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ORIGINAL CONTRIBUTION

Lingual tonsillectomy and midline posterior glossectomy for obstructive sleep apnea

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Radiofrequency plasma surgery;
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Sleep disorders;
Sleep medicine

Obstructive sleep apnea syndrome (OSA) results from the interaction between a structurally small and vulnerable upper airway and loss of compensatory reflexes. Surgical treatment is indicated in patients who fail medical treatment and aims to reduce obstruction by increasing airway size and decreasing collapsibility. Common components of airway obstruction in obstructive sleep apnea are relative macroglossia and lingual tonsil enlargement, both of which are amenable to surgical reduction. A technique is described that uses transoral, angled lens, rigid fiber-optic scopes with video camera to provide visualization and a malleable plasma surgery tool for tissue removal. Using this technique as part of a multilevel surgical approach, the apnea-hypopnea index was significantly reduced. Postoperative morbidity was generally low and included postoperative pain, dysphagia, transient change in taste, and bleeding. Patients were monitored in the outpatient ward and were discharged the morning following surgery. No patient required tracheotomy.

Obstructive sleep apnea syndrome (OSA) results from the interaction between a structurally small and vulnerable upper airway and loss of compensatory ventilatory control. It is widely accepted that multiple factors add to the risk of collapse and that when the sum of all anatomic and physiological factors reach a critical threshold for collapse, obstruction occurs. As multiple anatomic structures may contribute to a smaller airway including craniofacial structure or excess soft tissues, multiple surgical modifications may enlarge the upper airway. Included among these procedures are lingual tonsillectomy and partial glossectomy. These procedures have not been widely used due to partial effectiveness and concerns about difficult surgical exposure, postoperative airway control, and surgical morbidity.

Concept

Failure of uvulopalatopharyngoplasty may occur because of primary, persistent retropalatal obstruction, or secondary obstruction in the hypopharynx or retroglossal airway. Surgery for OSA has the goal of enlarging the airway by increasing the size of the skeletal enclosure or reducing the volume of soft tissue. To better understand how altering volume may affect multiple sites of obstruction in the pharyngeal airway, an analogy to a box of facial tissues may be used. This product includes a box of fixed size that has contents of both tissue and air. If the airspace is to be increased, the volume of air in the box may be increased by enlarging the box or reducing the soft tissue. Lingual tonsillectomy and posterior glossectomy reduce tissue volume and increase the size of the upper airway, likely altering both primary and secondary sites of upper airway obstruction.

Older methods of performing these procedures have been associated with difficult exposure, inadequate tissue removal, and excess morbidity. Both macroglossia and a smaller facial skeletal structure make exposure difficult especially under general anesthesia. Traditional exposure ob-

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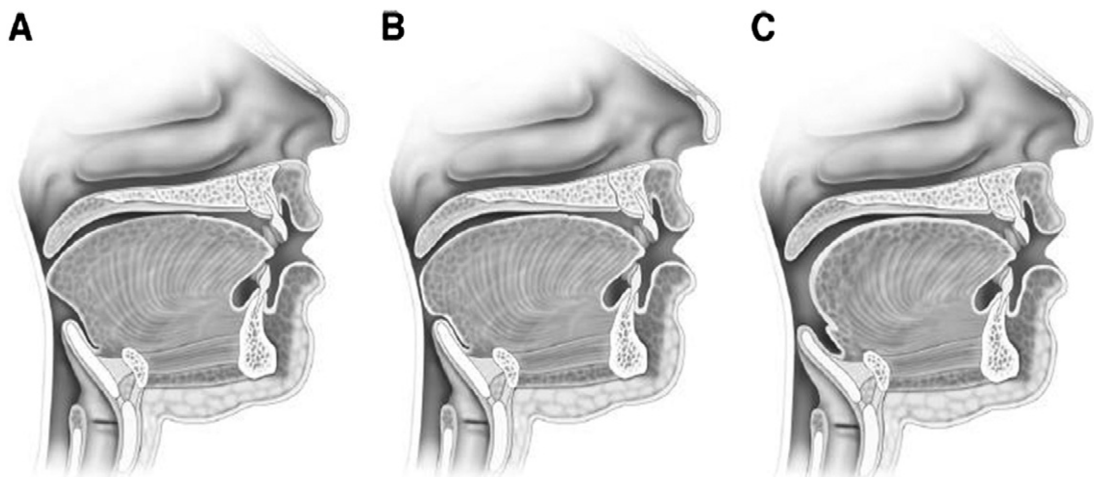

