Outcomes of Hyoid Suspension for the Treatment of Obstructive Sleep Apnea

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Objective: To examine the efficacy of hyoid myotomy and suspension as a treatment of hypopharyngeal obstruction in obstructive sleep apnea.

Design: Prospective, observational study.

Setting: Academic medical center.

Patients: Twenty-nine consecutive male patients with suspected hypopharyngeal obstruction.

Interventions: Patients underwent hyoid suspension. Uvulopalatopharyngoplasty with or without tonsillectomy was performed at the same time for those patients who had not undergone this procedure previously. Patients underwent clinical examination and sleep study prior to surgery and approximately 1 year postoperatively.

Main Outcome Measures: Primary outcome was a successful surgical result, defined as apnea-hypopnea index lower than 20, 50% or greater decline in apnea-hypopnea index, and no oxygen desaturations below 85% on the postoperative sleep study. Secondary outcomes included daytime sleepiness as determined by the Epworth Sleepiness Scale and the severity of snoring. Postoperative complications were also recorded.

Results: Only 5 (17%) of 29 patients achieved a successful outcome. The respiratory disturbance index did not change significantly for the group as a whole, although the lowest oxygen saturation did show some improvement.

Conclusions: Hyoid suspension does not provide results equivalent to those reported for genioglossus advancement or multisession tongue radiofrequency. Hyoid suspension alone is not an efficacious treatment for hypopharyngeal airway obstruction in most patients with obstructive sleep apnea.


Patients with obstructive sleep apnea (OSA) have both anatomic and physiologic dysfunction of the upper airway during sleep resulting in repeated airway obstruction and varying degrees of hypoxemia. Surgical treatment of OSA begins with examination of the upper airway to assess the likely area(s) of airway obstruction. After functionally dividing the pharynx into the retropalatal and the hypopharyngeal regions, Fujita and Simmons described 3 patterns of obstruction: type 1, retropalatal obstruction alone; type 2, both retropalatal and hypopharyngeal obstruction; and type 3, hypopharyngeal obstruction alone.

Fujita et al described the uvulopalatopharyngoplasty (UPPP) in 1981 as a treatment for patients with narrowing or collapse of the retropalatal region. Although the UPPP was highly effective for snoring, with a control rate ranging from 75% to 87%, a meta-analysis by Sher et al showed that the overall response rate for OSA (defined as a 50% decrease in the respiratory disturbance index [RDI] and a postoperative RDI <20 or a 50% decrease in the apnea index and a postoperative apnea index <10) for all patients treated with UPPP alone, regardless of site of obstruction, was only 40.7%. In patients with suspected type 1 narrowing alone, the response rate increased to 52.3%, but for those with type 2 and type 3 patterns, the response rate was only 5.3%.

Attempts to treat patients with type 2 and type 3 narrowing have led to the development of an array of procedures addressing the hypopharyngeal airway: genioglossus advancement, radiofrequency of the tongue, hyoid myotomy and suspension (hereinafter, “hyoid suspension”), surgical reduction of the tongue base, tongue base stabilization, and maxillomandibular advancement. These procedures can be performed either alone or in combination.

Previous studies have considered the efficacy of hyoid suspension when per-
formed in conjunction with genioglossus advancement (GAHM). In 1984, Riley et al\textsuperscript{6} published the first case report of a patient with OSA treated with GAHM. Two years later, the same group\textsuperscript{6} reported significant improvement in both mean RDI values and mean lowest oxygen saturation (LSAT) in 5 patients treated with GAHM, and in 1993, they showed a 60% response rate (defined as postoperative RDI equivalent to continuous positive airway pressure or < 20 with “normal oxygenation”) in 233 patients with type 2 collapse treated with UPPP and GAHM.\textsuperscript{7}

Initially, hyoid suspension was designed so that the hyoid bone was suspended to the inferior border of the anterior mandible in 2 places using fascia lata.\textsuperscript{3} In some cases, myotomy of a portion of the infrapharyngeal musculature was required to enable mobilization and suspension of the hyoid bone. This technique was used by Riley et al.\textsuperscript{7}

