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Rehabilitation of Dysphagia Following Head and Neck Cancer

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SYNOPSIS

Patients with cancers of the oral cavity, pharynx or larynx may be treated with surgery, radiotherapy, chemotherapy, or a combination of these modalities. Each treatment type may have a negative impact on posttreatment swallowing function; these effects are presented in this chapter. The clinician has a number of rehabilitative procedures available to reduce or eliminate swallowing disorders in patients treated for cancer of the head and neck. The various procedures--including postures, maneuvers, modifications to bolus volume and viscosity, range of motion exercises, and strengthening exercises--and their efficacy in treated head and neck cancer patients are discussed.

Keywords

head and neck cancer; surgery; radiotherapy; dysphagia; postures and maneuvers; swallowing therapy

This chapter will provide information concerning the rehabilitation of dysphagia following treatment for cancer of the head and neck. It is divided into two major sections. The first will describe the types of swallowing disorders that are observed in patients after cancer treatment; the second will identify the various intervention strategies that are available to the clinician for treating the disordered swallow in treated head and neck cancer patients.

DYSPHAGIA AFTER TREATMENT FOR HEAD AND NECK CANCER

Patients with cancerous tumors of the oral cavity, pharynx, or larynx will usually be treated for their disease with surgical removal of the tumor, radiotherapy, chemotherapy, or a combination of these procedures. Each type of cancer treatment may result in some degree of dysphagia. The type and severity of dysphagia will depend upon the size and location of the original tumor, the structures involved, and the treatment modality used for cure.

SWALLOWING FUNCTION AFTER SURGERY FOR CANCER OF THE HEAD AND NECK

Surgical removal of tumors of the head and neck is a long-standing and well-established treatment modality which is still in wide use today [1,2]. Swallow dysfunction is often observed

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after surgical excision of tumors in the head and neck; swallow disorders may occur in the oral preparatory, oral propulsive, and pharyngeal stages of the swallow. The type and degree of swallow disorder will depend upon the site and stage of the tumor, the extent of surgical resection, and the nature of the surgical reconstruction. In general, the larger the resection, the greater swallowing function will be impaired [3,4,5,6,7,8,9,10,11]. However, the degree of resection of structures vital to bolus formation, bolus transit, and airway protection such as oral tongue, tongue base, or arytenoid cartilages will have a greater impact on postsurgical swallow function than will the extent of involvement of other structures such as lateral floor of mouth or alveolar ridge [3,9,12,13].

Swallow Function after Surgery for Oral and Pharyngeal Tumors

Impact of Structures Resected and Extent of Resection on Swallow Function— The impact of resection of the oral tongue on swallowing function has been well-reported in the literature. Patients who have a portion of the oral tongue removed exhibit worsened swallow function characterized by prolonged oral preparatory time [14], slowed oral transit time [14, 15,16,17], increased oral residue [15,16], and increased pharyngeal residue [15]. Oral stage swallowing disorders tend to worsen for these patients as bolus viscosity increases [8,15]. As the extent of resection of the oral tongue increases, swallowing function also worsens [18]. Patients with resection of the oral tongue demonstrate increased oral transit time and increased oral and pharyngeal residue as the extent of resection increases [16,17]. The increased bolus residue is at greater risk of being aspirated after the swallow in those patients who undergo a total glossectomy.

Patients with resection of the tongue base may experience severe impairment of swallow function [10]. Those with resections of the tongue base have increased oral preparatory time, increased oral transit time, increased oral residue along with pharyngeal transit time increases [5,8,11,19], increased pharyngeal residue, and reduced oropharyngeal swallow efficiency [19,20]. Resection of greater than 25% of the tongue base is associated with inability to trigger a pharyngeal swallow, difficulty clearing the bolus from the pharynx, and severe postsurgical aspiration [6,8]. Swallowing disorders tend to worsen for these patients as bolus viscosity increases [8,15].

Surgical excision of oropharyngeal structures that do not contribute to normal swallowing function have little impact on swallow in the postsurgical patient [21]. Resection of the floor of mouth has been found to have limited impact on swallowing function [3,12,13], except when the resection extends to the geniohyoid or mylohyoid muscles [5]. With the resection of the floor of mouth muscles, patients may experience problems with hyolaryngeal elevation, resulting in residue in the pyriform sinuses that may be aspirated after the swallow.

Some tumors may infiltrate the alveolar ridge and mandible, which will require resection for disease control. A rim or marginal resection of the mandible may be all that is required when tumor invasion is limited to the alveolar ridge. A marginal resection will not disrupt the continuity of the mandibular arch and has little impact on swallowing function. More invasive tumors will require segmental mandibular resection, that is, removal of a section of the mandible that separates the remaining mandible bone into two sections. Although some investigators have found that the resected mandible is not functionally different from the intact mandible [22,23], more research indicates that segmental mandibular resection without reconstruction has a profound negative impact on oropharyngeal swallow efficiency and oral residue [13] as well as mastication [24,25,26,27].

Nature of Reconstruction—The swallow function of postsurgical cancer patients may also be influenced by the type of surgical reconstruction. Surgical closure or reconstruction after ablation of head and neck tumors fall into four general categories: Primary closure (approximation and surgical closure of the edges of the resection); skin grafts (transplantation of a superficial layer of skin from another site such as the thigh into the surgical resection); pedicled flaps (flaps of tissue lifted from a donor site and migrated into the surgical defect, with a pedicle or stem of tissue attached to the donor site to maintain the blood supply); and microvascular free flaps (flaps of tissue lifted from a donor site and sutured into the surgical defect with the blood vessels and sometimes nerves anastomosed to the existing supply at the excision site).

Some research indicates that patients closed primarily or with skin grafts have better postsurgical swallowing function than those reconstructed with pedicled or free flaps. [20,28, 29,30,31,32]. However, use of primary closure may result in some restriction in tongue movement if a large amount of the tongue is resected or if the tongue is sutured to the floor of mouth or alveolar ridge after a composite resection. Some patients reconstructed with skin grafts demonstrate superior tongue mobility when compared to those closed primarily [30]. Skin grafts however are often not viable in the oropharynx, especially if the patient has received radiotherapy which may disrupt the blood supply to the area.

Patients reconstructed with pedicled flaps such as the pectoralis major myocutaneous flap have been shown to demonstrate impaired tongue mobility scores [30], excessively long oral transit times, increased oral residue after the swallow [15,33], and reduced oropharyngeal swallow efficiency [15]. Pedicled flap reconstruction is often used in the head and neck population to close a large surgical defect [28]. These flaps are often considered to be bulky, which may interfere with movement of the remaining oral tissues [28,29]. Swallow impairment in patients reconstructed with pedicled flaps may also be related to the adynamic nature of the flap: Use of this type of flap introduces tissue with no sensation or motor control into an area where range, rate, and coordination are critical to normal swallow function [15,33].

Microvascular free flaps such as the radial forearm free flap have the advantage of being thin yet viable flaps that can be used to repair a surgical defect without adding excessive bulk to the oropharyngeal structures. This type of flap is flexible enough to permit lining of the floor of mouth without tethering the tongue. Adequate flap design permits the appropriate degree of closure without sacrificing tongue movement [34,35,36,37,38,39,40,41]. Some comparative studies have indicated no difference in swallow function after reconstruction with either a radial forearm free flap or a pedicled pectoralis major flap [18], while others have shown that the ability to swallow in patients reconstructed with free flaps is superior to that of patients reconstructed with pectoralis major myocutaneous pedicled flaps [42,43,44]. Nevertheless, swallow function is still impaired after resection and free flap reconstruction. Some studies have indicated worse levels of oropharyngeal functioning in patients with free flap reconstruction when compared with primary closure [45,46]. Additionally, oropharyngeal swallow efficiency has been shown to be severely reduced, accompanied by increased pharyngeal transit time and excessive oral and pharyngeal residues in patients reconstructed with free flaps [19,21] with no recovery of preoperative function by one year posttreatment [19,21,47].

Sensate flaps are microvascular free flaps that have not only their blood supply but also their innervation joined to the remaining supplies at the surgical resection site. Few objective swallow data are available for sensate flaps; some data indicate swallowing function is superior in patients with a reinnervated flap [48] while other research does not indicate the superiority of sensate flaps over nonsensate mirovascular free flaps in improving swallow function [47], oropharyngeal swallow efficiency [49], or oral sensation [47].

Reconstruction of the mandible after segmental mandibular resection can be achieved using microvascular free flaps containing bone. Reports of functional outcome after mandibular reconstruction are mixed. Some studies demonstrate a clear advantage for patients with mandibular reconstruction in most oropharyngeal functions [26], while others have indicated that reconstruction of mandibular continuity did not contribute to improved swallow function [12,32].

