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Soft tissue hypopharyngeal surgery for obstructive sleep apnea syndrome

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Sleep-disordered breathing is common. In its mildest form, it manifests as snoring which is often considered a cosmetic complaint. Sleep-related breathing disturbances increase in severity to include the upper airway resistance syndrome and obstructive sleep apnea syndrome (OSAS) having established medical morbidity and mortality risks. Overt OSAS affects an estimated 4% of men and 2% of women [1]. Because of its significant social, functional, and medical morbidity, OSAS frequently presents for treatment. Nasal continuous positive airway pressure has been the preferred treatment; however, when this or other conservative treatments fail, surgery may be offered. Surgery may bypass the upper airway obstruction or may reconstruct the upper airway, using either skeletal or soft tissue techniques. It is commonly accepted that airway obstruction in OSA is complex and in most patients multilevel [2]. Surgical goals are to increase airway size, decrease airway collapsibility, decrease airway resistance and the work of breathing, and reduce partial and complete airway obstructions (apnea and hypopnea). Improved ventilation reduces sleep and medical manifestations of OSAS. This article addresses specific surgical procedures to treat lower pharyngeal and tongue-related airway obstruction.

Algorithms for treatment

Various surgical algorithms have been described to treat both snoring and OSAS. Most decisions are based on the surgeon's preference. Multiple procedures exist potentially to treat OSAS and snoring. Outcome data on many procedures is limited [3]. Decisions are based on review of retrospective case series, best available clinical information, community practice, and clinical experience. Factor that may influence surgical treatment selection may be: (1) disease severity, (2) degree of airway pathology, (3) patient comorbidities, (4) risks and morbidity of the procedures, (5) cost and availability of procedures, (6) risk and morbidity of anesthesia, and (7) desired patient outcomes. For example, surgical treatment of snoring often includes treatment of nasal obstruction and palatopharyngoplasty. These choices have been driven by availability, patient acceptance, and lack of tolerable alternatives. Alternatively, more severe sleep apnea is treated by more aggressive and complex protocols. The more severe the disease, the more likely major airway reconstruction will be accepted. The most common of these is the "Stanford protocol" [4]. This algorithm separates procedures into stage I and stage II procedures. Stage I procedures include: palatopharyngoplasty, genioglossus advancement, and nasal and hyoid surgeries. Stage II procedures consist of maxillofacial surgery, and maxillomandibular advancement. Treatment is initiated using stage I procedures. Those patients who fail stage I are offered stage II procedures. Although this protocol has demonstrated effect, it has not found widespread acceptance. Comparative trials of effectiveness are lacking. Technical

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limitations may include patients who are edentulous or with inadequate dentition, poor candidates for osteotomies, those with primary soft tissue abnormalities of the upper airway, or patients who refuse osteotomies. In the Stanford protocol, glossectomy or other soft tissue surgeries are not specifically addressed in either stage I or stage II.

An alternative algorithm has been to treat soft tissue abnormalities. Several protocols and other approaches can be gleaned from the literature. Chabolle describes a specific algorithm for patients with soft tissue but without skeletal disproportion [5]. Patients with relative macroglossia, lingual tonsil hypertrophy, or redundant supraglottic tissues may be considered candidates for soft tissue surgeries. Soft tissue surgeries of the lower pharynx or hypopharynx range from several different types of excisional procedures to direct tongue suspension. Many are compatible with simultaneous UPPP. Because these procedures may be performed simultaneously with UPPP or with nasal surgeries, I have arbitrarily classified them as stage I procedures. For patients with severe disease, glossectomy is a major procedure requiring perioperative tracheotomy. These procedures are often staged or performed in conjunction with, or as an alternative to, maxillofacial surgeries, and I would perform them as stage II procedures.