Riley et al\textsuperscript{8} later revised the technique by securing the hyoid arch anteroinferiorly to the thyroid lamina rather than suspending it from the anterior mandible. This mobilization of the hyoid bone requires myotomy of a portion of the suprahypoid musculature (rather than infrahyoid) and division of the stylohyoid ligament. The technique revision was based on animal studies\textsuperscript{8} showing that the position of the hyoid arch and its muscle attachments strongly affect upper airway patency and tongue position. The advantages of the revised technique were the lower morbidity (no need to harvest fascia lata) and avoidance of the unfavorable cosmetic changes that could occur after advancement of the hyoid into the submental region. Riley et al\textsuperscript{8} reported data on 15 patients with OSA treated with this revised technique; all but 1 of these patients had prior genioglossus advancement and UPPP. There was a “significant improvement” in sleep-related breathing disorders and excessive daytime sleepiness in 12 (80%) of 15 patients. The mean (SD) RDI improved from 65.6 (18.3) to 21.3 (23.6), and the LSAT improved from 74.0% (14.0%) to 85.0% (4.8%). Six (40%) of 15 patients achieved surgical cure of OSA, defined as a postoperative RDI of lower than 20, a reduction in RDI of at least 50%, and LSAT of 85% or greater. If the LSAT criterion is dropped, 8 (53%) of 15 patients had a successful result.

Additional studies have demonstrated the efficacy of GAHM, with suspension of the hyoid to either the mandible\textsuperscript{7} or to the superior border of the thyroid cartilage.\textsuperscript{10,11} Neruntarat\textsuperscript{12} reported data for 32 patients treated with palate surgery (uvulopalatal flap) and hyoid suspension using the revised technique of Riley et al.\textsuperscript{8} Mean (SD) RDI improved from 44.4 (8.7) to 15.2 (5.6). Mean body mass index (BMI), calculated as the patient’s weight in kilograms divided by height in meters squared, was 29.4 (2.4) prior to surgery and did not change following surgery. Twenty-five (78%) of 32 patients achieved a successful outcome based on a 50% reduction in RDI with a final RDI of 20 or less. Our study was conceived, and all patients were treated, prior to publication of the Neruntarat\textsuperscript{12} study. Our objective was to determine the efficacy of hyoid suspension using the technique of Riley et al\textsuperscript{8} as the sole treatment of suspected hypopharyngeal airway obstruction in obtaining a successful outcome in OSA surgery.

METHODS

This was a prospective, observational study of patients who underwent surgical treatment of OSA at the Palo Alto Veterans Affairs Hospital in Palo Alto, Calif. All patients underwent a preoperative sleep study to establish the diagnosis of OSA. Most of the studies were level 3 unattended ambulatory sleep studies performed with a NovaSom QSG diagnostic device (Sleep Solutions, Pasadena, Md) arranged by the Pulmonary Medicine service at the Palo Alto Veterans Affairs Hospital; data were collected over 3 nights of sleep. The device measures oral and nasal airflow, chest wall impedance, oxygen saturation, heart rate, and snoring. The device has been tested against polysomnography in 2 separate studies. Using a threshold of an apnea-hypopnea index (AHI) of 15 to establish the diagnosis of OSA, the device has been shown to have a sensitivity of 85% to 91% and a specificity of 83% to 95%.\textsuperscript{13,14} The AHI was calculated as the mean total number of obstructive apneas and hypopneas per hour of sleep. Obstructive apneas were defined as the absence of airflow with respiratory effort for at least 10 seconds. Hypopneas were defined as a 50% decrease in airflow for 10 seconds or longer with a decrease in oxygen saturation of more than 4%. One patient had a level 1 monitored polysomnogram.

