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Minimally invasive tongue base surgery for obstructive sleep apnoea

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Abstract

Moderate to severe obstructive sleep apnoea is usually associated with multiple levels of pharyngeal airway collapse, including tongue base obstruction. A new technique has recently been introduced that improves the nocturnal retro-lingual airway. This study was a prospective, non-randomized single-institution evaluation of a recently introduced surgical technique. Nineteen consecutive patients with previously untreated moderate to severe obstructive sleep apnoea underwent tongue suspension using the Repose™ system and concomitant palatopharyngoplasty (multilevel pharyngeal surgery). The patient demographics and treatment outcomes were prospectively collected and retrospectively analysed.

There were 16 men and three women, with a mean (±SD) age of 44.9 years (± 14.2) and a mean pre-operative apnoea-hypopnoea index (AHI) of 42.8 ± 24.8. Twelve of the 19 patients (63.2 per cent) have had post-operative polysomnography; eight of these 12 (67 per cent) met the standard criteria for surgical response. Among these eight patients, the AHI improved from 32.4 to 14.4 ($p<0.01$); the individual scores fell by a mean of 51.7 per cent. The apnoea index improved from 7.4 to 0.9 ($p<0.01$), with the individual scores falling by a mean of 81.4 per cent. There was anatomic and radiographic evidence of multilevel upper airway enlargement. Notably, the body mass index remained essentially unchanged (31.5 ± 7.2 to 31.2 ± 7.6, $p>0.5$). Subjectively, the mean Epworth sleepiness scale score fell from 11.0 ± 5.4 to 5.4 ± 3.8 ($p<0.005$). Four patients suffered transient velopharyngeal insufficiency, and two patients complained of limited anterior excursion of the tongue. There were no serious, long-term complications.

The tongue suspension procedure represents a minimally invasive technique for improving the nocturnal retro-lingual airway in patients with obstructive sleep apnoea. It is easily performed by otolaryngologists, distinguishing it from other established techniques designed to address tongue base obstruction.

Key words: Sleep Apnoea, Obstructive; Surgical Procedures, Operative

Introduction

The successful surgical management of obstructive sleep apnoea (OSA) has relied heavily on the recognition that patients with moderate to severe sleep apnoea usually have sleep-related collapse of multiple segments of the upper airway. These segments were originally designated as retropalatal and retrolingual[1] although some authors have begun to quantify also the degree of lateral pharyngeal wall collapse (from lateral to medial).[2]

Multilevel pharyngeal surgery is typically required to overcome these multiple levels of pharyngeal airway collapse.[3] Fujita *et al.*[1] have achieved good outcomes by applying soft tissue modification to reverse retrolingual collapse in patients who failed palatopharyngoplasty; Riley *et al.*[4] pioneered the utilization of skeletal techniques to enlarge the upper airway, and were the first to advocate the simultaneous performance of surgery at multiple levels for patients in whom multiple sites of pharyngeal obstruction could be shown.[5]

A new technique has recently been introduced that also improves the nocturnal retrolingual airway, but without the morbidity of a midline glossectomy, nor the potential risks of a mandibular osteotomy with genioglossal advancement.[6] The tongue suspension procedure represents one of several new minimally invasive techniques that may prove valuable in the treatment of patients with the obstructive sleep apnoea syndrome. The surgical objective of this approach differs from those of the mandibular osteotomy and genioglossal advancement in that the

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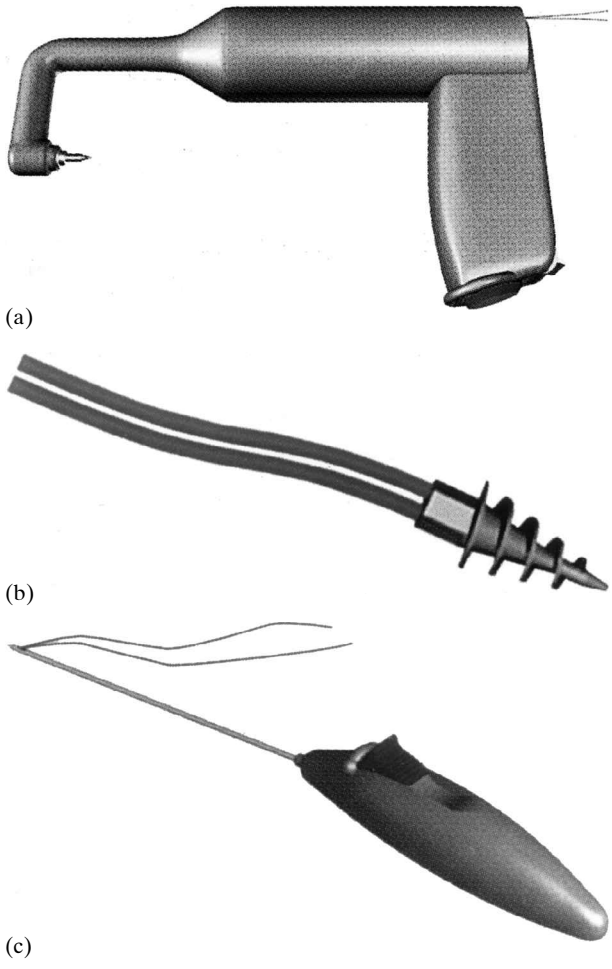