Figure 1 Moore Tongue base classification of hypopharyngeal obstruction pattern is depicted. Type A describes isolated upper tongue base obstruction. Type B is combined upper and lower tongue base obstruction. Type C is lower tongue base obstruction (retrohyoid/retroepiglottic). (Reprinted with permission from Woodson.[2])

tained using suspension tonsil mouth gag or rigid laryngoscopes was inadequate for proper visualization of the tissues to be removed. Furthermore, traditional tools and methods of excision, such as laser, cautery, or cryotherapy, are difficult to use transorally and have been associated with significant postoperative tissue edema and marked pain. Early techniques[1] of posterior midline glossectomy reduced apneas but had up to 30% complications. Due to risks of bleeding, edema, and excess pain requiring narcotics, a tracheotomy was often performed for protection of the airway. This limited acceptance of the procedures.

A technique that combines tissue removal by excision and low morbidity of ablation is desirable. Thus, the current excision technique[2] was developed using angled lens, rigid fiberoptic scopes attached to a video camera for better visualization. The procedure is performed transorally and combined using tongue retention sutures, a better view of the tongue base and lingual tonsils may be obtained. A malleable plasma surgery tool directly excises tissue from the tip of the wand and is flexible enough to access difficult areas. The plasma surgery tool, "Coblation" (Arthrocare Corp, ENTec, Sunnyvale, CA), is a bipolar plasma surgery tool that creates a low temperature plasma field, which breaks the molecular bonds between tissues. Volumetric tissue removal is relatively bloodless without char. This tissue removal method is less traumatic, has less edema, and decreases the morbidity.

Lingual tonsillectomy evaluation

Symptoms of lingual tonsil hypertrophy may include snoring, apneas, sleepiness, as well as other symptoms such as dysphagia, nocturnal choking, recurrent nocturnal awakening, and insomnia. Confirmation of lingual tonsil hypertrophy may be done with routine indirect mirror examination of the upper airway or flexible nasopharyngoscopy/laryngoscopy. Occasionally, sedated endoscopy may be needed to identify the enlarged lingual tonsils. Lingual tonsil hypertrophy may be otherwise missed by the routine nonotolaryngic examination, as it is not necessarily associated with other skeletal or soft-tissue abnormalities. It is not included in the Friedman[3] or Fujita[1] staging and requires a high index of suspicion. The etiology of lingual tonsil hypertrophy may include infection (eg, human papillomavirus), allergy, gastroesophageal reflux disease, or unknown causes. Rarely, a neoplastic disease may contribute. Evaluation and management may warrant MRI or CT imaging and trials of medical management. Speech, swallowing, and taste may all be altered by surgical treatment and should be clinically assessed before surgery. Objective testing may be warranted if abnormal, if patients have preexisting dysfunction, are at excessive risk of dysfunction, or engage in particular occupations (eg, professional chefs and taste changes, etc.).

Glossectomy evaluation

Enlarged tongue size or relative macroglossia may be associated with obesity, a smaller craniofacial structure and rarely amyloidosis, lingual thyroid, or other tumors. Symptoms are those of OSA and snoring. The Moore and Phillips[4] classification classifies abnormal hypopharyngeal anatomy into 3 basic types—A, high tongue base obstruction; B, combined of both high and low tongue base and retroepiglottic obstruction; and C, retroepiglottic obstruction (Figure 1). Glossectomy may be best indicated in both Moore type A and B. Absolute contraindications to glossectomy for sleep apnea may include patients with known severe swallowing or speech problems and those at severe risk of aspiration if any swallowing difficulties occur.