All patients in this study underwent an initial trial of nonsurgical treatment for OSA and elected surgical treatment. They then underwent a comprehensive clinical examination and fiberoptic pharyngolaryngoscopy. Nineteen had subjective analysis with the Epworth Sleepiness Scale (ESS) as a measure of daytime somnolence and a single question concerning the severity of snoring.\textsuperscript{15} Patients were included in the study if their airway obstruction was clinically categorized as Fujita type 2 or 3 (Fujita and Simmons\textsuperscript{1}). Cephalometric radiographs were not performed because the proper equipment was not available. Exclusion criteria included medical comorbidities that presented excessive risks for undergoing general anesthesia and upper airway procedures.

All patients underwent hyoid suspension according to the technique described by Riley et al.\textsuperscript{8} Those patients who had not undergone prior UPPP with or without tonsillectomy underwent this procedure using the standard technique described by Fujita and Simmons.\textsuperscript{1} For 2 patients, prior UPPP and tongue base stabilization with the Repose system had failed (Influent Medical LLC, Concord, NH). In addition, a varying number of procedures were performed at the same time. Patients with significant nasal obstruction also underwent concurrent bilateral inferior turbinectomy reduction with or without septoplasty. A subgroup of patients with significant submental liposis underwent submentoplasty through the incision used for hyoid suspension. Two patients with severe OSA also underwent tracheotomy. All procedures were performed by one of us (D.U.).

Postoperative sleep studies were performed no sooner than 4 months after surgery. Those patients with tracheotomy had their tube capped for the postoperative study. All postoperative sleep studies were level 3 unattended studies using the NovaSOM QSG device. Twenty-one patients also underwent postoperative assessment of daytime somnolence (ESS) and snoring severity. Descriptive statistics and OSA disease severity were calculated. Obstructive sleep apnea disease severity was categorized by AHI according to the classification scheme recommended by the American Academy of Sleep Medicine: AHI 5 to 15, mild; AHI 16 to 30, moderate; and AHI greater than 30, severe. The primary outcome of interest was a successful outcome, defined as meeting all of the following criteria: AHI lower than 20, 50% or greater decline in AHI, and no oxygen desaturations below 85% on the postoperative sleep study. Secondary outcomes included daytime sleepiness as determined by the ESS and the severity of snoring. Postoperative complications...
were also recorded. The t test was performed for comparison of individual variables. Logistic regression was performed to determine the association between a successful surgical outcome and specific variables. A P value less than .05 was considered statistically significant.

RESULTS

Twenty-nine patients underwent hyoid suspension. Preoperative and postoperative data are reported for individual patients in Table 1 and according to OSA severity subgroups in Table 2. The patients were all male, and the mean (SD) age was 53.9 (6.0) years. The mean preoperative BMI was 34.1 (6.4), and there was no change postoperatively (P = .29). There were no differences in BMI among the OSA severity groups.

Mean (SD) preoperative AHI was 36.5 (27.6). The distribution of preoperative OSA severity among all 29 patients was as follows: 6 (21%) mild, 9 (31%) moderate, and 14 (48%) severe. The LSAT prior to surgery was 72.7%.
Almost two-thirds (12/19, 63%) of the patients reported excessive daytime somnolence (defined as ESS >10); ESS was 13.8 (8.2), and all were heavy snorers. With only 1 exception, all patients had at least 1 additional procedure performed at the same time. Twenty-eight patients had concurrent UPPP, and 14 of these also underwent tonsillectomy. Five patients reported significant nasal obstruction; they all had bilateral inferior turbinate reductions performed, and 4 of them underwent concomitant septoplasty. Two patients with severe OSA (AHI of 77 and 105, respectively) had a tracheotomy at the time of the procedure. Submentoplasty was performed in 5 patients.

A postoperative sleep study was performed at a mean of 12.7 months after the surgery (range, 4-45 months). Mean postoperative AHI was unchanged. The LSAT showed improvement, but the mean value reflected residual oxygen desaturation in many patients. Considered as a separate group, the patients with mild OSA actually demonstrated an increase in mean AHI from 10.3 to 30.3. There were no other statistically significant changes for AHI or LSAT in the subgroups of OSA disease severity.