Assessing the relative impact of the various surgical closure procedures on swallowing function can be difficult because of the profound impact of extent of resection on swallow function. In addition, not all closures may be used with all resections. In the one study that controlled for extent of resection of the oral tongue and tongue base, no significant differences were observed on swallow function between those reconstructed with pedicled and microvascular free flaps. Those closed primarily or with skin grafts had higher oropharyngeal swallow efficiencies and less pharyngeal residue than those reconstructed with flaps [50].

Swallow Disorders after Surgery for Laryngeal Tumors

Cancerous tumors of the larynx may need to be removed surgically. Surgical excision of cancers of the larynx may also have a profound impact of swallowing function, primarily the risk of aspiration, depending upon the site of the tumor, the structures resected, and the resulting reconstruction. Many tumors may be removed without complete removal of the larynx, that is, a total laryngectomy. Partial laryngectomy procedures such as the supraglottic laryngectomy and hemilaryngectomy are performed with the intent to maintain as much normal laryngeal function as possible while controlling the disease.

Supraglottic Laryngectomy—For lesions involving the epiglottis, aryepiglottic folds, or false vocal folds with no involvement of the vocal folds, a supraglottic laryngectomy is the standard surgical intervention. A supraglottic laryngectomy, also referred to as a horizontal partial laryngectomy includes resection of the epiglottis, aryepiglottic folds, false vocal folds, and the superior aspect of the thyroid cartilage, sparing the true vocal folds and arytenoids [51,52,53]. Preservation of the hyoid bone, when possible, may help swallowing function postoperatively [54]. The classic supraglottic surgery included removal of the hyoid bone as well [55]. Some patients may present with swallow difficulties decades later, especially if the patient has received postoperative radiotherapy [56], so it is possible that clinicians currently practicing may come in contact with supraglottic laryngectomees who do not have a hyoid bone. Because structures involved in the protective mechanism of the airway are resected, patients who have received a supraglottic laryngectomy are at risk for aspiration during the swallow [51,57,58,59]. Rates of aspiration during the swallow as high as 74% have been reported [59]. The base of tongue and arytenoid cartilages play an important role in compensating for the supragottic structures resected in the surgery [60]. Patients who are able to achieve good tongue base to arytenoid contact after supraglottic laryngectomy will be able to prevent material from entering the airway during the swallow [58]. When the supraglottic laryngectomy procedure needs to be extended into the tongue base or to the arytenoid, this potential compensatory mechanism is compromised and aspiration during the swallow is the likely consequence [57,59,61]. Patients with extended supraglottic laryngectomy, especially into the base of tongue, take significantly longer to achieve preoperative diet and normal swallowing than do those patients with limited resections [62], and demonstrate increased pulmonary complications due to aspiration [63].

Hemilaryngectomy—Tumors limited to a true vocal fold may be treated with a hemilaryngectomy, also referred to as vertical partial laryngectomy. This resection includes one false vocal fold, one ventricle, and one true vocal fold, excluding the arytenoids but usually taking the vocal process, as well as a portion of the thyroid cartilage on the same side as the lesion [52,53,55]. Since the hyoid bone, epiglottis, and arytenoids are left in place, a patient receiving a standard hemilaryngectomy should not have difficulty with airway closure if properly reconstructed with bulk tissue on the operated side [53,64]. Various techniques exist for creating a pseudocord from pedicled and free flaps [53,65,66]; the goal of reconstruction is to provide enough bulk to allow the remaining vocal cord to make contact with the reconstructed site and permit protection of the airway [53]. Patients who receive hemilaryngectomy usually have fewer incidents of aspiration [67] and achieve oral intake and return to a normal diet sooner than those who have had any type of supraglottic laryngectomy [62]. However, if the resection is extended posteriorly to include the arytenoid cartilage, an important component of airway closure is affected, and the risk of aspiration during the swallow increases [64,68]. Aspiration rates of up to 91% during the swallow have been reported [59, 69].

Total Laryngectomy—Total laryngectomy may be used as the primary treatment in cases of advanced laryngeal carcinoma. Generally, aspiration is not a risk for those who have received a total laryngectomy unless there is leakage around or though a tracheoesophageal fistula, either created for voice restoration or resulting from healing complications [59]. In addition, patients who have received a total laryngectomy may experience other difficulties with their swallow. Manometric studies of patients with total laryngectomy have indicated that the post-laryngectomy swallow is characterized by significantly lower resting pressures in the pharyngoesophageal (PE) segment, lower peak pressures after swallow, greater numbers of swallows with discoordination between contraction of the pharyngeal constrictors and relaxation of the PE segment [70,71], a loss of the normal negative pressure preceding the bolus, reduced pharyngeal clearing force [60,72,73], and loss of asymmetrical contractile forces [74] when compared to subjects with normal anatomy. Bolus clearance through the oral cavity and pharyngocervical esophagus often is impaired in this group of patients [75,76,77], especially if resection is extended to the tongue base.

At the present time, total laryngectomy is used most often as a salvage procedure, either after recurrence or in the case of intractable aspiration [78]. The incidence of pharyngocutaneous fistula formation is higher after salvage laryngectomy than primary laryngectomy, especially in irradiated patients [59,79,80]. Completion laryngectomy for those treated with chemoradiation who experience intractable aspiration may not result in improved swallow function. Patients with total laryngectomy must typically generate pressures greater than normal during the swallow to achieve bolus transit [72]. Adequate tongue base motion is important in this pressure generation. Patients who have received chemoradiation to the head and neck often experience reduced tongue base retraction, as will be discussed in the following section. Completion laryngectomy may eliminate aspiration in these patients, but they may not be able to advance their diet beyond pureed consistencies if they are unable to produce sufficient bolus driving pressure [16,76].

The Impact of Postoperative Radiotherapy on Swallow Function

Radiotherapy is commonly used in conjunction with surgical excision of tumors of the head and neck to control for microscopic disease. Preoperative radiation has classically been used to reduce the size of the primary tumor prior to surgery; this modality generally has been replaced with induction chemotherapy. Postoperative radiotherapy is often focused on the lymph nodes of the neck to prevent spread of disease. Although radiotherapy provides important curative benefits, it also induces damage in normal tissues and may result in mucositis, xerostomia, fibrosis, soft-tissue necrosis, and osteoradionecrosis of the mandible [81,82,83,84,85]. The swallowing disorders observed during the first few months after surgery are the result of the surgical procedure; additional dysfunction or lack of improvement in swallow function observed after the initial postoperative period is the result of radiation damage to the tissues.

Many investigators have found that oropharyngeal functioning is worse in patients receiving postoperative radiotherapy when compared with those with surgical excision only [8,10,16, 45]. Multiple logistic regression has shown that radiotherapy is one of the main predictors of poor swallowing function after surgical excision of oral and oropharyngeal cancer [46]. Radiation treatments affect both the oral and pharyngeal stages of swallowing. Irradiated patients experience significantly increased oral and pharyngeal transit times, especially on thicker consistency boluses, greater pharyngeal residue, lower oropharyngeal swallow efficiency and shorter duration of cricopharyngeal opening [8,86]. Increased oral transit time is most likely the result of xerostomia. Increased pharyngeal residue, decreased OPSE and shortened cricopharyngeal opening duration in irradiated patients suggests a reduction in pharyngeal bolus driving pressure [86]. This reduction in pharyngeal driving force is the result of radiation-induced fibrosis of the oropharyngeal musculature, resulting in reduced tongue-base retraction, decreased bulging of the posterior pharyngeal wall and reduced duration of tongue base contact to the posterior pharyngeal wall [87].

In longitudinal studies of swallowing function in patients treated surgically for oral or oropharyngeal tumors, patients who received postoperative radiotherapy have worse swallow function characterized by lower swallow efficiencies and a significantly differ course of recovery of swallow function over time. Those who did not have any postoperative radiotherapy demonstrated a steady improvement in swallow efficiency between 3 and 12 months postsurgery, while those who received postoperative radiotherapy did not show any improvement in function [8,88].

Patients who have been treated for laryngeal cancer also experience the adverse effects of postoperative radiotherapy. A greater incidence of tracheosotomy dependence, delayed independent swallowing function, and an increased incidence of aspiration pneumonia are noted in patients requiring radiotherapy after supraglottic laryngectomy [52]. Patients with partial laryngectomy procedures will have delayed recovery of swallowing function if they have not achieved oral intake by the time their postoperative radiotherapy begins [62].