Anatomic landmarks

Few external landmarks guide the surgeon, and the anatomy may easily be distorted due to traction during the procedure. Sleep apnea patients have anatomy that is difficult to visualize due to a small mouth and relative macroglossia. Airway visualization is further compromised with loss of muscle tone under general anesthesia. Knowledge of the internal anatomy of the tongue is crucial to avoid damage to the neurovascular bundle. The lingual artery's path through the tongue is sigmoidal (Figure 2). Three anatomic segments are described (oblique, profunda, and anterior segments). The oblique segment enters the tongue posteriorly, generally passing parallel to the inferior border of the mandible, medial to the hyoglossus muscle, and medial to the hypoglossal nerve. Approximately, 2 cm from the posterior border of the tongue, the artery changes direction and courses vertically (profunda lingua segment). The profunda lingua courses lateral to medial. Cadaver dissection demonstrates that at its junction with the oblique segment, the profunda lingua is up to 2 cm from the midline, but at its junction with the anterior segment, it is immediately lateral to the genioglossus muscle approximately 1 cm from the midline (Figure 3). The anterior segment begins about 1 to 1.5 cm posterior to the frenulum and continues to course parallel to the genioglossus muscle. Since the lingual artery is identifiable with either ultrasound or Doppler, it provides a landmark for the hypoglossal nerve, which passes lateral to the vessel in the oblique segment and anterior and inferior to the profunda and anterior segments.

Anesthesia/preparation

For optimal exposure, the patient is placed in a semirecumbent position, with the top of the bed elevated at 30°. Mapping of the lingual artery is performed using ultra-

Figure 2 Anatomy of lingual artery. The sagittal view of the lingual artery and its sigmoid shape. (Color version of figure is available online.)

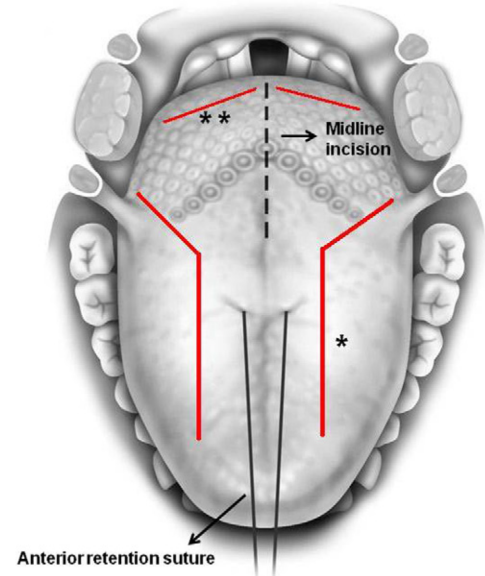

Figure 3 The red line with * depicts the axial view of the artery, ** depicts the hyoid branch at the base of tongue posteriorly. The artery has 3 segments in the tongue, that is, the oblique, profunda lingua, and anterior segments. At 2 cm from the posterior border of the tongue, the artery segment changes direction and courses vertically, oblique segment is 2 cm from the midline but then moves more to the midline. The anterior segment of the artery just lateral to the genioglossus muscle is 1 cm from the midline. (Reprinted with permission from Woodson.[2]) (Color version of figure is available online.)

sonography[5] or a high-resolution Doppler. The medial to lateral course of the anterior segment is marked on the dorsum of the tongue. Imaging can then identify the point where the artery diverges laterally. This marks the profunda segment, which can also be marked on the surface of the tongue. Tissue that is medial and posterior to these marks theoretically lies in the "safe zone of the tongue."

Lingual tonsillectomy and glossectomy are often performed under general anesthesia with nasotracheal intubation. Chlorhexidine gluconate (0.12%) mouth rinse is used for oral antisepsis. Prophylactic, broad-spectrum antibiotic (ie, cephalexin and metronidazole) and dexamethasone (10 mg) are administered. Local anesthetic is injected into the middle of the tongue and into the sites of planned tissue removal (Figure 4B). This provides preemptive analgesia but must be limited to avoid impairing tongue function on extubation. As with all airway surgery for OSA, coordination of the surgeon and the anesthesiology team is critical, and a plan of intubation, extubation, and perioperative management should be in place.

Endoscopic submucosal midline posterior glossectomy

Step 1

The surgical field is visualized with a 45° rigid sinus scope, although a 30° or 70° may also be used. The posterior