Airway evaluation is required for all segmental surgeries for OSAS. It is a critical (yet poorly understood) portion of surgical treatment. Multiple methods are available to evaluate the upper airway. Methods may include routine physical exam, endoscopic exam, cephalometric X rays, MRI or CT scans, and pharyngeal manometry [6–9]. Airway assessment both identifies the location and quantifies the degree of lower pharyngeal obstruction. Treatment of the upper airway requires assessment of postoperative airway risk and the possible need of tracheotomy. Hypopharyngeal collapse is often assumed implicit after UPPP failure, but this may not be a correct generalization. Failure occurs at palatal sites after UPPP failure [10,11]. Success with tongue base procedures does not prove this as a primary obstructive segment. Anatomic studies of jaw movement demonstrate that mandibular advancement may address upper (not lower) pharyngeal obstruction [12]. This anatomic linkage of airway segments may result in successful treatment of apnea even when secondary and not primary sites of obstruction are treated.

There is no clear consensus to define either the method or degree of hypopharyngeal obstruction. Nasopharyngeal endoscopy and lateral cephalometric X rays are used to determine sites of obstruction. Endoscopy may be performed during wakefulness or sleep, although the former is more accessible and utilized [13]. The methods of endoscopy even in wakefulness differ. Mueller's maneuver with collapse during an active inspiratory effort with blocked nostrils and mouth closed (a reverse Valsalva) and passive endoscopic techniques have been described [14]. Methods during sleep are both quantitative and qualitative.

Airway obstruction in OSAS is complex and may involve multiple anatomic sites and structures [11]. Following failed uvulopalatopharyngoplasty, obstruction may be complete (apnea) or partial (hypopnea). Sites of persistent obstruction vary both within the same patient as well as among different patients. Primary sites of obstruction following failed UPPP may include the lower pharynx or tongue base. Manometry and endoscopy during sleep have been used to confirm these sites as obstructive. Manometry demonstrates that obstruction is common in both the oropharynx and hypopharynx following failed UPPP. In UPPP failures, 50% may demonstrate hypopharyngeal sites of obstruction [15]. If one assesses airway obstruction as segments of airflow limitation, analysis is more complex. What percentage of individuals demonstrate the hypopharynx to be a site of increased resistance and airflow limitation either before or after UPPP is not known or well understood. Quantitative endoscopic evaluations during sleep identify single segments of narrow obstruction as uncommon. The most common site of isolated obstruction is in the upper pharynx. This is the sole site of blockage in only 20–30% of patients [16]. Most patients demonstrated multilevel obstructions involving upper and lower pharyngeal segments.

The cause of lower pharyngeal or hypopharyngeal obstruction is variable. Examples include lingual tonsilar hypertrophy and supraglottic tissue redundancy; rarely, tumors, cysts, or lingual thyroid may occur. In most individuals with OSAS, specific pathologic lesions do not occur. Instead, disproportionate anatomy of the tongue base, lateral pharyngeal wall collapse, or other causes of obstruction are observed. This disproportionate anatomy may directly obstruct the airway or may cause increased upper airway resistance. This increased work of breathing may then contribute to the apneic cycle. Often in OSAS, the tongue is not overtly pathologic, but it is obstructive. Macroglossia is related to obstruction of the pharynx and not the oris. The relationship of the size of the tongue and the size of the oral cavity has been shown to be significantly disproportionate. In OSAS patients compared with those without OSAS, oral airway volume is compromised. Tongue and palatal contact on lateral cephalometric X rays is increased [16]. Tongue size is objectively increased, and this has been linked to obesity and body mass index [17]. Pathophysiologically, tongue size has been objectively related to airway volume. It is then speculated that decreasing tongue size will increase airway volume. Decreased volume may decrease airway resistance and lessen the likelihood of airway obstruction. Also, the tongue is the anterior wall framework for the lower pharynx and, furthermore, is anatomically linked to the remainder of the pharynx. As the tongue and its position change, so does the pharynx. By reducing soft tissue tongue size, the boundaries of the pharynx may be altered. Although most airway obstruction in adults is assumed to be caused by base of tongue obstruction, proximal hypertrophy and obstruction may occur and may require anterior wedge resections to reduce tongue size.

For base of tongue obstruction in OSAS, a wide variety of glossectomy methods have been developed. Specific procedures with published data on OSAS include midline glossectomy, lingualplasty, hyo-epiglottoplasty, and radiofrequency ablation. Tools to perform glossectomy may include traditional surgical steel, CO_2 laser, KTP laser, electrosurgery, or radiofrequency [18]. Each has its own advantages and disadvantages.