FIG. 1(a)–(c)

The drill-driver device (a) is used to install the screw-mounted suture (b) on the lingual cortex of the anterior mandible. The specially designed suture passer is used to insert the polypropylene suture through the tongue and into the oropharynx (c).

procedure is designed to stabilize and support the posterior tongue, rather than to advance it.

Methods and materials

A retrospective analysis was undertaken of data that were prospectively gathered on patients evaluated by the University Otolaryngology service at Stanford University between March of 1998 and April of 2000 for the presence of sleep-disordered breathing (SDB). All patients underwent a complete head and neck evaluation (including fibre-optic endoscopy and a Müller manoeuvre), polysomnographic testing, and lateral cephalometric radiography.

Demographic data that were collected included age, gender, severity of SDB (apnoea/hypopnoea index (AHI), apnoea index, and lowest recorded oxygen saturation (LSAT)), degree of sleepiness as determined by the Epworth sleepiness scale (EPW), body mass index (BMI), type of surgery and surgical outcomes. Patients in whom evidence of both retropalatal and retrolingual obstruction was manifested were offered multilevel pharyngeal surgery, consisting of a palatopharyngoplasty with either mandibular osteotomy with genioglossal advancement or tongue suspension with the Repose™ bone screw system (Influ-Ent Inc., San Francisco, CA) (Figures 1(a)–(c)). The choice of surgery was made by the patient, and therefore this was a non-randomized study. Patients who opted for palatopharyngoplasty with mandibular osteotomy with genioglossal advancement were not considered further.

Twenty-eight consecutively treated patients underwent multilevel pharyngeal surgery with tongue suspension; 19 of these patients had no history of prior surgery for sleep-disordered breathing and had undergone recent polysomnography. These 19 patients comprise the cohort evaluated in this study; all of these patients underwent a simultaneous palatopharyngoplasty.

Polysomnographic techniques

All patients underwent pre-operative polysomnographic testing, either an attended in-hospital study or ambulatory polysomnography. The attended study consisted of nocturnal polygraphic monitoring with the lights out from 10:30 pm to 7 am. This study included electroencephalogram (C3/A2, C4/A1, and O2/A1 electrodes of the international electrode placement system), electro-oculogram, chin and leg electromyogram, and electrocardiogram (modified V2 lead). Oronasal airflow (thermistors), thoracic and abdominal movements (inductive plethysmography), snoring sounds (subminiature electric microphone type MCE-2000 (ME-SAM-4 equipment, Conrad Electronics, Hirchau, Germany) taped above the larynx), and ear oximetry were used to monitor respiratory status.

Ambulatory polysomnographic studies were performed with an Edentec portable device (Edentec Monitoring System, model 4700 Scanner, Eden-Prairie, MN) measuring nasal/oral airflow (thermistors), chest wall impedance, finger pulse oximetry, heart rate, and movement.

Data were recorded for the stages of sleep, oxygen saturation, and number of hypopnoeas and apnoeas per hour. Hypopnoeas were defined as a 50 per cent decrease in maximum thermistor output compared with baseline and an associated decrease of SaO_2 to below 92 per cent from a baseline of at least 94 per cent or a fall of SaO_2 of at least three per cent if the baseline was below 90 per cent. Apnoeas were defined as cessation of breathing for longer than 10 seconds. The AHI represented the sum of the number of the apnoeas and hypopnoeas per hour.

Surgical techniques

The palatopharyngoplasty procedure utilized has been described previously.[7] Briefly, the tonsils are removed (if present), and the palate is marked at a point just inferior to the levator aponeurosis. The palate is incised with a deliberate bias so that the posterior (nasal) surface of the palate is longer than the anterior (oral) surface. An effort is made to square off the palatal arch, to avoid cicatricial scarring. The wound is closed with interrupted 3-0 absorbable sutures. The tongue suspension proce-