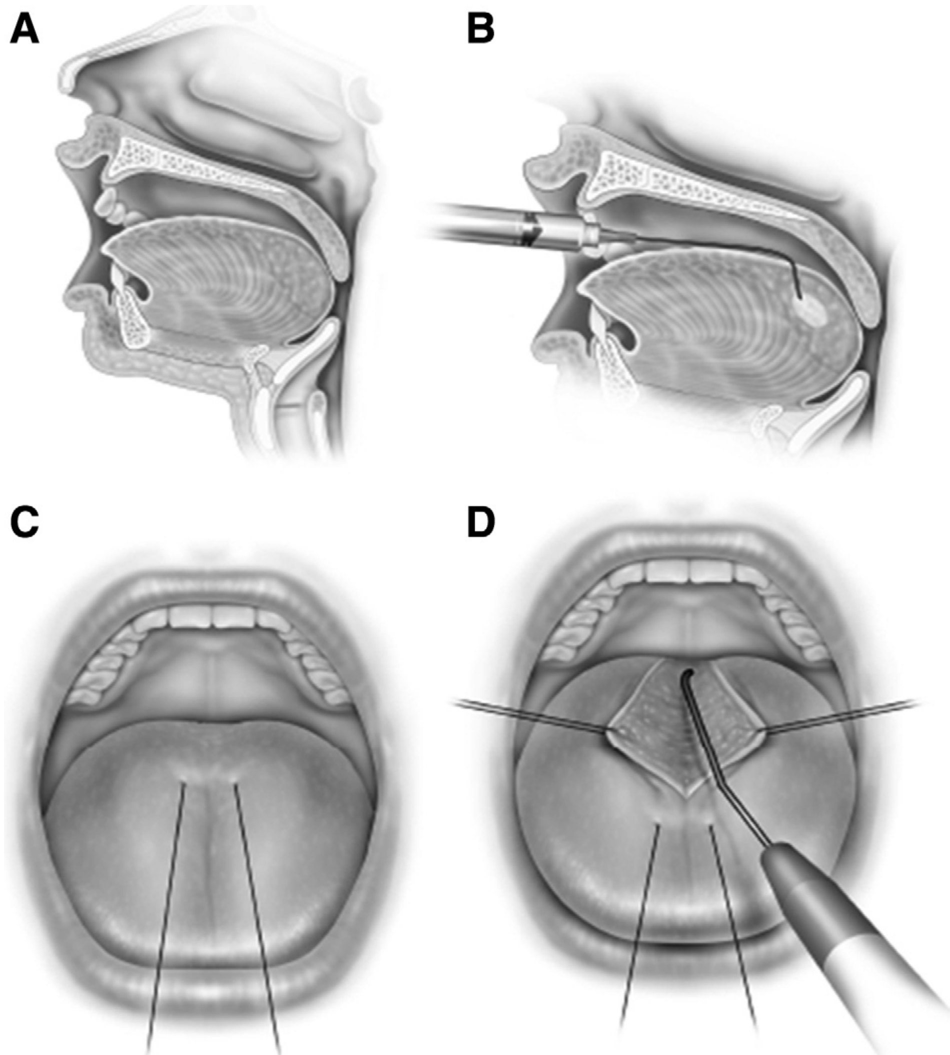

Figure 4 Submucosal glossectomy is depicted. The primary site to be excised is posterior oral and hypopharyngeal tongue (A). Local anesthesia is facilitated by bending the injection needle (B). Midline retraction suture should be placed as far posteriorly as possible (C). After the midline incision is created, 2 lateral traction sutures are placed, and a plasma wand is used to progressively excise tissue (D). (Reprinted with permission from Woodson.[2])

tongue is observed using a video camera system, with a magnified view on the screen. Three retention sutures are placed. The first is in midline of the tongue anterior to circumvallate papillae will allow (Figure 4C). After a midline trench incision is created, 2 additional retraction sutures are placed on the lateral edges of the trench Figure 4D. All retention sutures are tied with an "air knot," which is then threaded by an elastic catheter of the surgeon's choice. These flexible catheters can then be "clipped" to the surgical drapes to provide a self-retaining tongue retractor.

Step 2

Tissue is then removed using a plasma wand (Coblation Evac 70 tonsil and adenoid wand, Arthrocare, Sunnyvale, CA). Medium-to-low saline flow rates may be achieved using a pressure cuff on the saline bag, but ample saline must flow through the coblation wand to prevent tissue overheating. Coblation settings of 6 to 9 are used, as lower settings are associated with less "current leak" and muscle stimulation. Bending the midportion of the probe facilitates its use. The wand may become obstructed and may need to be flushed manually with saline using a 10-mL syringe attached to a 3-way stop cock on the suction port of the device. Occasionally, the probe may wear during the procedure requiring replacement with a new one.

The initial tissue removal is at the midline trench that is subsequently used for 2 retention sutures. Alternatively, especially if more anterior tongue removal is required, a 1.5-cm wide midline segment of tongue is demarcated either with the plasma wand or cautery. This can be grasped with Allis forceps, and then tissue can be aggressively excised posteriorly. When exposure is restricted, the tissue is amputated and the midline trench method is continued as mentioned later in the text. The midline trench combined with placement of traction sutures provides much improved visual exposure and working space for the posterior tongue.