Although conceptually simple, glossectomies may pose several difficulties including exposure for visualization, access to the surgical site to remove tissue and control bleeding, and airway control. With all methods, there is concern about damage to the lingual and hypoglossal neurovascular pedicle. Access to the surgical site may be intraoral (with or without tongue protrusion), endoscopic with laryngoscopes, or transcervical. Tongue protrusion with mouth opening provides limited visualization of tissues posterior to the circumvallate papilla. Contamination of the surgical wound in the oral cavity is a risk for infection. Intraoral approaches do not provide definitive landmarks to identify the neurovascular pedicle. Transcervical approaches allow identification and protection of the neurovascular pedicle. The transcervical approach also allows removal of large volumes of tissues; however, it requires external scars, tracheotomy, and prolonged recovery.

Tongue base procedures

Laser midline glossectomy

Initially described by Fujita, midline glossectomy (MLG) treated patients with severe OSAS who required tracheotomy [19]. Midline glossectomy is directed at removing a posterior strip of tongue base and performed intraorally without tongue protrusion using a CO_2 laser for access [12]. The procedure removes 1.5–2.0 cm in width tongue beginning at the circumvallate papillae. The excision is directed in the midline toward the valleculae. By staying in the midline, the lateral neurovascular pedicle is safely avoided. Care must be taken during the procedure to ensure that the midline is correctly identified, and reference maintained. Tissue is removed as aggressively as can be tolerated toward the valleculae. Posterior midline tongue, lingual tonsils, and redundant epiglottis are removed. Fujita observed that 10 out of 11 patients had removal of tracheotomy, but only 25% had clinically definitive reduction in the Respiratory Disturbance Index (RDI). The CO_2 laser allows exposure in an often-crowded and anatomically small lower pharynx. It is, however, a cumbersome method to remove large tongue volumes. The laser and endoscope also provide means of accessing the lingual tonsils and redundant supraglottic tissues. Suspension laryngoscopes may remove tissue in the hypopharynx and supraglottic larynx that may not be corrected with maxillofacial or skeletal techniques. This includes anatomic abnormalities of the supraglottis and lingual tonsils.

Lingualplasty

Woodson and Fujita described lingualplasty [20]. This procedure more aggressively removes tissue and combines midline glossectomy with lateral tongue excisions. The procedure was performed using CO_2, KTP, lasers, or electrosurgery. MLG was performed, but, in addition, a lateral wedge of tissue was removed. The remaining posterior tongue was then grasped and sutured anteriorly. In 22 patients, lingualplasty demonstrated a high success rate (70%). This was apparently a higher rate of success than MLG alone. In their series, all patients required perioperative tracheotomy. A more aggressive surgical approach resulted in a higher complication rate with a 25% perioperative complication rate observed. Complications included bleeding, edema, and persistent dysphagia.

Other glossectomy

Michelson reported MLG in another group of markedly obese patients (Body Mass Index of 38 kg/M2) with severe OSAS. He used electrosurgery [21]. Routine laryngoscopy, lingual tonsillectomy, or supraglottoplasty was not performed. Glossectomy was successful in 25%. All patients had preexisting or concurrent tracheotomy. Recovery was short with a low complication rate and minimal morbidity.

Multiple studies have combined glossectomy with other surgical procedures [22–24]. Because of widely varying patient populations and multiple concurrent procedures, results are difficult to compare. Significant improvements in OSAS are observed compared with historical controls. Meta analysis by Sher et al [14] reports that patients with Fujita Type II airway anatomy (obstruction at both upper and lower pharyngeal airway sites) UPPP alone would be expected to have a success rate of 5.3%. In Down syndrome glossectomy, palatopharyngoplasty, and maxillofacial surgery have demonstrated improved success over UPPP alone. In adults prospectively classified as Fujita Class II, a protocol with midline glossectomy and UPPP demonstrated higher success [25]. Glossectomy performed with radiofrequency demonstrates significant tongue reduction using a minor surgical procedure [26]. In selected patients, improvements in RDI and sleepiness are observed [27]. A multi-institutional study demonstrates significant clinical improvement in patients undergoing glossectomy with radiofrequency ablation [28]. The definitive treatment– success rate with this method was low, however (20–30%).