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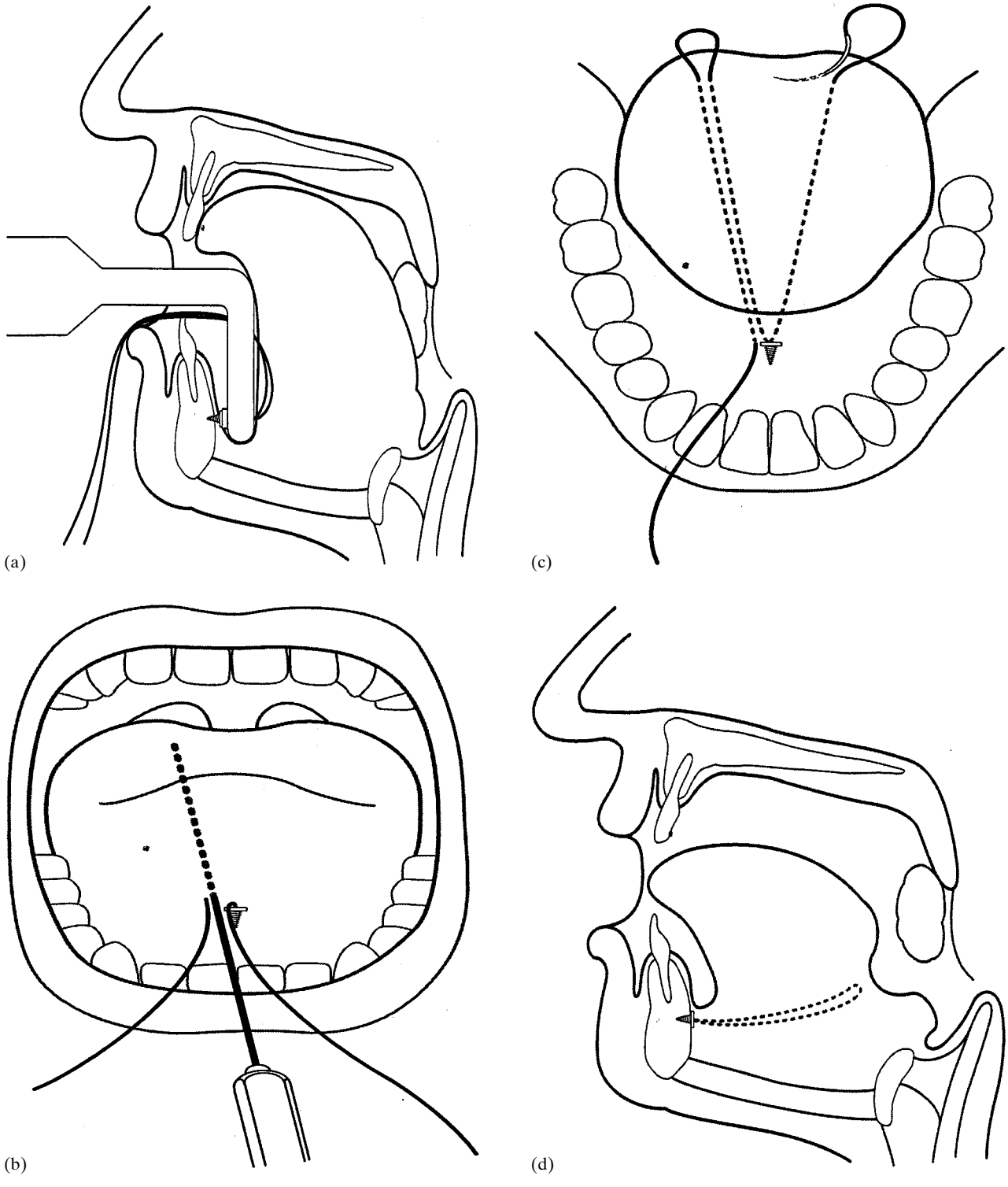

FIG. 2(a)–(d)

After an incision is made in the floor of the mouth, and the periosteum removed from the lingual surface of the anterior mandible, the drill-driver device is placed against the mandible, and the screw is mounted (a). The temporary loop of suture and the permanent polypropylene suture are passed through the tongue and into opposite sides of the oropharynx (b), and then a free needle is used to pass the polypropylene suture across the posterior tongue to the site of the temporary loop of suture (c). The final appearance of the tongue, as seen from the sagittal view (d), with a slight dimple depicted at the point of maximal tension.

dure was performed through a floor-of-mouth incision using the Repose™ device as described originally by DeRowe *et al.*[6] A small (4 mm) screw, to which a #1 polypropylene suture is attached, was secured to the lingual cortex of the anterior mandible (Figure 2(a)). Ideally, this screw is placed below the level of the tooth roots, although the screw is sufficiently short that even if it is placed at the level of the roots, it is unlikely to cause dental injury. A specially designed suture device was used to pass a

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temporary suture loop through the same incision, and out of the tongue base at the circumvallate papillae (Figure 2(b)). Similarly, the polypropylene suture was passed to the tongue base on the opposite side. Using a free cutting needle, the polypropylene suture was then passed back through its exit site, and across the tongue base to the site of the temporary suture loop (Figure 2(c)). The loop was used to pull the polypropylene suture back to the floor-of-mouth incision, effectively triangulating the tongue in a submucosal fashion. The polypropylene suture was tied at the front in the floor of the mouth (Figure 2(d)), and the incision was closed with absorbable sutures. The procedure takes no longer than 15 minutes to perform. Patients were admitted to a regular hospital bed for at least one day, and treated prophylactically with broad-spectrum antibiotics (cephalexin) and systemic corticosteroids (dexamethasone). Because of the potential for lingual oedema, out-patient surgery is not advisable.

