



Research Paper

Hyoid myotomy and suspension without simultaneous palate or tongue base surgery for obstructive sleep apnea[☆]



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KEYWORDS

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Abstract *Objective:* Determine the effects of hyoid myotomy and suspension (HMS) without concurrent palatal or tongue base sleep surgery for obstructive sleep apnea (OSA).

Method: Patients with OSA treated with HMS were identified using CPT code (21685) at an academic and private sleep surgery clinic. Those who underwent concurrent palatal or tongue base sleep surgery were excluded. Outcomes included simultaneous procedures, apnea-hypopnea index (AHI), lowest oxyhemoglobin saturation (LSAT), and Epworth Sleepiness Scale (ESS).

Results: Nineteen patients with OSA underwent HMS without palatal or tongue base sleep surgery. The average age at surgery was (55.3 ± 13.5) years with a majority of patients being male (71%). Concurrent procedures included the following: torus mandibularis excision ($n = 1$), endoscopic sinus surgery ($n = 4$), septoplasty ($n = 10$), inferior turbinate reduction ($n = 12$), and nasal valve repair ($n = 2$). AHI improved significantly from (39.7 ± 21.2) events/h to (22.6 ± 22.7) events/h after HMS ($P < 0.01$), which represented a 43% reduction. LSAT

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significantly increased from $(82.2\% \pm 9.9\%)$ to $(86.6\% \pm 6.2\%)$, $P < 0.01$. There was no improvement in ESS after surgery (8.2 ± 4.4) to (8.3 ± 5.2) , $P = 0.904$. A subset of patients with severe OSA (AHI > 30 events/h) had an improvement in AHI from (49.9 ± 16.6) events/h to (29.1 ± 24.9) events/h, $P < 0.01$.

Conclusion: HMS without palatal or tongue base sleep surgery improves OSA severity. It can be considered as a valid option in the treatment of OSA in appropriately-selected patients.

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Introduction

Obstructive sleep apnea (OSA) is a condition characterized by recurrent partial or complete obstruction of the upper airway during sleep, which affects approximately 2%–4% of middle-aged adults.¹ Although the first-line treatment for moderate-to-severe OSA is continuous positive airway pressure (CPAP), long-term compliance is poor and estimated to be as low as 50%.² Alternatively, upper airway surgery has been proposed as a salvage therapy in order to decrease the repetitive obstructions in those intolerant of CPAP therapy. Multiple surgeries have been introduced including tissue removal or remodeling procedures of the palate and base of tongue to address the different levels of collapse seen in the upper airway.³

Another potential site of collapse in addition to the palate and the tongue base is at the level of the hypopharynx.⁴ Anatomic studies have shown that those with OSA often have an abnormally low hyoid bone which has a tendency to cause hypopharyngeal obstruction with posterior collapse of the epiglottis and a reduced retroepiglottic airway.⁵ One solution is to reposition the hyoid bone, thus stabilizing both the tongue base and advancing the epiglottis away from the posterior pharyngeal wall. Recently, a bone-anchored mandibular suspension suture system (AirLift; Siesta Medical, Inc., Los Gatos, California) has been adapted for hyoid myotomy and suspension (HMS), which repositions a retroflexed epiglottis in an anterior and superior vector using suspension sutures anchored on the lingual surface of the anterior mandible.

Prior studies have studied varying techniques for HMS; however, no study has reviewed the use of mandibular suture suspension systems as an isolated procedure for OSA.^{6–8} The purpose of the study is to determine the effects of HMS without concurrent palatal and tongue base sleep surgery on polysomnographic and clinical outcomes. In addition, the effectiveness of the technique for severe OSA is also investigated.

Materials and methods

Study design

Patients who underwent HMS for obstructive sleep apnea between January 2011 and November 2015 were identified using the CPT code 21685. This was performed at both a private (Metropolitan ENT, Alexandria, VA) and academic

(Medical University of South Carolina [MUSC], Charleston, SC) sleep surgery clinic. Identified patients were limited to those undergoing HMS the AirLift system. Identified patients were limited to those undergoing HMS with the AirLift system. In addition, those who underwent concurrent sleep surgery of the palate (ex. uvulopalatopharyngoplasty) or tongue base (ex. glossectomy, lingual tonsillectomy, submucous lingual excision, or radiofrequency ablation) or did not have both preoperative and postoperative polysomnography results were excluded. Patients with concurrent nasal surgery or non-sleep procedures were included since multiple studies have demonstrated that nasal surgery has no appreciable effect of AHI.⁹ The following variables were obtained: demographics [age, sex, body-mass index (BMI)], concurrent surgical procedures, polysomnographic data [apnea-hypopnea index (AHI), lowest O₂ saturation (LSAT)], and clinical data [Epworth Sleepiness Scale (ESS), complications]. Approval from the Institutional Review Board of the Medical University of South Carolina was obtained for this study (Pro00050486).