Summary: Swallowing Function after Surgery for Cancer of the Head and Neck

Swallowing problems after surgery for head and neck cancer will be dependent upon the extent of the resection, the specific structures resected, and to a limited extent, the nature of reconstruction. Patients with resections involving the oral tongue will experience difficulty with bolus formation, slowed oral transit, and increased oral residue. As food viscosity increases, these swallowing problems tend to be more problematic. Aspiration is not usually a problem in patients with resections limited to the anterior oral cavity unless resection extends into the tongue base. When resection involves the tongue base or arytenoid cartilage, the risk of aspiration increases. The nature of reconstruction of the surgical defect also may have an impact on postsurgical swallowing problems; however, since type of reconstruction is often dictated by the extent of resection, it is not clear how much of an impact reconstruction type itself has on postoperative swallow function. The few available multivariate studies of surgical parameters on swallowing function [6,10,13,89] suggest that the extent of resection, more specifically of the tongue base, has a greater impact on postsurgical swallowing function than does the nature of reconstruction. Postoperative radiotherapy has an additional negative impact on swallowing function by increasing fibrosis of the irradiated head and neck tissues.

SWALLOWING FUNCTION AFTER PRIMARY RADIATION OR CHEMORADIATION

There has been an increase over the past twenty years in the use of radiotherapy with or without chemotherapy as a primary treatment modality for cancer of the head and neck [91-100].

Although the primary goal of treatment is cure, a perceived additional benefit of this modality is the preservation of the organs of the head and neck, with the underlying assumption being that preservation of structure will result in preservation of function [101,102]. The current literature on swallowing function in patients treated with radiotherapy with or without chemotherapy for cancer of the head and neck indicates that, despite preservation of the structures of the head and neck, swallow function is not maintained at normal levels after treatment [103-114]. Reported rates of posttreatment aspiration range considerably from as low as 5% to a high of 89% [107,109,112,114,115,116,117,118,119,120,121,122,123,124] with silent aspiration reported at rates of 22% to 42% [117,120,121,123,124].

Studies of swallow function in patients treated with chemoradiation for cancers of the head and neck have focused on both early and late effects. A body of literature indicates significant functional abnormality during the first year post treatment completion. Swallow motility disorders reported at frequencies of greater than fifty percent for patients treated with chemoradiotherapy to various sites in the head and neck include reduced anterior-posterior tongue movement [125], reduced tongue strength [118], reduced tongue base retraction [103, 105,107,109,118,125,126], increased oral residue [118], increased velopharyngeal closure duration [118], reduced epiglottic inversion [103,106,126], slowed or reduced laryngeal elevation [105,106,107,109,126], impaired pharyngeal constrictor motility [106], increased pharyngeal residue [118], delayed pharyngeal swallow [103], and delayed laryngeal vestibule closure [105,106,109,125].

Chemoradiated patients tend to exhibit similar swallowing disorders regardless of the site of the primary tumor. Patients treated for nasopharyngeal tumors exhibit problems with both the oral stage (increased oral stasis and residue [122], reduced tongue control [115,118], impaired bolus transit [115]), and pharyngeal stage of the swallow (reduced tongue base retraction [118], reduced pharyngeal contraction [115], increased pharyngeal residue [115,122]) despite having the primary tumor confined to the nasal cavity. Patients with tumors of the oropharynx demonstrate the expected pharyngeal motility disorders such as reduced tongue base retraction [56,107,109,118], reduced pharyngeal contraction [109], and increased pharyngeal residue requiring multiple swallows to clear [107,109]; however, they also have problems with laryngeal mobility (reduced laryngeal elevation [56,107,109], reduced laryngeal vestibule closure [56,109,125], and reduced true cord closure [56]). In addition to reduced laryngeal elevation [121], patients treated with chemoradiation for cancer of the larynx also demonstrate difficulty during the oral preparatory and oral propulsive stages of the swallow (impaired bolus formation [121], reduced tongue control leading to premature spillage [112], reduced tongue strength [118], reduced anterior to posterior tongue movement [121,125], increased oral cavity stasis [121], reduced tongue base retraction [118]) as well as increased pharyngeal residue in the vallecula and pyriform sinuses [112,121]. Patients treated with traditional external beam radiotherapy to most sites in the head and neck have similar structures involved in the treatment volume [56,107,112,118,122]. Radiation-induced fibrosis in the irradiated structures results in limited mobility of the oral tongue, tongue base, pharynx, and larynx [56,104,117,121]; therefore the observed swallow disorders after treatment are similar despite the site of the primary tumor.

Swallow disorders that are evident early after treatment with chemoradiation appear to persist with little if any recovery of function either by the end of the first year posttreatment [108, 115,125] or in the long-term. Severe impairments of swallowing function are observed years after completion of treatment including reduced tongue control resulting in premature spillage into the pharynx [112,122,127], reduced tongue base retraction [56,116], impaired pharyngeal contraction [117,122,123,127], increased vallecula and pyriform sinus residue [112,116,122, 123], impaired epiglottic function [122,127], reduced laryngeal elevation [56,117], and reduced laryngeal vestibule and true cord closure [56]. Dysphagia persists decades after treatment [117]; a longer duration after treatment does not yield a more proficient swallow [112], and in fact there is evidence of continued deterioration of swallowing function for years after chemoradiation as a result of progressive fibrosis in irradiated tissues of the head and neck [122,127].

Attempts have been made to minimize the amount of damage to normal tissues and hopefully reduce the adverse effects of treatment on swallowing function. A comparison of two groups of patients treated with altered doses of radiotherapy to the primary tumor (74.4 Gy versus 60.0 Gy) for lesions of the oropharynx or hypopharynx indicates a significant reduction in odynophagia, aspiration, and gastrostomy use at 4 an 12 months posttreatment with lowered dosage [128]. The intensity of the radiation beam also can be modulated in order to decrease doses to normal structures without compromising the doses to the target. Intensity modulated radiotherapy (IMRT) is an advanced form of 3-D conformal radiation therapy with the ability to precisely target and escalate radiation doses to the tumor while reducing radiation exposure to surrounding normal structures. Initially studied in terms of its impact on salivary flow and xerostomia (the perception of “dry mouth”), IMRT has proven successful in reducing damage to the parotid gland and preserving salivary flow [129,130]. The impact of IMRT on posttreatment swallowing function has also been investigated. Patients treated with tissue sparing techniques demonstrate less severe ratings of dysphagia [131,132], significantly fewer days of tube feeding [132], increased oral intake, lower pharyngeal residue, and better oropharyngeal swallowing efficiency [131]. There has been particular interest in applying IMRT techniques to reduce the dose to structures specifically related to swallowing function, especially the pharyngeal constrictors, supraglottic larynx and glottic larynx [133,134]. With lower doses to the pharyngeal constrictor muscles, fewer problems with dysphagia are observed [134]. Reduced epiglottic inversion, reduced laryngeal elevation, and aspiration are related to significantly higher doses to the pharyngeal constrictors, glottis and supraglottic larynx [135]. There is obvious benefit in reducing the radiation dose to normal tissues, especially in those structures contributing to swallow function. Future refinement of techniques to reduce radiation dosage to normal structures should yield additional improvement in swallowing function.

Other Adverse Effects of Chemoradiation That May Impact Swallowing Function

In addition to inducing fibrosis, which appears to be the primary reason for swallowing dysfunction after treatment, chemoradiation causes other side effects that may have an impact on swallowing function.

Reduced Salivary Flow and Xerostomia—Radiation for cancers of the head and neck will often include the salivary glands in the treatment volume; damage to the salivary glands results in significantly reduced salivary flow [85,129,136,137]. The parotid gland is especially sensitive to the effects of radiotherapy; radiation doses in excess of 55 to 64 Gy appear to result in permanent damage with no anticipated long-term recovery of salivary function [136,137]. Studies of saliva flow after treatments designed to reduce the dose to the parotid gland indicate that with doses below 24 to 26 Gy, saliva flow is persevered and will increase toward pretreatment levels over the first year. Glands receiving a mean dose higher than the threshold will produce little saliva with no recovery over time [129].

The relationships among reduced salivary flow, xerostomia or the perception of “dry mouth,” and swallow function are not clear. Although patients with significantly reduced saliva production after radiotherapy also have increased reports of perceived difficulty swallowing, dry mouth, needing water while eating, food sticking in the mouth or throat, and changes in taste [85,138], patients with objective improvement in salivary flow over time may still complain of xerostomia [136]. Reduced saliva weight does not correlate with slowed or inefficient swallow. Instead, reduced saliva weight seems to change the patient's perception of swallowing ability and, on that basis, affects diet choices [85,138].

Mucositis—Mucositis is a frequent and severe consequence of radiotherapy to the head and neck [84]. Oral mucositis is defined as an injury to the oral mucosa, characterized by erythema (redness) and ulcerative lesions [139,140]. Mucositis is limited to the tissues in the field of radiation, with nonkeratinzed tissues such as buccal and labial mucosa, ventral and lateral surfaces of the tongue, floor of mouth, and soft palate affected more often than other tissues [139,140]. Mucositis also may affect other sites along the digestive tract as a result of high dose chemotherapy [84,141].

