and colleagues (1993) conducted a randomized, double-blind, placebo-controlled trial of 162 individuals following radiation therapy for head and neck cancer. Significant improvement was found in symptomatic relief as indicated by a questionnaire, improvement on a visual-analog scale, and increased salivary flow as measured by sialometry. Cevimeline is another cholinergic agent approved for use in patients with Sjogren's syndrome and demonstrates modest improvement. Khurshudian (2003) studied the efficacy of interferon-alpha lozenges on 12 patients with Sjogren's syndrome. Patients had significantly improved unstimulated salivary flow and improved ocular dryness versus no change in the placebo group.

Amifostin has been studied as a preventative agent. Antonadou, Pepelassi, Synodinou, Puglisi, and Throuvalas (2002) studied the prophylactic use of amifostin in patients with head and neck cancer and found that it was effective in reducing the severity of persistent xerostomia. Brizel and colleagues (2000) conducted a Phase III trial using amifostin to prevent xerostomia in 303 patients with head and neck cancer receiving from radiation therapy. They found patients that received amifostin had improved salivary flow; 0.26 g versus 0.10 g in the control group. In addition, acute patients with grade 2 or higher xerostomia improved from 78% to 51% and chronic patients with grade 2 or greater xerostomia improved from 57% to 34%.

**Alternative Treatments**

Acupuncture has been explored to manage symptomatic xerostomia. Blom and Lundeberg (2000) conducted a longitudinal study on the efficacy of acupuncture in 70 individuals with xerostomia due to either Sjogren’s disease or radiation therapy for head and neck cancer. Patients received 24 acupuncture sessions over a 4-month period and additional treatment as needed. Outcome was assessed by measuring salivary flow rates stimulated and unstimulated, before and after each session, and at 6-month intervals post-treatment for 3 years. Significantly increased stimulated and unstimulated salivary flow was found, with the greatest improvement in irradiated patients. They speculated that the needle stimulation may
lead to the release of neuropeptides to signal increased blood flow and salivary production. Lu, Posner, Wayne, Rosenthal, and Haddad (2010) retrospectively studied the effect of acupuncture on ten patients treated with chemoradiation. Nine of the ten reported subjective improvement in xerostomia and swallowing function; six out of seven (86%) that were PEG-tube–dependent had their feeding tubes removed. Johnstone, Niemtzow, and Riffenburgh (2002) evaluated the impact of acupuncture on 50 patients that underwent radiation with or without concomitant chemotherapy. They found a 70% favorable response rate with variable duration that was improved with monthly sessions after the initial intensified program.

**Summary**

In summary, xerostomia is a common clinical problem with wide-ranging consequences for affected patients who require carefully planned and multifaceted care to manage its deleterious effects. The prevalence of xerostomia is likely to be greater as lifespan increases, new infections emerge, and new drug therapies continue to be developed. Novel approaches are needed for individuals who are not helped by current salivary enhancing therapies. Before specific therapies can be developed, a greater understanding of underlying pathologies of salivary gland dysfunction is needed.

**References**


Oral Integrity Related to Head and Neck Cancer Treatment

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Head and neck cancer treatment can result in devastating side effects that diminish quality of life, sometimes for a lifetime. The purpose of this article is to highlight the importance of oral integrity in minimizing side effects to optimize long-term function in patients treated for head and neck cancer. We will present the value of a comprehensive pre-treatment assessment. We will describe the oral complications associated with surgery, radiation, and chemotherapy and offer approaches in management of acute and chronic complications.

Head and neck cancer is the sixth most common cancer worldwide, accounting for about 640,000 cases annually and resulting in approximately 350,000 deaths per year (Siegel, Ward, Brawley, & Jemal, 2011). The 5-year survival rate for patients with head and neck cancer remains largely unchanged over the last 3 decades despite advances in care. The choice of treatment modalities depends on the primary site, tumor stage, histology, prior treatments, impact on quality of life, medical comorbidities, and patient preference.

Treatment modalities with curative intent include surgical resection and radiation therapy. Chemotherapy may play a role as an adjunct treatment following surgery, a concurrent treatment with radiotherapy, an induction regimen, or a palliative therapy. Stage I and II cancers localized at the primary site can often be definitively treated with a single modality. If surgical resection is the primary treatment selected for stage I and II cancers, radiation therapy or chemoradiation may still be indicated post-operatively dependent upon pathologic findings. Stage III and IV cancers typically require multimodality treatment, which may include surgery, radiation, and chemotherapy, in sequential or combined regimens.