Patients included in this study were initially seen in the sleep surgery clinic for history and physical examination. Preoperative evaluation revealed hypopharyngeal collapse with retroflexion of the epiglottis without significant palatal or tongue base narrowing on supine upper airway endoscopy which was confirmed on subsequent drug-induced sleep endoscopy (DISE). Patients underwent HMS using a mandibular suture suspension system. Concurrent nasal procedures or non-sleep related procedures were performed as determined by the operating surgeon. Patients were regularly followed up during the postoperative period to evaluate progression of healing and to manage any complications that occurred. Patients were also scheduled for postoperative polysomnography to determine whether there was change in sleep-related respiratory parameters.

Surgical technique for hyoid myotomy and suspension

The submental crease and a natural skin crease over the hyoid bone were marked and infiltrated with 2–3 ml of 1% lidocaine with 1:100,000 epinephrine. The submental incision was made and carried down to the mandible. The bone of the central lingual portion of the mandible was cleaned of soft tissue using electrocautery and periosteal elevators. Care was taken to not detached the tendon at the genio-glossus tubercle. A drill hole was placed on either side of

the midline followed by insertion of the anchor screws for a total of two screws.

A separate 3–4 cm incision was made in a natural skin crease over the hyoid bone. Electrocautery dissection was carried down to the anterior border of the hyoid. The central portion of the hyoid bone was visualized without significant release of the hyoid musculature. Using a specialized suture passer, a suture loop was passed around the hyoid bone in two locations and the tails of the suture then passed through the loop to fully encircle the hyoid in two locations.

The tip of a clamp was passed from the submental incision to the hyoid incision in the subcutaneous tissue using blunt dissection. The ends of the two sutures were grasped by the clamp and pulled through the submental incision. The sutures were then separated and one suture was placed through the eye of each anchor screw. By pulling the suture through the eye of the screw, the amount of tension and lift of the hyoid bone could be precisely adjusted. Once the desired tension was placed on each suture, the adjustable screw in each anchor was tightened to secure the screw in that position. Excess suture was cut leaving a small tag that could be found in the tissue at a later date should the tension on the suture need to be adjusted. The wounds were thoroughly irrigated and closed in layered fashion without use of a drain. A light pressure dressing was then applied to the wound.

Statistical analysis

All data analyses were performed with SPSS 23.0 (IBM Corporation; Armonk NY). Categorical variables are presented as frequencies and percentages (%), and continuous variables are presented as mean \pm standard deviation. The Kolmogorov–Smirnov test was used to test if continuous variables were normally distributed. Preoperative and postoperative outcome measures were tested using either the dependent *t*-test or Wilcoxon signed rank test. A *P*-value less than 0.05 was considered statistically significant for all statistical tests.

Results

A total of 19 patients who underwent HMS without concurrent palatal or tongue base sleep surgery were identified with a mean age of 55.3 years (range, 31–76 years). Most patients were not obese with a majority of patients having moderate to severe obstructive sleep apnea. The most common concurrent procedures were nasal surgery, most commonly endoscopic sinus surgery, followed by septoplasty (Fig. 1). No postoperative complications were noted in this series. Descriptions of patient variables are summarized in Table 1.

The outcomes of HMS are listed in Table 2. Both AHI and LSAT improved significantly postoperatively; however, ESS was unchanged. Surgical success (postoperative AHI <20 events/h and >50% reduction of preoperative AHI) was achieved in 47.4% of patients. Table 3.

A subset of patients ($n = 13$) with severe obstructive sleep apnea (AHI >30 events/h) were also evaluated (Table 2). Simultaneous procedures were inferior turbinate reduction ($n = 7$), septoplasty ($n = 6$), endoscopic sinus

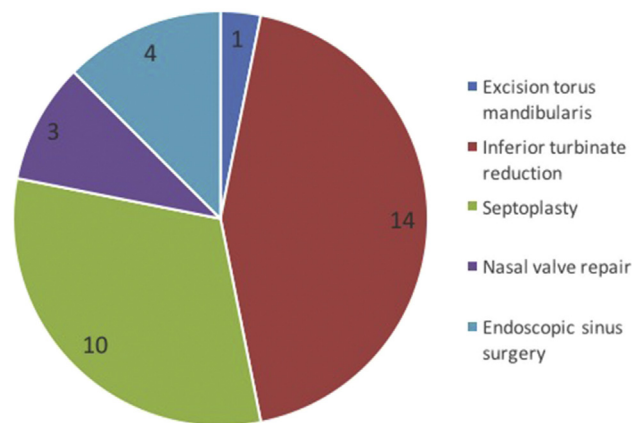


Fig. 1 Concurrent procedures performed with hyoid myotomy and suspension.