Nearly all patients receiving conventional (once daily) radiotherapy (97%) or chemoradiotherapy (90%) experience mucositis. It is reported that 100% of patients who receive altered fractionation (twice daily treatments) have mucositis, with more than half experiencing the highest grades (worst level) of this toxicity [84]. The severity of oral mucositis is directly proportional to the dose of radiation administered to the head and neck [139,142]. The first mucosal reaction can be observed as a white discoloration after a cumulative radiation dose of 10-20 Gy. Deepening erythema is usually visible after 20 Gy of cumulative radiation, and ulcerations, often covered with a pseudomembranous layer, develop after about 30 Gy, usually occurring after 3 weeks of conventional radiotherapy. After completion of radiotherapy, mucositis will generally decline after 2 to 6 weeks [139,143].

Pain is a common side-effect of mucositis; the ulcerative stage is especially painful [84,139]. Ulceration of the oral mucosa and the resulting pain can impair a patient's ability to swallow and eat [84,139,144]. In the few studies that report dietary-related outcomes, there is a high and significant correlation between severity of mucositis and the incidence of gastrostomy tube feeding and weight loss [84].

Any irritants to the oral mucosa such as spicy foods or alcohol should be avoided while mucositis is present. There is great need for education of the patient and family on proper oral care during mucositis [144]. The dysphagia rehabilitation specialist (commonly a speech language pathologist) can play an important role in reinforcing oral care procedures with the patient suffering from mucositis.

Stricture—Stricture, a segment of narrowing or complete closure in the pharynx or esophagus, occurs at reported rates of 8% to 24% after chemoradiation and has a profound impact on swallowing function by limiting or blocking the passage of food or liquid [110, 114,124,127,145]. The average time after treatment completion to diagnosis is 6 to 7 months. Strictures rarely develop until radiation dose to the hypopharynx or esophagus exceeds 60 to 70 Gy [126,146], so the proximal esophagus is another organ to consider sparing with intensity-modulated radiotherapy techniques.

The hypothesized pathophysiology of stricture formation begins with ulceration after severe mucositis along with a relatively immobile larynx secondary to radiation-induced fibrosis and lack of passage of food or liquid through lumen, possibly due to use of gastrostomy. These conditions lead to healing of the opposing anterior and posterior mucosal surfaces resulting in adhesions which lead to narrowing and possible obstruction [126,147]. The hypopharynx is especially susceptible to stricture formation because of the close proximity of the mucosal membranes in the posterior cricoid area and posterior pharyngeal wall [145].

It has been suggested that use of gastrostomy tubes may contribute to the development of strictures [148]. Patients with gastrostomy tubes may be at increased risk of stricture formation because of the relative inactivity of the upper esophageal/hypopharyngeal musculature as compared to those without feeding tubes. Those with gastrostomy tubes are likely to cease all efforts at passage of food or liquid especially when suffering from mucositis. Formation of stricture therefore may not be related to radiation dose but to whether the patient swallowed during the course of treatment, resulting in less significant muscular fibrosis in the treated area than in those patients who did not swallow routinely throughout the course of treatment [145,147]. Lack of swallowing may result in atrophy of hypopharyngeal muscles. Patients undergoing chemoradiation should be strongly encouraged to swallow orally even if they have gastrostomy tubes or other supplemental feeding tubes in place. The use of the swallow mechanism should limit adhesion formation and disuse atrophy of pharyngeal muscles [147].

Summary: Swallowing Function after Primary Radiation or Chemoradiation for Cancer of the Head and Neck

The use of radiotherapy with or without chemotherapy for treatment of cancer of the head and neck as a primary treatment modality has increased significantly over the past twenty years. Despite preservation of the structures of the head and neck, swallow function is not maintained at normal levels after treatment. Aspiration rates approaching 90% have been reported in the literature for patients after treatment with primary chemoradiotherapy. Dysfunction is observed across all stages of the swallow in most tumor sites treated with standard external beam radiation. The uniformity of swallow disorders after this treatment modality is related to the wide field of radiation required for effective cure. Fibrosis of the irradiated tissue of the head and neck results in impaired movement of the oral tongue, tongue base, pharyngeal constrictors, and larynx, leading to dysfunction. Swallow disorders persist through the first year post-treatment and may be present many years after completion of radiotherapy.

Reduced salivary flow, xerostomia, mucositis, and hypopharyngeal or esophageal strictures are also side effects of chemoradiotherapy that may have a profound and negative impact on posttreatment swallow function.

Attempts have been made to minimize the amount of damage to normal tissues and reduce the adverse effects of treatment on swallowing function by reducing radiation dose to swallow-critical structures. Less swallow impairment is observed when the dose to the pharyngeal constrictors, supraglottic and glottic larynx, and proximal esophagus is reduced.

DIAGNOSIS AND TREATMENT PLANNING

The management of dysphagia after treatment for cancers of the head and neck begins with an imaging procedure in order to properly diagnose the pathophysiology of the swallow. Given the reported rates of silent aspiration, especially in those treated with chemoradiation, use of an imaging procedure is vital in the proper diagnosis of dysphagia.

The most useful imaging techniques for diagnosing swallowing disorders are the Modified Barium Swallow (MBS) procedure with videofluorography (VFG) and fiberoptic endoscopic examination of swallow (FEES). Both procedures have been thoroughly addressed in this issue. During the MBS, patients are administered calibrated boluses of radio-opaque material of varying consistency. The patient’s swallow is viewed in the lateral plane with videofluorography so that disorders of the swallow during oral preparation, the oral propulsive stage of swallow, and the pharyngeal stage of swallow may be observed and documented. FEES visualizes the pharynx from above by placing an endoscopic tube transnasally such that the end of the tube is suspended over the end of the soft palate. This procedure gives a different view of the pharynx than seen videofluoroscopically and permits observation of true cord closure; however FEES does not provide information concerning the oral stage of swallow, which may be the most problematic for some patients with head and neck cancer who have been treated surgically for oral cavity tumors. MBS therefore is the most commonly used technique to observe the swallow, diagnose dysphagia, and develop a treatment plan for patients with impaired swallow function [149,150,151,152,153,154]. It is especially suited to determining the effects of trial therapy. After the dysphagia rehabilitation specialist documents the specific swallowing disorders observed on MBS, he or she can introduce interventions to treat the disorder or compensate for the swallow impairment.

INTERVENTIONS DURING MBS

The goal of the MBS assessment is to define the presence and cause of any aspiration and motility disorders, and to determine whether there are interventions that will eliminate or reduce the aspiration and improve swallow function. Therefore, patients should be given trial therapy to determine the effectiveness of strategies such as postures, maneuvers, and modifications to bolus size or consistency.

Postures

Postures are used to control the flow of the bolus and to reduce or eliminate aspiration. There are a number postures that are effective in treated head and neck cancer patients. After determining the cause of aspiration or swallow dysfunction, the clinician should attempt under fluoroscopy an appropriate posture or postures in order to determine the effect in each individual patient. Changes in head or body position have been shown to eliminate aspiration of at least one liquid bolus volume in 77% of patients with various medical diagnoses [155] and in 81% of postsurgical head and neck cancer patients [156]. The efficacy of postures will vary depending upon the swallowing disorder identified as causing the aspiration [157].

Chin Down—The chin-down posture (also referred to as chin tuck or neck flexion) is useful for patients who have a delayed pharyngeal swallow, reduced tongue base retraction, or reduced laryngeal elevation. The patient is instructed to touch the chin to the neck while swallowing. This action pushes the anterior pharyngeal wall posteriorly, and the tongue base and epiglottis closer to the posterior pharyngeal wall, thereby narrowing the airway entrance. This posterior shift with the chin down posture improves airway protection so it is useful for patients with reduced laryngeal elevation or laryngeal vestibule closure. The vallecular space is also widened, giving a potentially larger place for the bolus to set before the pharyngeal swallow is initiated [158,159].

The chin down posture, alone or combined with other postures or maneuvers such as head rotation, head back to chin down movement, or voluntary airway protection (to be discussed later) has been reported as successful in eliminating aspiration in 72% of patients with various medical diagnoses [157]; success with postsurgical head and neck cancer patients ranges from 50% in patients with tongue base resection [8] to 81% in esophagectomy patients [160] and 90% in patients with oral or laryngeal resections [156]. The chin down posture has been shown to significantly reduced depth of bolus penetration into larynx and trachea [161]. The chin down posture is a simple technique patients prefer to other interventions such as thickening liquids [162] and is easy for most to perform correctly [160,161].

Head Back—The head-back posture uses gravity to clear the bolus from the oral cavity in patients who have difficulty with oral transit of the bolus [149,163]. If there is a question about adequate airway protection, the patient may be instructed in various voluntary airway protection maneuvers that will be discussed later. In appropriately selected patients, the head-back posture has been shown to be 100% effective in transporting the bolus out of the oral cavity and into the pharynx [156].