Head and neck cancer and its treatments are often associated with undesirable outcomes affecting quality of life. The side effects of treatment impact function on an acute or chronic basis. Considering the potentially degraded state of the oral cavity upon diagnosis (Maier, Zoller, Herrmann, Kreiss, & Heller, 1993), combined with treatment-associated complications, maximizing oral integrity is a critical component of caring for patients prior to, during, and following treatment. Due to the complex nature of treatment, a multidisciplinary team approach is advocated for optimal oncologic and functional outcomes.

This article will discuss the comprehensive pre-treatment oral evaluation, considerations in treatment planning, and necessary patient education. Additionally, we will highlight the oral complications associated with surgery, radiation, and chemotherapy and present the approaches in management of acute and chronic complications.
**Pre-Treatment Assessment**

**Oral Assessment**

The dental oncologist’s role is to prevent and manage acute and chronic oral complications of cancer treatment (Murdoch-Kinch & Zwetchkenbaum, 2011). All aspects of the patient’s care must be reviewed with the patient and multidisciplinary team. The current status of oral care must be closely scrutinized, especially when multiple treatment modalities are planned, as this may impact future oral conditions.

The dental oncology workup consists of preventative measures. The dental oncologist should perform a complete oral and dental exam—to identify existing infection, pathological conditions, and potential sites of complications—and a clinical and radiographic assessment. The dental oncologist should identify all mucosal irregularities, existing periodontal disease, dental abscesses, and ill-fitting removable prostheses (Toth, Chambers, & Fleming, 1996) and review the complications of treatment with the patient as well.

The dental oncologist must develop a more aggressive treatment plan for a patient who has a limited understanding of dental care, lack of care, history of insufficient regularly scheduled dental care, poor oral hygiene, and evidence of periodontal disease. The dental oncologist must evaluate and review with the patient the potential impact of trismus on oral hygiene and dental treatment. If the patient resides in a skilled nursing facility during and after treatment, more aggressive dental treatment may be recommended in order to prevent future complications, because the importance of oral care post-treatment is more likely to be overlooked in this setting. The dental oncologist must also consider the patient’s motivation and his/her ability to cooperate if there are anticipated oral complications from the chosen treatment. Dental extractions should not be undertaken after radiation treatment due to greater risk of osteoradionecrosis (ORN). The dental oncologist must identify and eliminate the risk of ORN prior to radiation treatment.

**Functional Assessment**

Pre-treatment functional evaluation should include a baseline clinical examination of communication and swallowing ability. There is a high incidence of dysphagia in this patient population (Francis, Weymuller, Parvathaneni, Merati, & Yueh, 2010), especially in patients receiving multimodal treatment. If the patient has signs and symptoms of dysphagia, instrumental evaluation of swallowing is indicated. The dental oncologist shares the results of these evaluations with the multidisciplinary team to help determine the optimal treatment for the patient. Once the oncologists share the oncologically sound treatment option(s) with the patient, the speech-language pathologist (SLP) should educate the patient on side effects of treatment related to communication and swallowing function, including strategies to prevent and manage the anticipated side effects.

**Considerations for Patients Requiring Surgical Resection**

Preoperative dental management and oral care will impact postoperative healing of the oral wound, reducing complications. The patient should undergo a dental cleaning/debridement and supra- and subgingival plaque removal to ensure a clean operative field. Teeth requiring extractions must be removed peri-operatively. Proper communication and combined procedures will prevent delay in cancer ablation (Chandu, Stulner, Bridgeman, & Smith, 2002).

Attention to oral hygiene after head and neck surgery can reduce the risk of wound infection (Sato et al., 2011). Post-operative wound infection may be a poor prognostic indicator for patients with head and neck cancer (Grandis, Snyderman, Johnson, Yu, & D'Amico, 1992). Wound infection may also delay adjuvant oncologic treatment. Though there are many factors that affect wound infection, oral hygiene is one of the only factors that patients and caregivers can control. Immediately post-operatively, SLPs are involved in swallowing and/or speaking
valve evaluations. Although oral hygiene may not be something specifically addressed by the SLP during the evaluation process, it is certainly something that should be reinforced with the patient and ancillary staff.

Oral and dental hygiene regimens may differ based on the extent of surgery, physician preference, and, in some cases, presence of dysphagia. A patient with dysphagia or risk of aspiration may require modifications to the typical oral hygiene regimen. Some examples include using rinses that are safer if aspirated (such as sodium bicarbonate), using a toothette with suction attached, incorporating aspiration precautions during oral care, and increasing the frequency of oral care. Langmore and colleagues (1998) found that dysphagia was not a significant predictor of aspiration pneumonia, whereas poor oral hygiene with aspiration of pathogenic secretions, dependency on others for oral care, and frequency of brushing were significant contributors. Inadequate oral hygiene also increases patient discomfort and inflammation of the surrounding tissues, inducing mucositis and gingivitis. It has also been shown that dental plaque can harbor nosocomial pathogens that may lead to pneumonia (Chandu et al., 2002).