Table 1 Description of patients undergoing hyoid myotomy and suspension.

Patient variable	
Female, No. (%)	6 (29)
Male, No. (%)	15 (71)
Mean age, y (range)	55.3 (31–76)
Mean BMI (range)	29.2 (22.8–43.4)
Mild apnea (AHI <15 events/h), No. (%)	2 (11)
Moderate apnea (AHI 16–30 events/h), No. (%)	4 (21)
Severe apnea (AHI >30 events/h), No. (%)	13 (68)
Complications, No. (%)	0 (0)

Table 2 Outcomes before and after hyoid myotomy and suspension ($n = 19$).

Outcome variable	Pre	Post	<i>P</i> value
BMI, mean (SD)	29.2 (5.7)	28.9 (6.1)	0.172
AHI, mean (SD)	39.7 (21.2)	22.6 (22.7)	<0.01
Lowest O ₂ saturation, mean (SD)	82.2 (9.9)	86.6 (6.2)	<0.01
Epworth Sleepiness Scale, mean (SD)	8.2 (4.4)	8.3 (5.2)	0.904
Surgical success (>50% reduction in AHI and postoperative AHI <20 events/h), No. (%)	9/19 (47.4)	–	–
Final AHI <10 events/h, No. (%)	8/19 (42.1)	–	–

Table 3 Description of patients with severe apnea (AHI >30).

Patient variable	
Female, No. (%)	4 (31)
Male, No. (%)	9 (69)
Mean age, y (range)	55.3 (31–76)
Mean BMI (range)	30.6 (22.9–43.4)

surgery ($n = 1$) and nasal valve repair ($n = 1$). Six (46%) underwent HMS alone. AHI was significantly reduced postoperatively (49.9 ± 16.60 to 29.1 ± 24.9 , $P < 0.01$), as was LSAT ($80.9\% \pm 11.0\%$ to $85.7\% \pm 7.3\%$, $P = 0.024$). There was no significant difference in ESS postoperatively (8.8 ± 4.1 to 8.8 ± 5.4 , $P = 0.906$). Five (38.5%) patients achieved surgical success. Individual preoperative and postoperative AHI outcomes for this subset are seen in Fig. 2.

Discussion

The position of the hyoid bone and associated musculature play an important role in OSA. It is thought to affect upper airway patency as well as resistance, and abnormal positioning can cause an increased propensity for upper airway collapsibility.^{5,10} In addition, another factor causing hypopharyngeal obstruction is reduced neuromuscular tone during sleep in patients with OSA causing further malpositioning of the hyoid bone.^{11,12}

Since the recognition of hypopharyngeal collapse as a contributor to OSA, multiple surgical procedures have been developed to address this issue. These include mandibular osteotomy and genioglossus advancement, and hyoid repositioning procedures such as hyoid myotomy and suspension, hyothyroidopexy, expansion hyoidoplasty, and hyoid sectioning.¹³ HMS was first described by Riley et al in the 1990s, in which the infrahyoid musculature was resected and the hyoid bone was suspended to the mandibular periosteum using fascia lata, in order to shift the hyoid bone more anteriorly.¹⁴ Later, this technique was modified to secure the anteriorly positioned hyoid bone to the thyroid cartilage (thyrohyoidopexy) with the goal of stabilizing the base of tongue using a single incision approach.¹⁵

An evidence-based literature review found that the thyrohyoidopexy technique had a mean success rate of 50% (range, 17%–78%) in the combined 101 patients from four studies when performed in conjunction with a previous or simultaneously performed palate surgery which is only marginally better than the 40% success rate of UPPP alone.¹³ Another study found that only 21% (6/29) of patients undergoing thyrohyoidopexy with a previous or

simultaneously performed UPPP achieved a 50% reduction in AHI and an overall AHI <20 events/h.¹⁶ Conversely, a case series of OSA patients undergoing HMS with a mandibular screw suspension system with or without concurrent UPPP demonstrated an overall surgical success (AHI reduction $\geq 50\%$; overall AHI <20 events/h) rate of 70%. The authors of that study proposed that HMS may be more effective at pulling the epiglottis anteriorly via the hyoepiglottic ligament than at stabilizing or advancing the base of tongue. Secondly, the anterior–superior vector is the normal vector of the hyoid during swallow and allows for greater displacement than the more anterior–inferior vector of a thyrohyoidopexy.⁷ In a series of patients with persistent OSA after upper airway surgery, 0% of patients who had undergone HMS was observed to have epiglottic collapse on drug-induced sleep endoscopy compared to 24% of patients not received HMS.¹⁷ This study provides further evidence that the main effect of HMS is enlargement of the retroepiglottic airspace and not tongue base stabilization.