Only 5 (17%) of 29 patients met the criteria for a successful outcome. In 15 patients (52%), AHI increased postoperatively, and in 8 of these patients (28% of the study population), the AHI increased by 50% or more. Logistic regression analysis revealed that there was no relationship between OSA cure and BMI, preoperative AHI, or concomitant nasal surgery. All 5 patients who underwent concurrent submentoplasty with UPPP and hyoid suspension did not achieve a successful outcome.

The mean (SD) postoperative ESS score was 10.9 (6.2). Daytime somnolence was improved or resolved (ESS ≤10) in 8 (38%) of 21 patients. All patients were habitual and heavy snorers prior to surgery. Postoperatively, snoring was either improved or eliminated in 7 (30%).

Complications were few. One patient had acute alcohol withdrawal while hospitalized. This resolved with supportive measures. Another patient had a small postoperative neck hematoma. This was managed with observation alone, and it resolved without significant problems. Other than transient dysphagia lasting 3 to 4 days in the minority of patients, no other perioperative complications occurred.

Overall, the combination of hyoid suspension and palate surgery offered poor results in our population of OSA patients with perceived retropalatal and hypopharyngeal obstruction. Only 5 (17%) of 29 patients achieved a successful outcome based on polysomnography, although twice that percentage (8/21; 38%) of those tested improved subjectively.

This is the second study that has evaluated hyoid suspension alone without previous or concurrent genioglossus advancement in patients with OSA. Our results are substantially worse than those of Neruntarat,12 who reported successful outcomes in 78%. The criteria for successful outcome in both studies were similar, the only difference being our addition of a threshold for postoperative LSAT. Possible explanations for the differences in results include the fact that our patients were, on average, heavier (BMI, 34.1 [6.4] vs 29.4 [2.4]; P<.001) and had a lower LSAT on the preoperative sleep study (72.7% vs 82.1%; P<.05). The latter difference may suggest a greater degree of hypopharyngeal obstruction in our population, and hyoid suspension may not be as effective in patients with lower LSAT during sleep.

It is worth comparing our results with those achieved by other combinations of palate surgery and single procedures to improve the hypopharyngeal airway. Reported OSA cure rates for UPPP and genioglossus advancement are 39%, 75%, and 78%, respectively, in 3 series.8,10,17 The combination of multisession radiofrequency of the tongue and UPPP has been shown to have an OSA cure rate of approximately 40% in 2 studies of patients with suspected retropalatal and hypopharyngeal obstruction.18,19 For UPPP and tongue base stabilization with the Repose system, a similar criteria for success has been met in 20% and 50%, respectively, in 2 small series.20,21 The low cure rate in the present study suggests that hyoid suspension by itself is not a substitute for genioglossus advancement or multiple sessions of tongue radiofrequency as a treatment of hypopharyngeal airway obstruction in OSA.

With the available data, it is not possible to determine how well hyoid suspension compares with tongue base stabilization. Instead, hyoid suspension may be most effective as an adjunctive treatment of the hypopharyngeal airway. This is supported by the work of Riley et al.,8 which demonstrates the potential of hyoid suspension to improve on the results of a previous unsuccessful UPPP and genioglossus advancement. While there is no data directly comparing the efficacy of GAHM vs genioglossus advancement alone, 2 studies by Riley et al.7,8 suggest that the combination (60% success) is better than genioglossus advancement alone (38% success).

A major concern is the high percentage of patients in the present study, especially those with mild disease preoperatively, who had a significantly worse RDI following surgery. Neruntarat12 did not report how many patients experienced a worsened RDI, but it was apparently far fewer than in the present study.

Another unresolved question is the relative benefit achieved with the 2 distinct hyoid suspension techniques—namely, how the results of hyoid suspension to the inferior border of the mandible compares with suspension to the thyroid cartilage. Clearly, the original technique described by Riley et al.7 has certain disadvantages: requiring harvest of fascia lata (because other materials such as sutures did not provide sufficient stabilization of the hyoid to the mandible in their experience), increased fullness of the submentum, and the need to drill holes in the mandible. These concerns inspired the development of the revised technique.8 However, there are no comparisons of hyoid suspension to the mandible vs attachment to the thyroid cartilage to assess relative efficacy and morbidity.