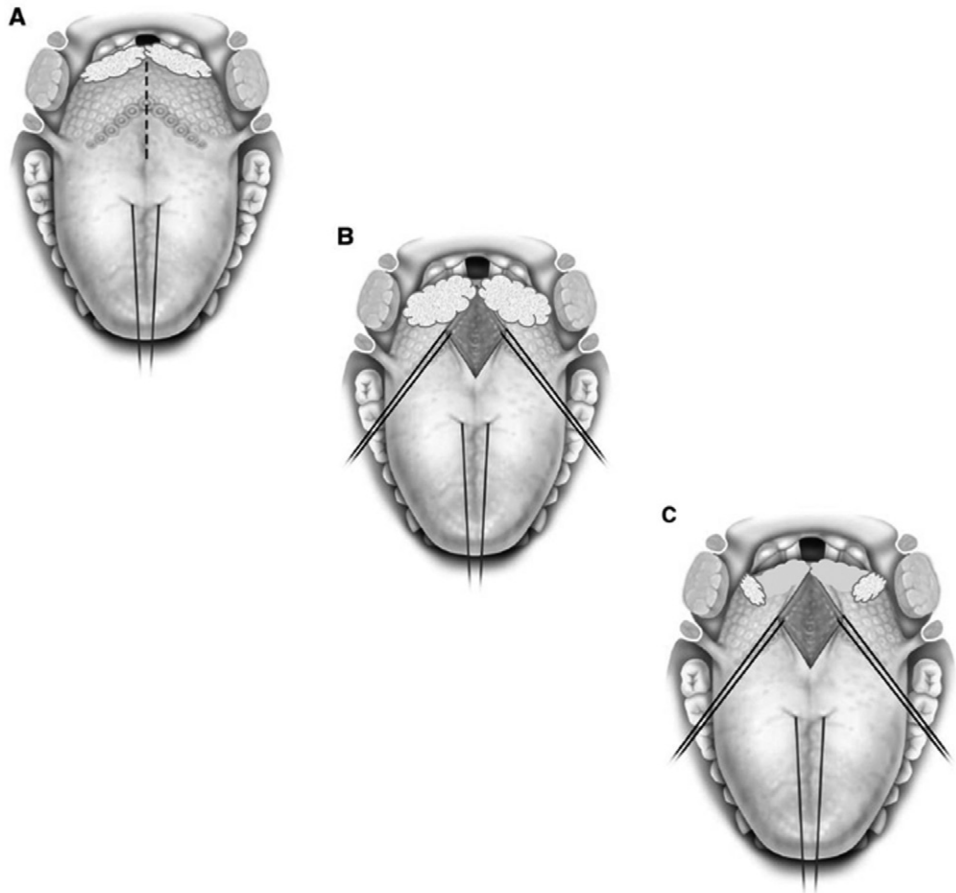

Figure 5 Lingual tonsillectomy exposure is depicted. Approach for visualization is similar to glossectomy, but often in OSA patients, lingual tonsils may not be readily exposed without lateral traction sutures (A). Three traction sutures expose the lingual tonsils and a midline trench created in the posterior tongue can further enhance visualization (B). Lingual tonsil tissue is removed posteriorly and laterally with a remaining lateral cuff of tissue preserved (C).

Lateral and posterior tongue tissues can now be excised. The goal is to avoid or minimize mucosal damage to the tongue. No attempt is made to avoid mucosal removal in lingual tonsillectomy. As the surgeon continued surgery submucosally near the vallecula, a hyoid branch of lingual artery can be encountered. Bleeding from this vessel may require suction cautery for control or rarely suture ligature. During dissection, attention must be taken to maintain a midline orientation, by equal lateral traction and frequent verification of the position. Releasing the tongue back to neutral position may aid in verification of orientation and provide restoration of venous blood outflow to the tongue. The tongue should be released every 30 to 40 minutes to avoid excessive vascular congestion. When the tongue is aggressively pulled forward, a tooth guard may be used to protect the ventral surface of the tongue from sharp lower teeth.