The AirLift system (Encore Medical, Inc.) technique described in this study is similar to other mandibular screw-anchored hyoid suspension techniques with a couple of key differences. In this technique, each suture is passed through anchoring screw allowing the amount of hyoid advancement to be precisely adjusted depending on the amount of suture pulled through the anchor. In addition, the tension on the hyoid can be adjusted at a later date if needed. Unlike earlier reports, this study presents the outcomes of HMS using the AirLift system as an isolated procedure as treatment for OSA without simultaneous palatal or tongue base surgery. The study did include patients who had concurrent nasal or non-sleep related procedures. Although nasal surgery reduces respiratory event related arousals (RERAs) and daytime sleepiness, it has a negligible effect on AHI which was the main outcome variable of this study.⁹

The current study revealed a significant decrease in both polysomnographic parameters studied: AHI and LSAT. LSAT significantly increased from 82.2% to 86.6% while AHI was reduced from 39.7 events/h to 22.7 events/h which is an AHI reduction of 43.1%. This is consistent with a recent meta-analysis, which showed that AHI is reduced by 38.3% after HMS for OSA.¹⁸ In our study, ESS was unchanged postoperatively; however, the mean preoperative ESS score (8.2) was already within the normal range and therefore less likely to change.

Interestingly, reviewing the subset of patients with severe OSA showed a similar AHI reduction of 41.8% postoperatively to a mean AHI consistent with moderate OSA. Prior studies have shown that prevalence of multilevel upper airway collapse increases with severity of OSA; however, whether all sites must be treated remains uncertain.⁴ In this study, despite having severe OSA, 46% of patients had a postoperative AHI <20 events/h, and shows that in the appropriately selected patient, even patients with severe OSA can have significant improvements in sleep-related respiratory disturbances after isolated HMS.

Patients in this study were selected as surgical candidates for isolated HMS if there was evidence of retroflexed epiglottic collapse shown on awake, supine endoscopy and drug-induced sleep endoscopy (DISE) without clinically significant collapse at the palate or tongue base. Although some consider HMS to be an adjunct to tongue base

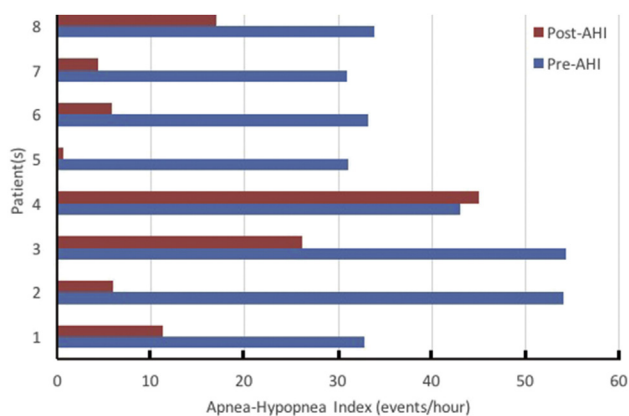


Fig. 2 Individual preoperative and postoperative AHI outcomes for patients with severe obstructive sleep apnea.

stabilization procedures, it is a valid stand-alone procedure for treatment of OSA. Another advantage of this technique is sparing of the infrahyoid musculature, which are important for maintaining physiologic swallowing and speech function.

Limitations include its retrospective nature and small sample size. Selection bias is important as patients were selected as surgical candidates who were thought to benefit from isolated HMS and did not require additional surgical treatment of the palate or tongue base. Unfortunately, the DISE videos were not available for review to determine whether those who failed required further treatment.

Conclusion

Hyoid myotomy and suspension without concurrent palatal or tongue base sleep surgery improves severity of OSA, but its effect on daytime sleepiness is unclear. It can be considered as a valid option in the treatment of OSA in appropriately-selected patients. Future studies should evaluate patient characteristics and specific anatomic variants which are more likely to successfully respond to this procedure.

Financial disclosures and conflicts of interest

The other authors have no financial disclosures or conflicts of interest.

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