Head Rotation—Head rotation toward the weak or damaged side of the pharynx or larynx closes the damaged side so that the bolus flows down the more-nearly normal side. This posture is useful for patients with unilateral pharyngeal wall impairment or unilateral vocal fold weakness. Head rotation to the weaker side causes the bolus to lateralize away from the direction of rotation, and also increases upper esophageal sphincter (UES) opening diameter while causing a significant reduction in UES pressure [164]. During head rotation, compensatory movement of the arytenoid on the healthy side has been observed on videofluoroscopy [165]. Serial computed tomography of the pharynx in a patient with lateral medullary syndrome using head rotation indicates that hemipharyngeal closing occurs at the level of the hyoid bone and in the hypopharyngeal cavity above the pyriform sinus [166].

Head rotation performed either alone or in combination with other postures or maneuvers is effective in reducing aspiration in postsurgical head and neck cancer patients 71% of the time [156]. Since head rotation may cause compensatory movement of the arytenoid on the healthy side [165], this posture may be effective in hemilarygectomee patients who have difficulty achieving closure of the remaining vocal fold against the reconstructed pseudocord. Also, since UES opening diameter is increased and resting pressure is decreased during head rotation, patients with cricopharyngeal dysmotility problems may also benefit from the posture.

Lateral Head Tilt—The lateral head tilt posture may be used for a patient who has both unilateral oral and pharyngeal impairment on the same side. The patient tilts the head to the stronger side so that gravity drains the bolus along the stronger side and avoids the weaker side [149]. There are no reports in the literature on the efficacy of this posture in the head and neck population but the clinician may find it useful to try this procedure in patients with unilateral impairment.

Swallow Maneuvers

Swallow maneuvers are designed to place specific aspects of the oropharyngeal swallow under voluntary control. Maneuvers should be checked fluoroscopically to verify that the patient is performing them properly and to determine the impact on aspiration and swallow motility disorders.

Supraglottic Swallow and Super-Supraglottic Swallow Maneuver—The goal of the supraglottic and super-supraglottic swallow maneuvers, also referred to as voluntary airway closure techniques, is to close the vocal folds before and during the swallow in order to prevent aspiration [149,167]. For the supraglottic swallow, the patient is instructed to take a deep breath and hold it, swallow while continuing to hold the breath, and cough immediately after the swallow to expel any residue from the airway entrance. The super-supraglottic swallow maneuver is designed to close the entrance to the airway voluntarily by tilting the arytenoid cartilage anteriorly to contact the base of the epiglottis before and during the swallow, and closing the false vocal folds tightly. The patient is instructed to “Inhale and hold your breath very tightly, bearing down. Keep holding your breath and bearing down while you swallow. Cough when you are finished.” Videofluoroscopic and videoendoscopic evaluations have demonstrated that airway closure duration is prolonged during both the supraglottic and super-supraglottic maneuver in normal subjects and treated head and neck cancer patients [168, 169]. Normal subjects also experience earlier cricopharyngeal opening, prolonged pharyngeal swallow, some degree of laryngeal valving before swallow, and change in extent of vertical laryngeal position before swallow. These changes in swallow physiology are more pronounced with the super-supraglottic maneuver [169].

The supraglottic swallow maneuver was originally conceptualized for use with patients who have undergone supraglottic laryngectomy, to improve the ability to protect the airway and prevent aspiration during the swallow [170]. Endoscopic studies have demonstrated that true cord closure may not always be achieved during the supraglottic swallow so the airway may not be protected in all patients using this procedure. The super-supraglottic maneuver however provides an additional level of airway protection by tilting the arytenoid cartilages anteriorly to contact the base of the epiglottis (or tongue base if the epiglottis has been resected) [167]. The super-supraglottic swallow maneuver also influences other aspects of the swallow aside from airway protection. In irradiated head and neck cancer patients, the super-supraglottic swallow maneuver not only closes the airway entrance earlier than without the maneuver, but also results in improved tongue base motion [171], greater hyoid and laryngeal elevation at the time of cricopharyngeal opening, and increased maximal hyoid and laryngeal elevation [172]. These results suggest that the super-supraglottic swallow maneuver not only improves airway closure at the entrance but also improves tongue base movement as well as speed and extent of hyolaryngeal movement, especially early in the swallow.

Based upon the observed effects of the super-supraglottic swallow on oropharyngeal biomechanics, this maneuver is useful not only for patients with reduced laryngeal airway closure, but also for those with reduced tongue base retraction and reduced laryngeal elevation. It has been shown to be effective in eliminating aspiration in patients who have undergone supraglottic laryngectomy [58] as well as those treated with a full course of radiotherapy to the head and neck [172].

Effortful Swallow Maneuver—The effortful swallow is designed to increase tongue base retraction and pharyngeal pressure during the swallow in order to improve bolus clearance from the valleculae [149]. The patient is instructed to squeeze hard with all their muscles as they swallow.

The effortful swallow is believed to increase pharyngeal pressures, thus pushing the bolus through the pharynx and cricopharyngeous, leaving less residue in the pharynx after the swallow. Studies designed to measure oral, pharyngeal, and esophageal pressures during the effortful swallow provide conflicting information concerning the pressures generated with the procedure.

Effortful swallows performed by healthy normal adults are characterized by significantly higher oral pressures, diminished oral residue, longer laryngeal vestibule closure, hyoid excursion, and extent of hyoid elevation [173] as well as longer pharyngeal pressure duration and upper esophageal sphincter (UES) relaxation duration [174]. The effortful swallow also has an effect on the esophageal phase of swallow with significantly increased peristaltic amplitudes within the distal smooth muscle region of the esophagus, possibly as a result of overflow effort from the maneuver [175].

There are limited data on the effortful swallow in patient populations. In patients with pharyngeal dysfunction, the effortful swallow does not alter either peak amplitude or duration of the intrabolus pressure [176]; however, use of the effortful swallow in these patients significantly reduces depth of contrast penetration into the larynx and trachea. Although there is no impact on pharyngeal residue, the hyoid is held in a more superior position prior to onset of the swallow [161]. In treated head and neck cancer patients, the effortful swallow is associated with higher pharyngeal pressure amplitudes and longer pressure durations than swallows with no maneuver; compared to other maneuvers tested, the effortful swallow produces the highest pharyngeal pressure and results in slightly less pharyngeal residue [171].

Although the effortful swallow was conceived to increase pharyngeal pressure during the swallow in order to improve bolus clearance from the vallecula, data also indicate that the maneuver also has an impact on other aspects of both the oral and pharyngeal stages of the swallow. Therefore the effortful swallow may be appropriate to use with treated head and neck cancer patients who demonstrate reduced tongue strength, reduced pharyngeal contraction, reduced laryngeal elevation, reduced laryngeal vestibule closure, and cricopharyngeal dysmotility.

Mendelsohn Maneuver—The Mendelsohn maneuver is a voluntary prolongation of laryngeal excursion at the midpoint of the swallow, intended to increase the extent and duration of laryngeal elevation and thereby increase the duration of cricopharyngeal opening [177]. Patients are instructed to "Swallow normally. When you feel your voice box go up, grab it with your throat muscles and don't let it go down. Hold it for 3 counts, and then let it go." This maneuver can be practiced without food, and then food may be introduced with the maneuver once the patient has learned to perform it correctly.

Videomanometric data confirm that use of the Mendelsohn maneuver in healthy adults results in increased duration of anterior-superior excursion of the larynx and hyoid and consequently prolonged cricopharyngeal opening by maintaining traction on the anterior sphincter wall [171] as well as increased peak pharyngeal contraction and duration [178]. Significantly longer bolus transit times occur as well, as would be expected when the subject is instructed to prolong laryngeal elevation.

In treated head and neck cancer patients, swallows performed with the Mendelsohn maneuver have been shown to exhibit higher tongue base pressure amplitudes and longer pressure durations, as well as less pharyngeal residue when compared to swallows with no maneuver [171]. Use of the Mendelsohn maneuver can improve coordination and timing of pharyngeal swallow events, including timing of posterior movement of the tongue base to the pharyngeal wall in relation to airway closure and cricopharyngeal opening, with elimination of aspiration [168].

Prolonged cricopharyngeal opening times associated with the Mendelsohn maneuver may allow passage of a larger amount of the bolus into the esophagus; also the improvement in laryngeal elevation may reduce residue in the pyriform sinus after the swallow. Increased duration and magnitude of pharyngeal pressure might result in improved propulsion of bolus into the esophagus. The Mendelsohn maneuver therefore is a useful technique for patients with reduced laryngeal movement, delayed or reduced cricopharyngeal opening, or discoordinated swallow.