Step 3

Prolapse of the tongue tissue will generally obliterate the space created. One or 2 absorbable sutures are placed anteriorly to decrease dead space and reduce formation of an excessive furrow in the midline of the tongue. The wound is left open posteriorly to allow the drainage of any fluids and to reduce the possibility of a closed space abscess, which may compromise the airway.

Lingual tonsillectomy

A 45° or 70° angled rigid fiberoptic scope is used for visualization similar to the glossectomy technique (Figure 5A). Three traction sutures, as used in the glossectomy, are used to retract the tongue forward and also pull up the lingual tonsils (Figure 5B). If tonsils are readily visible, a curved Allis forceps maybe used to grasp the lingual tonsil tissue, and an en bloc dissection is performed using the coblation wand. Such exposure is infrequent in the OSA patient. Even the most experienced endoscopists cannot often expose the surgical field for lingual tonsillectomy in OSA patients, and a small partial glossectomy is required to visualize the lingual tonsils. Tonsil tissue is then removed posteriorly and laterally. Mucosa is not preserved in most cases. Blood vessels may be countered laterally as lingual tonsils merge with palatine tonsils. The coagulation mode of the coblation wand is used to secure hemostasis, although occasionally a suction cautery is required. It is imperative

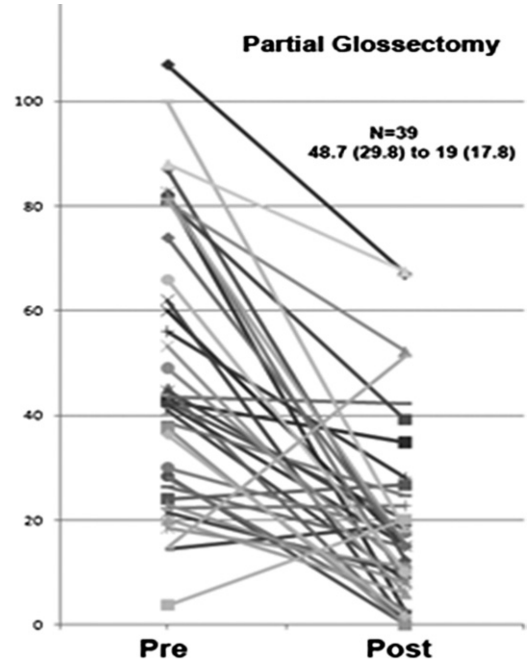

Figure 6 Change of AHI after partial glossectomy.

that a lateral cuff of tissue is left adjacent to the palatine tonsil and lateral pharyngeal wall to prevent hypopharyngeal stenosis (Figure 5C). As with glossectomy, intermittent release of traction on the tongue is required to reduce tongue edema and ischemia.

Postoperative care

Special attention is given to the extubation process; there are risks of desaturation, laryngospasm, upper airway obstruction, and bleeding. Prophylactic intravenous antibiotics are given for 1 day, and the authors empirically use oral antibiotics (antistreptococcal) for 5 days. To decrease antibacterial load, chlorhexidine mouth rinses are also used for 1 week postoperatively. Pain is controlled using a multimodal analgesia regimen comprising of non-steriodal anti-inflammatory drugs, narcotics, acetaminophen, and an analgesic mouth wash mix (lidocaine/diphenhydramine/antacid). Topical sucralfate for a swish and swallow is administered to reduce pain.[6,7] Low-dose systemic steroids

Table 1 Change in AHI following partial glossectomy or lingual tonsillectomy

Procedures	n	AHI Pre	AHI Post	*P* value
Partial glossectomy	39	48.7 (29.8)	19 (17.8)	<0.0001
Lingual tonsil	23	45.9 (35)	16.8 (19.0)	<0.0001
Total	62	47.6 (29.7)	18.2 (17.9)	<0.0001

AHI, apnea-hypopnea index.

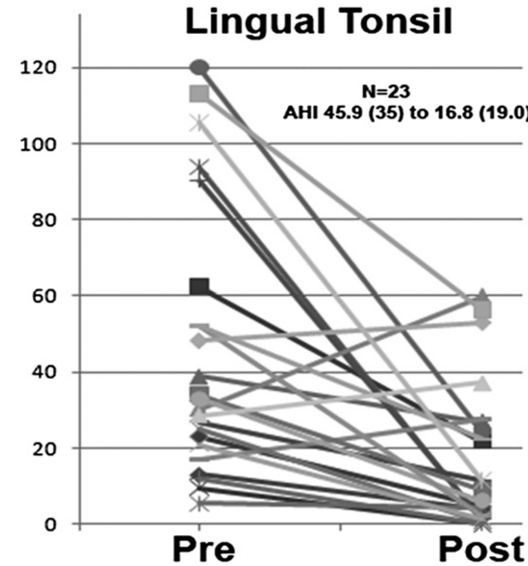

Figure 7 Change of AHI after lingual tonsillectomy.