There are multiple methods for performing post-operative oral and dental hygiene, including rinsing, mechanical cleaning, and wound irrigation. To minimize aspiration risk, these methods are typically initiated once the patient is awake and alert after surgery. Irrigation of oral wounds following a maxillectomy or mandibulectomy promotes good oral hygiene, improves comfort, and hastens wound healing while minimizing risk of contamination. Flushing with sodium bicarbonate rinse using a bulb syringe while applying moderate pressure has been shown to be effective for washing oral defects. The flow of irrigation is multidirectional and therefore reaches the surgical defect and loosens debris and dried crust, allowing greater surface hygiene with exertion of less pressure at any specific tissue site (Chambers, Lemon, & Martin, 2003). This procedure should be performed 4–6 times per day. Patients with dentition should be encouraged to begin brushing with a soft bristle toothbrush 2–3 times per day. In all post-operative patients, with or without reconstruction, sodium bicarbonate rinses should be performed 4–6 times per day.

Oral dysphagia, resulting in oral residue, is common following oral cancer resections. Finding ways to eliminate residue through compensatory strategies and oral care is especially important to reduce risk of infection and dental complications. Oral care has also been shown to stimulate oral membranes, facilitating activation of the swallowing reflex and stimulation of saliva secretion and muscle function (Sato et al., 2011). Patients with free flap reconstruction are typically required to remain NPO for periods anywhere from 2 to 6 weeks. When a patient is NPO, oral hygiene is often overlooked. Bacteria and yeast will still colonize on the tissue regardless of oral intake status. It is especially important in these cases to reinforce the procedures for oral care, because the risk of complications with free flap reconstruction is higher than those with primary closure. These patients may use a toothette with suction attached for gentle cleaning without compromising tissue integrity.

**Considerations for Patients Who Undergo Radiation Therapy With or Without Chemotherapy**

**Complications of Treatment**

Dental care is important for patients with head and neck cancer undergoing radiation and/or chemotherapy treatment due to associated complications of these therapies. Combined treatments may pose greater risk of mucositis and secondary infection, which negatively impact quality of life (Toth et al., 1996).

**Xerostomia:** Salivary glands are sensitive to radiation treatment, causing changes in the quantity and quality of saliva produced. Xerostomia leads to a shift in saliva pH, providing a highly acidic oral environment and resulting in rampant dental decay, sometimes evident as
early as 3 months after completion of radiation treatment. Patients will also develop more
dental plaque due to xerostomia, exacerbating the presence of bacteremia, gingival
inflammation, and dental decay.

**Mucositis:** Ulceration and atrophy of tissues (*mucositis*) results in pain with the potential
for dysgeusia, dysphagia, dehydration, malnutrition, and hospitalization. Bacteria, fungi, and
viruses emerge and further damage the atrophied tissues, which leads to the ulcerative
conditions (Kostler, Hejna, Wenzel, & Zielinski, 2001).

**Candidiasis:** The increase of *candidiasis* (fungal infection) is encouraged by radiation-
induced xerostomia and a more acidic oral environment. Candidiasis can present as a
pseudomembranous white plaque, erythema, and a burning discomfort.

**Periodontal disease:** Radiation therapy decreases oxygenation and vascularization to the
tumor bed. Teeth are attached to the dental sockets by blood vessels and ligaments. Teeth and
surrounding soft tissue in the direct field of radiation will be devascularized. Coupled with
xerostomia, the overgrowth of bacteria accelerates the periodontal attachment loss from the
tooth.

**Osteoradionecrosis:** Osteoradionecrosis (ORN) is caused by devascularization and
deoxygenation effects of radiation therapy on bone. Clinically, ORN presents as exposed bone
in the oral cavity. Commonly, ORN is associated with extraction of teeth after radiation therapy
due to lack of blood and oxygen supply in the dense bone. Micro-trauma of the tissues in
compromised bone may also lead to ORN.

**Trismus:** Trismus is evident when the patient gradually loses vertical oral opening. This
condition may be intensified by surgery prior to radiation. Patients most likely to develop
trismus are those with tumors of the palate, nasopharynx, and maxillary sinus. Radiation of
the highly vascularized temporomandibular joint (TMJ) and muscles of mastication will lead to
trismus. Chronic trismus gradually leads to fibrosis. Trismus impedes proper oral care and
treatment and may cause speech/swallowing deficits.