Hyoepiglotoplasty

Hyoepiglotoplasty described by Chabolle has a reported 80% success rate when combined with UPPP [5]. This procedure is a transcervical suprahyoid pharyngectomy, glossectomy, and hyoid resuspension. It has the advantage of being able to remove large tissue volumes. Neurovascular structures of the tongue are identified and preserved. The hyoid bone is then resuspended in an anterior and superior location. The position provides increased airway stability. Although Chabolle described 10 patients, patients were prospectively accrued, and no patients were lost to follow-up. Confounding variables such as weight loss were also addressed. Patients demonstrated significant soft tissue disproportion and lack of skeletal abnormalities using head and neck exam, endoscopy, MRI scanning, and lateral cephalometric X rays.

Tongue suspension suture

DeRowe described the tongue suspension procedure using a proline suture "sling" into the tongue base [29]. The tongue suspension suture theoretically prevents posterior displacement and passive collapse of the tongue base. Canine studies demonstrated decreases in airway collapse after the procedure [30]. Several case series have subsequently been presented observing various degrees of clinical improvement. A prospective multi-institutional case series of the tongue suspension suture procedure has been performed [31]. Patients in this study included a wide range of sleep-disordered breathing including both snoring and sleep apnea. Objective improvement in respiratory disturbance was observed in the OSAS group. The improvement was small with changes noted primarily in the hypopnea index and not the apnea index. Objective sleep measures did not change, but symptomatic improvement was observed in both snoring and sleepiness. Most other studies supporting the tongue suspension suture combine patients having multiple procedures such as concurrent UPPP [32]. No study includes control groups. Results are difficult to interpret. Variable outcomes may reflect the widely diverse patient population, different surgical techniques, and the learning curve of surgeons performing the procedure. Advocates suggested that the procedure is more widely accepted by patients than limited osteotomies. Comparative trials are necessary to determine if in patients with multilevel obstruction, the procedure offers benefit over uvulopalatopharyngoplasty alone.

Hyoid suspension

Hyoid suspension is often used as part of the treatment for obstructive sleep apnea syndrome. Conceptually, this procedure is most amenable when there is retro-epiglottic airway obstruction. The hyoid bone may be advanced anteriorly to the mandible or alternatively advanced onto the laryngeal cartilage [33,34]. The ideal vector of movement is not known. Moving the hyoid superiorly decreases the mandibular plane to hyoid distance (MPH). This distance is a major cephalometric abnormality observed in OSAS populations. If MPH is the critical distance, hyomandibular movement may be optimal. Other studies demonstrate that anterior and inferior movement of the hyoid apparatus stabilizes the airway to the maximum degree. If anterior inferior movement is best, hyolaryngeal advancement may be preferred. No direct comparisons exist. It is not generally intended that hyoid suspension be performed as an isolated procedure. Most studies review hyoid suspension performed concurrently with other procedures. Riley et al assessed the impact of isolated hyoid suspension in patients who had failed prior UPPP and genioglossus advancement. In eight of fifteen patients, clinically signficant improvement in RDI was observed with hyoid suspension alone.

Summary

Surgical treatment of OSAS continues to evolve. It is appreciated that airway collapse and obstruction is complex and multifactorial. Obstruction likely occurs because of abnormalities in multiple segments in many patients with OSAS. Successful procedures to treat multilevel obstruction and severe OSAS exist. Because of real or perceived morbidity, however, aggressive procedures are not widely accepted by patients or physicians. To improve the low success of site-specific pharyngeal procedures, a variety of adjunctive procedures have been developed or utilized. Sites of obstruction that may be surgically addressed include the nose, palate, lingual tonsils, supraglottis, and tongue base. Conceptually, each of these may help achieve the goal of a larger, more stable upper airway. Comparative studies assessing effectiveness using a scientifically based approach to correcting the upper airway is lacking. Future studies will ultimately better define algorithms using appropriate surgical procedures. At this time, clinical judgment based on a comprehensive evaluation of the upper airway, disease severity, and patient wishes must be used to select these procedures.

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