Tongue Hold—The tongue hold maneuver is a technique for enhancing posterior pharyngeal wall movement. Contact between the tongue base and posterior pharyngeal wall is important for applying pressure on the bolus to aid in transport through the pharynx [179]. Patients with head and neck cancer who have resection of the tongue base or radiation to the oropharynx may experience difficulty achieving tongue base to pharyngeal wall contact. The tongue hold maneuver was designed to augment posterior pharyngeal wall movement.

The patient is instructed to protrude the tongue and hold it between the central incisors while swallowing. Young adult subjects demonstrate a significant increase in posterior pharyngeal wall bulging while performing this maneuver [179]. Treated head and neck cancer patients produce higher pressure at the level of the tongue base and pharyngeal wall while performing this maneuver [171].

Unfortunately, the tongue hold maneuver also results in increased pharyngeal residue, especially in the vallecula; reduced laryngeal vestibule closure; and delayed triggering of the pharyngeal swallow [179]. Although as originally conceptualized the tongue hold maneuver is to be used with a bolus, it is advisable to utilize the tongue hold as an exercise without food for treated head and neck cancer patients because of the significant risk of aspirating vallecular residue during a swallow delay. A trial of the tongue hold maneuver under fluoroscopy is recommended to see whether the posterior pharyngeal wall responds as anticipated.

Bolus Size and Consistency Modifications

Modification of bolus size and consistency may also be effective in eliminating aspiration in patients treated for head and neck cancer. These changes should be observed under fluoroscopy so the clinician can determine their impact on swallow physiology. For some patients, a larger volume bolus may be more effective at eliciting a more rapid pharyngeal swallow. Larger bolus volumes may provide greater sensory input for the patient and increase awareness of the bolus in the oral cavity [180,181]. However, patients who require multiple swallows to clear a single bolus will probably benefit from smaller bolus sizes in order to reduce residue and the risk of aspiration [182].

Patients with oral stage problems such as reduced tongue range of motion, coordination, or strength will have greatest difficulty with thick foods. Patients with a delayed pharyngeal swallow or reduced airway closure may benefit from eliminating thin liquids or thickening them to a more viscous consistency. Those with swallowing disorders that result in retention of bolus in the pharynx (such as reduced tongue base retraction, reduced laryngeal elevation, and cricopharyngeal dysfunction) will have greater difficulty with thicker, higher viscosity foods. [183]

Removal of specific food consistencies from the diet should be the last strategy to be contemplated [149]. Elimination of certain food consistencies from the diet such as liquids can be difficult for the patient and may have an impact on the patient's nutritional status. Bolus consistency modifications should be considered when postures and maneuvers are not feasible or are unsuccessful.

THERAPY PROCEDURES

Aspiration may be eliminated by the use of postures, maneuvers, and modifications to bolus size and consistency; however, until the swallow physiology can be improved, a patient will need to use these techniques consistently while eating in order to maintain oral intake. There are active therapy procedures that have been designed to improve impaired swallow function after treatment for cancer of the head and neck.

Range of Motion Exercises

The normal range of motion of the lips, jaw, tongue, and larynx is often disrupted after treatment for cancer of the head and neck, as a result of either surgical resection and reconstruction of the structures or fibrosis induced by radiation. Range of motion (ROM) exercises are designed to improve the movement by extending the target structure in a desired direction until a strong stretch is felt. The stretched position is held for one second and then the structure is relaxed [149]. It has been shown that postsurgical patients who performed ROM exercises in the first three months after surgery have significantly better swallowing function than those who do not perform these exercises [184]. Range of motion exercises can be used for the lips, jaw, oral tongue, tongue base, larynx, and hyoid-related musculature. Although the optimal frequency and duration of ROM exercises is not yet determined, five to ten repetitions of each exercise for five to ten sessions per day are generally recommended [149,184,185].

Jaw ROM—Restricted mouth opening, often referred to as trismus, may result from surgical resection of the muscles of mastication, scarring after ablation of a portion of the mandible, or fibrosis of irradiated tissues. Current methods used to increase mouth opening include unassisted jaw ROM exercises, finger-assisted stretching exercises, stacked tongue depressors, and mechanical assistance with a device such as Therabite.

The jaw may be exercised by instructing the patient to open the mouth as widely as possible without causing pain and holding this position for two seconds. Next, move the jaw to the right side as far as possible, hold for two seconds, then relax; repeat the same movement to the left side. Finally the patient should move the jaw in a circular movement, relaxing after completing a full circle. Repeat the preceding exercises five to ten times per session, with the goal of five to ten sessions per day.

Patients with very restricted oral aperture may assist jaw opening by stacking wooden tongue blades and inserting them between the teeth, adding additional tongue blades as range of motion increases. Mechanical devices such as the Therabite may provide assistance with mouth opening. Use of a mechanical device may increase jaw opening more than other methods of stretching [186]; however research indicates that unassisted stretching exercises, use of stacked tongue depressors, and assistance by mechanical devices are all effective at increasing jaw opening in treated head and neck cancer patients [187,188].

Tongue ROM Exercises—Scarring of the tongue after surgery may prevent sufficient range of motion to clear the bolus from the oral cavity; reconstruction procedures that tether the tongue anteriorly will negatively impact tongue base retraction. Fibrosis after radiotherapy will also reduce the tongue's ability to move normally. Range of motion exercises may be used for the oral tongue and tongue base to improve movement.

Oral Tongue ROM Exercises—Tongue range of motion exercises for the oral tongue include extension, lateralization, elevation, and retraction [149]. Instruct the patient to stick out the tongue as far as possible past the lips without feeling pain, hold for 2 seconds, then relax. Next have the patient move the tongue to the right corner of the mouth, stretching as far as possible and hold for 2 seconds, then relax. Repeat this extension to the left side. To elevate the front of the tongue, instruct the patient to lift the tip of the tongue and place it behind the top teeth along the alveolar ridge. Hold the position for 2 seconds and then relax. To elevate the back of the tongue, instruct the patient to raise the tongue as if to produce /k/ or /g/; hold the position for 2 seconds, and then relax. As the patient's tongue elevation improves, extend the stretch by instructing the patient to lower the jaw as far as possible while holding the elevated tongue positions. For tongue retraction, instruct the patient to pull the tongue straight back in the mouth as far as it will go, hold for 2 seconds, then relax. Suggesting imagery of gargling or yawning may elicit greater retraction [189]. Repeat the preceding exercises five to ten times.

Bolus Manipulation Exercises—Bolus manipulation exercises are a form of ROM exercise intended to enhance tongue movements required for chewing, bolus formation, and bolus transport [149]. The exercises may be performed with a strip of gauze soaked in water or beverage, a flexible licorice stick or similar candy, or a small lollipop on a stick.

Tongue Cupping: This exercise is to practice holding a bolus in the oral cavity. Instruct the patient to take a piece of soaked gauze (or licorice stick, lollipop, etc.) and place it on the middle of the tongue, holding on to the other end outside the mouth. Hold the gauze against the roof of the mouth so that the tip of the tongue is sealed behind the alveolar ridge and the sides of the tongue are against the roof of the mouth near the molars (or gums if the patient has no teeth). Hold the position 5 seconds then relax. Repeat five to ten times.

Tongue Side to Side Movement: This exercise is to practice moving the bolus back and forth onto the teeth or gums for chewing. Instruct the patient to take the gauze and place it on the tongue, holding the end of the gauze outside the mouth. Maneuver the gauze around in the mouth over to the left, then to the middle, then to the right, and back again. Repeat this circuit five to ten times. As the patient improves with lateralizing the gauze, they may be challenged by using a piece of loose hard candy.

Tongue Posterior Movement: This exercise is to practice transporting the bolus through the oral cavity. Instruct the patient to take a piece of gauze and place it on the tongue, holding the other end outside the mouth. Move the gauze up and back with the tongue, as if attempting to swallow the gauze. If the gauze is soaked in a beverage, ask the patient to try to squeeze the liquid from the gauze and swallow (if it is safe for the patient to swallow). Repeat this task five to ten times.

Tongue Base ROM Exercises—Retraction of the tongue as far back as possible in the oral cavity will exercise the tongue base. Other exercises for tongue base range of motion include pretending to gargle and pretending to yawn, as discussed in the oral tongue ROM section. The gargle task has been demonstrated to elicit the most tongue base retraction when compared to pretending to yawn and pulling the tongue back as far as possible [189], although it is easy to try several techniques for the individual patient to determine what is most effective. If reduced tongue base retraction is identified on MBS, it is wise to determine the effects of tongue pull-back, yawn, and gargle imagery under fluoroscopy so that the most effective procedure may be integrated into the patient's swallow therapy plan.