There are certain limitations to the present study. There were no internal control groups such as one receiving continuous positive airway pressure or UPPP alone or a sham surgery group. Instead of incorporating controls...
within the study, we compared our results against those of other prospective observational studies describing combinations of palate surgery and either genioglossus advancement, multisession tongue radiofrequency, or tongue stabilization. To provide some uniformity with the patient populations of those studies, we specifically selected patients with suspected hypopharyngeal obstruction based on a combination of history, physical examination, and fiberoptic pharyngolaryngoscopy.

The performance of concurrent procedures other than UPPP and hyoid suspension in the present study is another possible weakness. However, these procedures were performed to treat patients with specific abnormalities, and this eliminated confounding factors such as residual nasal obstruction. We do not believe that the procedures in question had a major effect on our primary outcome of OSA cure. Prior studies have not found a significant impact of nasal surgery on sleep-related breathing disorders.22-24 and no published data exist on the impact of submentoplasty on OSA (although one would imagine that if it were to have any impact, it would be beneficial). Although we did not find any significant differences between responders and nonresponders in terms of synchronous nasal surgery, submentoplasty, or tracheotomy (tested with the tracheostomy tube closed), our study sample size did not provide sufficient power to make conclusions regarding potential relationships.

Another potential limitation is that our patient population may differ from those of other studies reporting UPPP and hypopharyngeal procedures. Obesity is associated with OSA severity, and at least 1 large series has shown poorer surgical outcomes in patients with higher AH1 and BMI.7 The mean BMI of 34.1 in the present study is higher than the mean BMI values for the populations in the UPPP/genioglossus studies of Riley et al8 and Johnson and Chinn16 (28.6 and 32.7, respectively) and in the UPPP/tongue radiofrequency study by Friedman et al19 (31.5). Because our results suggest OSA cure rates far below those reported in these other studies, we suggest that differences in BMI may explain some, but not all, of the observed differences. It is interesting to note that in spite of the higher BMI in our sample, the preoperative AH1 (36.5) was actually lower than in the other studies (43.9-65.6).8,16,18

There are inherent difficulties in comparing procedures across separate case series. With heterogeneous populations, diverse methods of evaluation, and different surgical techniques at centers, it can be difficult to draw the strongest conclusions from case studies alone. Randomized controlled trials and cohort studies provide greater scientific rigor and can offer stronger conclusions to specific research questions; in some cases, a multi-institutional trial is necessary to provide sufficient patient numbers to address research questions appropriately. However, in spite of their limitations, case series have the advantages of being less expensive than the other study designs and of generating research ideas and pilot data that can serve as the foundation for larger, more expensive trials. The present study is only the second to address the role of hyoid suspension alone for treatment of hypopharyngeal airway obstruction in OSA, and, as such, we believe these findings are important to further research.

Finally, most of our patients underwent unattended level 3 sleep studies. While a recent meta-analysis of studies comparing level 1 with level 2/3 studies showed the level 2/3 studies to have an overall sensitivity of 78% to 100% and specificity of 62% to 99%, the authors of the meta-analysis concluded that there was “insufficient evidence that any multi-channel portable device can be used reliably in the home setting.”25 However, the existing data affirm that the NovaSOM QSG technology used for the present study is accurate and has the advantage of collecting data over 3 nights of sleep.13,14 While level 1 preoperative and postoperative sleep studies might have improved the accuracy of the AH1 and LSAT values, the significant differences between our results and those reported for genioglossus advancement and tongue radiofrequency suggest that our conclusions remain valid.

In conclusion, the OSA cure rate for the combination of UPPP and hyoid suspension was low in our population, and the figures are lower than those reported for the combination of UPPP and either genioglossus advancement or multiple treatments of tongue radiofrequency. Our findings suggest that hyoid suspension alone is not an efficacious treatment for hypopharyngeal obstruction in OSA for most patients.

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