are prescribed and tapered over 5 days to reduce the hyper-inflammatory response associated with the supercontamination of the oral wound.[8] Gastroesophageal reflux is treated prophylactically with H2-receptor antagonists. Ice popsicles applied intraorally are also used to reduce pain, and anecdotally, some patients state that an external ice pack on the neck helps relieve pain. A liquid or soft diet can be started on day 1. If transient pharyngeal dysphagia from food residue in the hypopharynx is experienced; a modified supraglottic swallowing technique may be helpful. Patients are observed overnight for any respiratory complications or risks of bleeding and discharged the following day. Continuous positive airway pressure (CPAP) usage is encouraged perioperatively if tolerated; polysomnography is repeated after 6 weeks or more. Tongue swelling, edema, and pain often are minor compared with other prior glossectomy lingual tonsillectomy techniques.

Results

Patient data were collected from November 2006 to March 2010. A total of 195 patients enrolled for surgery after they failed to respond to a trial of CPAP treatment. The surgery algorithm consisted of staged and multilevel surgery, which comprised lingual tonsillectomy and/or partial glossectomy with subsequent palatoplasty. A total of 71 patients underwent lingual tonsillectomy and/or partial glossectomy. Sixty-two patients had pre- and postoperative polysomnography, 76% were male and 24% were female. Thirty-nine patients underwent partial glossectomy. Mean body mass index was 32.3 (±8) kg/m^2. Mean apnea-hypopnea index (AHI) presurgery was 48.7 (±29.8) events/h. Mean AHI after surgery was 19 (±7.8) events/h (Figure 6 and Table 1). Twenty-three patients underwent lingual tonsillectomy without partial glossectomy. Their mean body mass index was 32.5 (±3) kg/m^2. Mean AHI presurgery was 45.9 (±35) events/h and mean AHI after surgery was 16.8 (±SD 19) events/h (Figure 7).

Complications

Retrospective analysis of charts was performed. All patients experienced pain postoperatively, controlled with the multimodal analgesia regimen. Data on pain were not reported, as they were not prospectively measured; the first author anecdotally reports pain to be significantly lower than in traditional methods. Patients were monitored in the outpatient ward and were discharged the morning following surgery, and none required additional hospitalization or IV hydration. Minor bleeding that did not require hospitalization or emergency room visits was occasionally reported. One patient had postoperative tonsillar bed bleeding treated in the operation room. One patient had a residual midline tongue defect that retained debris and required surgical revision. Two patients whose OSA did not resolve continued CPAP treatment, reporting that CPAP was more tolerable than before surgery. A small number of patients who underwent lingual tonsillectomy experienced dysphagia, but symptoms were mild and improved without any further diagnostic or therapeutic interventions. This dysphagia at the level of the vallecular space is presumably due to the epiglottis acting as a "scoop" that may catch or trap food with swallowing. Minor alterations in taste were more common postoperatively following lingual tonsillectomy, but no patient was objectively noted to have persistent taste changes in this group.

Discussion

In previous studies, partial glossectomy was performed after uvulopalatopharyngoplasty failure, with a success rate of 25% to 67%,[9-11] since first described by Fujita et al.[1] The major obstacles to acceptance of tongue surgery in the past were the high morbidity and risk of serious bleeding. Subsequently, radiofrequency thermal ablation was described with lower morbidity but limited effectiveness.[12] The current technique was developed to maximize soft-tissue removal and minimize morbidity. As morbidity is low, the procedure can be repeated safely if additional volume reduction is required. Soft tissue, volumetric, excisional surgery is rarely curative, but as results demonstrate, a marked reduction in disease severity is often observed. Such a reduction may often reduce disease to a level below that which is associated with major cardiovascular and medical complications.[13] However, as it is not definitive, we believe surgical treatments must minimize side effects and rate of complications.

Although the aforementioned results are promising, future studies are required to better define outcomes, complications, and subsets of patients most likely to benefit from these tongue base procedures. Clinically relevant outcomes independent of a surrogate marker such as the AHI are required.[14]

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