Some maneuvers are also very effective at increasing tongue base ROM. As discussed in the section on interventions during the MBS study, the Mendelsohn maneuver, Effortful Swallow, and Super-Supraglottic Swallow are not only effective at producing their intended target move but also result in increased tongue base retraction [168,171]. Practicing these maneuvers with or without food as indicated for swallow safety may exercise the tongue base and enhance retraction.

Laryngeal ROM Exercises—Reduced laryngeal elevation is often reported in treated head and neck cancer patients, especially in those who have been irradiated. It has been demonstrated that reduced laryngeal elevation is significantly correlated with limitations in oral intake and diet during the first year after cancer treatment [190] so improving laryngeal range of motion is a very important goal when formulating a swallow therapy plan for treated head and neck cancer patients.

Falsetto Voice—A falsetto voice exercise may be useful in improving laryngeal range of motion for elevation. During falsetto voice production, the larynx elevates nearly as much as it does during the swallow. The patient is asked to slide up the pitch scale as high as possible, into a high squeaky voice. At the top of the scale, the patient should hold the note for several seconds with as much effort as possible. The clinician may manually assist the patient in raising the larynx if necessary, with the ultimate aim to eventually eliminate the manual assist.

Mendelsohn—As previously discussed in the Maneuvers section, the Mendelsohn maneuver is a voluntary prolongation of laryngeal excursion at the midpoint of the swallow, intended to increase the extent and duration of laryngeal elevation and thereby increase the duration of cricopharyngeal opening. Research has indicated that it is effective at increasing the extent and duration of laryngeal elevation as well as duration of cricopharyngeal opening [168,177]. The Mendelsohn maneuver may be practiced with or without a bolus as dictated for safety.

Shaker Exercise for Hyolaryngeal ROM—Another exercise that holds promise for patients with cricopharyngeal dysfunction is the Shaker Exercise. Because the suprahyoid muscle group responsible for displacement of the hyolaryngeal complex and opening of the UES appears responsive to external influences, a simple isometric/isokinetic head lift exercise aimed at these muscles was developed and tested [191].

The Shaker Exercise consists of three repetitive 1-min sustained head raisings in the supine position, interrupted by a 1-min rest period. Sustained head-raising exercises are followed by 30 consecutive repetitions of head raisings in the same supine position. For both sustained and repetitive head raisings, subjects are instructed to raise the head high and forward enough to be able to see their toes without raising shoulders off the ground. The rationale for the exercise is to build strength in the suprahyoid musculature, thus enhancing hyoid and laryngeal elevation, which may permit longer and wider opening of the UES.

The Shaker exercise has produced encouraging results in remedying or improving UES related dysphagia [192,193] although its efficacy for treating dysphagia after treatment for head and neck cancer has not yet been demonstrated.

Neuromuscular Electrical Stimulation—Surface neuromuscular electrical stimulation (NMES) has recently been proposed as a treatment option for pharyngeal dysphagia [194]. Surface electrical stimulation is applied through electrodes placed on the neck with the goal of promoting increased hyoid or laryngeal elevation. If surface NMES, commonly referred to as Estim, can actually stimulate the deep strap muscles of the head and neck, it could benefit treated head and neck cancer patients who experience reduced laryngeal elevation. Because surface NMES is intended to improve hyolaryngeal elevation, it can be considered a ROM exercise and is therefore discussed in this section.

NMES for dysphagia has become a widely utilized clinical procedure, yet is accompanied by considerable controversy because of a lack of physiologic rationale and limited published efficacy data. The available literature yields mixed results concerning the ability of NMES to improved swallow function. Reported success rates after treatment with surface NMES range from 40% for patients with severe dysphagia [195] to 98% in patients with dysphagia after stroke [194]. Significant improvements also have been reported in swallow function in a long-term acute care setting [196].

Conversely, research investigations have shown that 85% of subjects failed to exhibit gain in myoelectrical activity in the submental muscles after ten 1-hour sessions of NMES [197]. Videofluoroscopic evaluation of hyolaryngeal movement during surface NMES revealed that, contrary to the intended goal of treatment, NMES provided through nine differed recommended loci of electrode placement actually significantly lowered the hyoid and larynx. Stimulated swallows were also judged as less safe then nonstimulated swallows using the NIH Swallowing Safety Scale [198].

Meta-analyses indicate that there is a small but significant summary effect size for surface NMES for swallowing, but that the small number of available studies and their poor methodology indicate the need for more rigorous research in the area [199]. Implementation of NMES in clinical rehabilitation settings is premature [200].

Stroke is the most common etiology of dysphagia treated with surface NMES [201]. No published efficacy data on the use of NMES with treated head and neck cancer patients are available. Given the potential for surface NMES to actually depress the hyoid and larynx, the clinician should proceed with caution when considering use of this technique with treated head and neck cancer patients. It is advisable to observe the effects of NMES under fluoroscopy if the clinician chooses to try this procedure.

Laryngeal Closure Exercises—Patients who have received surgical intervention or radiation to the larynx may have difficulty protecting the airway. Laryngeal closure exercises may be used to improve airway closure at the level of the true cords or higher at the vestibule.

Vocal cord adduction exercises such as producing hard glottal attacks may be used to improve range of motion and enhance true cord closure [149]. The Super-Supraglottic Swallow, discussed in the section on maneuvers, is designed to close the entrance to the airway voluntarily by tilting the arytenoid cartilage anteriorly to contact the base of the epiglottis before and during the swallow, and closing the false vocal folds tightly. The patient may practice this maneuver with or without food as needed for swallow safety in order to enhance closure of the laryngeal vestibule.

Tongue Resistance or Strengthening Exercises

Oral tongue strength may be reduced in patients with cancer of the head and neck [202,203]. Resistance or strengthening exercises are used to build or maintain strength in the oral tongue with the rationale that stronger muscles will function better during the swallow. Strengthening exercises usually involve pushing the target structure against some type of resistance and holding it for several seconds [149]. While using a wooden tongue depressor or another item to provide resistance such as the back of a spoon, instruct the patient to extend the tongue, pushing it against the tongue depressor as hard as possible without causing pain. Resist the force of the tongue with the tongue depressor, holding for two seconds and then relax. Proceed to the side of the tongue. Depending upon the patient’s range of motion, the tongue may be extended outside the corner of the mouth to the right or left side and pushed against the tongue depressor as hard as possible, held for 2 seconds, and relaxed. If tongue ROM is very limited, the patient may place the tongue inside the cheek, making it bulge. Instruct the patient to press against the bulged cheek with a finger, hold for 2 seconds, and relax. Repeat this exercise to the opposite side. Finally, instruct the patient to push down on the tongue with the tongue depressor while simultaneously pushing up with the tongue. Push against the resistance for 2 seconds, and then relax. Each strengthening exercise should be repeated five to ten times per session, with the goal of five to ten sessions per day.

A biofeedback instrument such as the Iowa Oral Pressure Instrument (IOPI) may be useful to the patient in monitoring maximum pressure during tongue strengthening exercises [204], although a study of the effects of tongue strengthening exercises in young healthy adults indicates that there are no significant differences in tongue strength after using either a tongue depressor or the IOPI [205]. As with ROM exercises, the optimal frequency and intensity of tongue strengthening exercises has not been determined. The efficacy of tongue strengthening exercises for patients treated for cancer of the head and neck has not yet been demonstrated.

Thermal/Tactile stimulation

Delayed triggering of the pharyngeal swallow has been observed in treated head and neck cancer patients. Thermal/tactile stimulation is designed to sensitize or stimulate the area of the oral cavity where the swallow reflex is thought to trigger. The procedure consists of applying cold pressure to the base of the anterior faucial arches [206]. The clinician may perform thermal/tactile stimulation on the patient and may instruct the patient how to perform the technique for home practice. Instruct the patient to dip a laryngeal mirror into a cup of ice and ice water for 10 seconds. Firmly rub vertically up and down on the anterior faucial arch approximately 5 times on each side, making sure that the metal side of the mirror is against the tissue. Repeat on the other side if it is anatomically intact. Remove the mirror, pipette a few drops of water at the faucial arch and swallow. Repeat the procedure ten times.

The effects of thermal/tactile stimulation have been investigated primarily in healthy adults and neurologically-impaired patients with delayed pharyngeal swallow, with some data indicating that thermal/tactile stimulation has no impact on the swallow [181,207,208,209], while other studies support the use of the technique for improving swallow physiology [206, 210,211,212,213]. There are currently no published data demonstrating the efficacy of thermal/ tactile stimulation with treated head and neck cancer patients.