### Pre-Treatment

Once a treatment plan has been established for the head and neck cancer patient, the
dental oncologist must evaluate all sources of potential infection. Extract any teeth that are
considered at risk for ORN prior to treatment, and provide preventative treatment in a timely
manner. The patient should have dental cleaning. Eliminate and restore dental caries and
avoid ill-fitting dentures. If the patient is to retain his/her teeth, create custom dental trays for
fluoride therapy. Initiate prescription fluoride treatment, which should be used daily for the
rest of the patient’s life. The oral care regimen should also consist of brushing and flossing. It
is of utmost importance for the dental oncologist to closely follow the patient to maintain
compliance and detect early disease (Murdoch-Kinch & Zwetchkenbaum, 2011).

As oral dysphagia may hinder the patient’s ability to maintain optimal oral hygiene, oral
integrity should be optimized through dysphagia management strategies targeting oral control,
manipulation, and bolus clearance. The SLP should also reinforce the recommended oral
hygiene regimen. The team may provide swallowing exercises to patients prior to onset of
radiation as a preventative measure due to concerns regarding radiation fibrosis of the
swallowing musculature (Carroll et al., 2008). Perform measurements of vertical oral opening to
establish a baseline. If the patient is at risk of or demonstrates trismus, implement exercises or
appropriate jaw mobilization devices to promote adequate jaw mobilization. The patient’s
dentist or head and neck surgeon should assist in identifying contraindications of exercise if
there is concern regarding tumor involvement, poor healing, or ORN.

### During Treatment

Supportive treatment is the goal for oral mucositis, candidiasis, and xerostomia during
treatment. Evaluate mucosal wounds that develop to determine if they are related to toxicity or
infection. Mouth rinses are prescribed to provide hydration to the mucosa to manage the oral
wound and reduce severity of symptoms. Rinses must be non-irritating and non-dehydrating.
Avoid solutions containing alcohol or phenol. Counsel patients regarding diet consistency, as eating hard, abrasive foods is mechanically traumatizing and may cause ulceration of the mucosa. Encourage patients to brush their teeth often throughout the day using an ultra-soft bristle toothbrush. Elimination of dental plaque, which causes irritation to the friable oral mucosa, is of utmost importance to prevent overgrowth of microorganisms. Mucositis treatment for patients undergoing chemotherapy does not differ from the treatment prescribed for patients undergoing irradiation (Toth et al., 1996).

The goal of the SLP is to intervene during radiation therapy to help the patient maintain the highest level of oral function for communication and swallowing. The intervention should include management of dysphagia, trismus, and other side effects that may prevent oral alimentation. The SLP may introduce strategies to reduce discomfort when eating, including saliva substitutes, postural strategies, adaptive equipment, or establishing a “swallowing schedule” to coincide with peak effects of prescribed pain medications. Reinforce oral care, swallowing exercise, and trismus exercise regimens (Baranano, Rosenthal, Morgan, McColloch, & Magnuson, 2011; Buchbinder, Currivan, Kaplan, & Urken, 1993). If the patient is unable to maintain adequate oral nutrition/hydration, he/she may require a feeding tube. The SLP should reinforce attempts to continue and improve oral intake to prevent disuse atrophy (Carroll et al., 2008).

Post-Treatment

After completion of radiation therapy, severe oral complications gradually resolve, typically over a period of 6–8 weeks. Compliance with fluoride treatment typically decreases a few months after treatment is complete, which may cause dental decay as soon as 3 months post-treatment (Murdoch-Kinch & Zwetchkenbaum, 2011). A structured network of the multidisciplinary team is important to encourage compliance with lifelong oral care and fluoride treatment to prevent the risk of ORN (Thariat et al., 2011).

If the patient has been unable to tolerate dysphagia rehabilitation during radiation and/or chemotherapy treatment, he/she should undergo re-evaluation of dysphagia. Resume rehabilitation as the acute side effects of cancer treatment resolve. In the absence of dysphagia, encourage an exercise program that includes swallowing and jaw exercises in order to maintain mobility and range of motion. If a functional maintenance program is not prescribed, the patient may experience limited range of motion and decreased muscle strength and use due to late onset of radiation fibrosis. Assisting the patient to full oral intake versus dependency on a feeding tube is a goal for the multidisciplinary team.

Conclusions

Due to the complexities of the treatment and co-morbidities, a multidisciplinary team approach is vital for optimal care of the patient with head and neck cancer. As a team, the ultimate goal should be maintaining quality of life for the patient who has undergone intensive oncologic treatment. By incorporating the expertise of the dental oncologist and the SLP, we can optimize oral integrity while improving functional outcomes.

References