Intraoral Prosthestics

Intraoral prosthetics are developed by a maxillofacial prosthodontist with input from the surgeon and speech pathologist for patients who received surgical resection in the oral cavity for head and neck tumors. Several varieties of intraoral prostheses may be constructed to compensate for the loss of oropharyngeal structures in postsurgical oral cancer patients. Maxillary reshaping prostheses, also known as palatal drop or palatal lowering prostheses, are used to recontour and lower the palatal vault so that the remaining portion of the resected tongue can make contact with the palate for speech and swallowing [214,215,216]. Obturators fill a palatal defect to create separation of the oral and nasal cavities, thereby preventing loss of bolus into the nasopharynx and reestablishing intraoral pressure [215,217,218]. An intraoral prosthesis may incorporate both an obturator and a maxillary reshaping component. Use of intraoral prosthetics may result in a marked reduction in oral residue [214,219,220]. The maxillary reshaping/lowering prosthesis allows the patient to clear more of the bolus from the oral cavity because the resected tongue is able to make contact with the prosthesis, thereby reducing the inaccessible portions of the palate. Obturation of a soft palate defect restores the continuity of the oral cavity chamber required for bolus transport and adequate intraoral pressure, thereby permitting the patient to build sufficient pressure to improve clearance of the bolus from the oral cavity while preventing passage of the bolus into the nasal cavity.

The Table 1 summarizes the types of swallowing disorders most often reported for treated head and neck cancer patients. Associated with each disorder are postures, maneuvers, exercises, and other interventions that have some evidence in the literature for being effective in alleviating the disorder or reducing its negative impact on swallowing. This table should not be considered all-inclusive. As understanding of swallow physiology and the effects of cancer treatment evolves, more interventions will be developed and become available to the clinician.

TIMING OF DYSPHAGIA REHABILITATION FOR PATIENTS WITH HEAD AND NECK CANCER

The speech pathologist or other dysphagia rehabilitation specialist who works with head and neck cancer patients will be part of a multidisciplinary team that may include surgeons, radiation and medical oncologists, dentists or maxillofacial prosthodontists, nurses, physical therapists, and social workers. Ideally the clinician will have the opportunity to provide pretreatment counseling to inform the patient and family of the possible swallowing problems that may occur during and after treatment, as well as to provide information concerning posttreatment swallow rehabilitation. Surgical patients are often admitted to the hospital on the day of surgery, so the clinician may not have an opportunity for pretreatment counseling in person, but may communicate necessary information by phone. Patients who will be treated with chemoradiotherapy may be counseled at bedside just prior to the onset of treatment [221].

Because fibrosis of irradiated tissues is related to many of the swallowing problems experienced by treated head and neck cancer patients, exercises for preventing or reducing the effects of fibrosis should be provided prior to treatment. Range of motion and resistance exercises may be used as a strategy for preventing swallowing disorders before they develop in patients undergoing treatment for cancer of the head and neck. Use of tongue and jaw range of motion exercises during either primary or postoperative radiotherapy may help prevent trismus, reduce the formation of fibrotic tissue, and improve pharyngeal clearance by maintaining adequate tongue base to pharyngeal wall contact. Some limited data indicate that patients who perform range of motion exercises prior to and during chemoradiation have significantly greater quality of life for swallowing than do those who perform the exercises posttreatment only [222]. Patients should also be encouraged to keep using the swallow mechanism for oral intake even if there is a gastrostomy tube in place. As discussed in the section on Adverse Effects of Chemoradiation, strictures are more likely to develop in the hypopharynx or proximal esophagus when a gastrostomy tube is in place rather than a nasogastric tube because of both secondary healing of opposing ulcerated tissue in the postcricoid hypoharynx and disuse atrophy [145,147,148]. It is possible that patients who continue to use the swallowing mechanism, even just a small amount, may reduce the potential for stricture development.

Patients should be encouraged to perform their exercises every day; however, as radiotherapy progresses, most patients will feel that they do not have the energy to practice. Also, signs of mucositis may appear as early as the first couple of weeks into radiotherapy [139,143]. The pain associated with mucositis will also impact a patient’s desire to work with ROM and resistance exercises. Although this reluctance is understandable, the clinician should continue to encourage the patient to practice as much as they can during the course of treatment in order to reduce the severity of posttreatment swallow disorders.

After treatment is completed, the dysphagia rehabilitation specialist should evaluate the patient’s swallow function and formulate a plan for therapy as soon as the patient is medically cleared to begin work on swallowing function. Early initiation of swallowing therapy is generally advocated [126,145,223], although there is little research available that demonstrates the optimal timing, intensity, or duration of such treatment. A randomized study of swallow therapy initiated more than a year after completion of cancer treatment revealed no significant improvement in swallowing function [185], suggesting that amelioration of long-standing dysphagia may not be possible. However, since fibrosis of irradiated tissues may continue to develop years after completion of cancer treatment [117,122,127], patients should continue to practice ROM and resistance exercises regularly for the rest of their lives in order to keep the negative effects of fibrosis on swallowing function at a minimum.

EFFICACY OF SWALLOWING THERAPY PROCEDURES FOR PATIENTS WITH HEAD AND NECK CANCER

Throughout this chapter, the efficacy of individual postures, maneuvers, and other therapy procedures reported in the literature has been noted. Although there is considerable evidence that these interventions work with treated head and neck cancer patients, there are still many questions unanswered concerning the relative contributions of the various therapy techniques to improve swallow function, the optimal frequency, timing, and intensity of swallow rehabilitation programs, as well as the impact of patient practice and feedback strategies. Randomized clinical trials are the gold standard in treatment efficacy studies. A number of randomized clinical trials have been instituted in the past few years that address some of these issues and may demonstrate the superiority of various therapy procedures in treated head and neck cancer patients [224]. One study funded by the National Institute of Diabetes and Digestive and Kidney Disease compares the effects of the Shaker exercise with range of motion exercise in treated head and neck cancer patients and post-stroke patients. The second study, funded by the National Cancer Institute, compares a program of range of motion exercises with postural/sensory intervention in treated head and neck cancer patients. Both these trials were completed in 2007; the results have not been published at this time. A third clinical trial funded by the National Cancer Institute compares surface NMES combined with ROM exercises with ROM exercises alone in irradiated head and neck cancer patients. This trial will begin accrual in 2008. The results of these and future randomized clinical trials for swallowing therapy procedures will aid the clinician in choosing the most effective approaches for rehabilitating dysphagia after treatment for cancer of the head and neck.

CONCLUSION: REHABILITATION OF DYSPHAGIA FOLLOWING HEAD AND NECK CANCER

Patients with cancers of the head and neck may be treated with surgery, radiotherapy, chemotherapy, or a combination. Each treatment modality may have a negative impact on posttreatment swallowing function. The clinician has a number of rehabilitative procedures available to reduce or eliminate swallowing disorders in patients treated for cancer of the head and neck. After diagnosing the swallowing disorder with the modified barium swallow procedure, the clinician can use postures, maneuvers, and exercises to treat the swallow disorder and help the patient achieve optimal function. The efficacy of various treatment procedures for dysphagia still needs to be examined in carefully controlled randomized clinical trials. The field of dysphagia rehabilitation will continue to grow as novel approaches for cancer treatment are developed, resulting in possibly new manifestations of swallow dysfunction. Dysphagia rehabilitation specialists will continue to meet these challenges by developing new interventions to reduce the adverse effects of cancer treatment on swallowing function.

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Table 1

Swallowing disorders most often reported for treated head and neck cancer patients are listed with associated postures, maneuvers, exercises, and other interventions that may be effective in alleviating the disorder or reducing its negative impact on swallowing

swallow-related disorder	possible interventions
reduced mouth opening	jaw ROM exercises
reduced tongue control/shaping	chin down posture SSG swallow tongue ROM exercises bolus manipulation exercises tongue strengthening exercises
reduced vertical tongue movement	tongue ROM exercises maxillary reshaping prosthesis
reduced anterior-posterior tongue movement	head back posture multiple swallows alternate liquids and solids tongue ROM exercises bolus manipulation exercises maxillary reshaping prosthesis
reduced tongue strength	effortful swallow tongue strengthening exercises
delayed pharyngeal swallow	chin down posture SSG swallow thermal/tactile stimulation
reduced tongue base retraction	chin down posture effortful swallow SSG swallow tongue hold maneuver Mendelsohn maneuver tongue ROM exercises gargle/yawn for tongue base retraction
reduced laryngeal vestibule closure	chin down posture SSG swallow effortful swallow Mendelsohn maneuver gargle/yawn for tongue base retraction
reduced laryngeal elevation	Mendelsohn maneuver chin down posture SSG swallow effortful swallow laryngeal ROM exercises Shaker exercise
reduced glottic closure	head rotation to weaker side SSG swallow thickened liquids vocal fold adduction exercises
reduced pharyngeal constriction/clearance	head rotation to weaker side effortful swallow Mendelsohn maneuver multiple swallows alternate liquids and solids gargle/yawn for tongue base retraction tongue hold maneuver
reduced/impaired cricopharyngeal opening	head rotation to weaker side Mendelsohn maneuver Shaker exercise effortful swallow