Cephalometry was done prior to surgery, then early after surgery (within two or three days, to assess the impact of oedema on the airway) and again approximately six weeks after surgery. The assessment of the radiographs was carried out with the evaluator blinded to the pre-operative or post-operative status.[2] The Müller manoeuvre was performed prior to surgery as previously described,[8] and then repeated six weeks after surgery, in a non-blinded fashion (post-operative changes are evident during the examination). The degree of collapse at the palate, lateral pharyngeal walls, and tongue base were individually quantified on a five-point scale. Post-operative polysomnography was performed no sooner than three months following surgery.

Statistical analysis

A paired, 2-tailed Student's *t*-test was utilized to explore differences between pre-operative and post-operative datasets. An unpaired, 2-tailed *t*-test was used to compare demographic data between the group of patients responding to surgery, and the group of patients that did not respond.

Results

Sixteen men and three women comprised the study cohort. The mean (± SD) age was 44.9 years (± 14.2). The group had moderate to severe OSA, with a mean (± SD) pre-operative AHI of 42.8 ± 24.8, a mean apnoea index of 10.6 ± 8.3, and a mean LSAT of 78.9 per cent.

Anatomical changes which occurred as a result of surgery are depicted in Figure 3, and reflect highly significant improvement of the airway at the tongue base ($p<0.001$) and palate ($p<0.001$), with less dramatic increases in the airway at the lateral pharyngeal wall ($p<0.005$). The radiographic changes are also indicated in Figure 3, with modest improvement of the posterior airway space (PAS) evident ($p<0.01$). As expected, there was a temporary narrowing of the PAS early after surgery in most instances, that resolved within six weeks. An

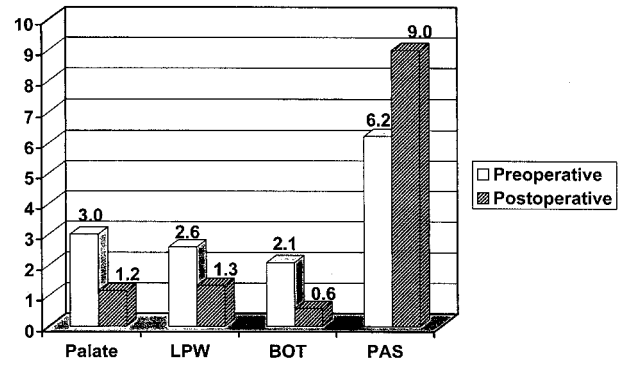

FIG. 3

Comparison of pre-operative and post-operative values for both anatomic (n = 13) and radiographic (n = 9) measures of the upper airway in patients who underwent multilevel pharyngeal surgery (palatopharyngoplasty and tongue suspension with the Repose™ device). The palate, lateral pharyngeal wall (LPW), and base of tongue (BOT) collapse were measured on a 5-point scale from 0 to 4 (see text); the posterior airway space (PAS) is measured in millimetres. Note the moderate improvement in palatal, LPW, and BOT collapse seen on Müller manoeuvre examination, as well as mild improvement in the PAS seen on lateral cephalometric X-ray.

example of the improvement in PAS is seen in Figures 4(a)–(b). The position of the radiopaque screw is also demonstrated (Figure 4(c)).

Twelve of the 19 patients (63.2 per cent) have had post-operative polysomnography. Eight of these 12 (67 per cent) met the standard criteria for surgical response[9] (50 per cent reduction in the AHI and a post-operative AHI<20, or 50 per cent reduction in the apnoea index and a post-operative apnoea index <10), while six of 12 (50 per cent) met the stricter criteria acknowledging only the improvement in the AHI. Among the eight patients manifesting a response to surgery, the AHI improved from 32.4 to 14.4 ($p<0.01$); the individual scores fell by a mean of 51.7 per cent. The apnoea index improved from 7.4 to 0.9 ($p<0.01$), with the individual scores falling by a mean of 81.4 per cent.

Among the subjective outcome measures, excessive daytime somnolence was significantly improved, with the mean EPW falling from 11.0 ± 5.4 to 5.4 ± 3.8 ($p<0.005$). Snoring improved in all patients. Notably, the BMI remained essentially unchanged (31.5 ± 7.2 to 31.2 ± 7.6; $p>0.5$).

Complications

There were no intra-operative complications. Post-operatively, four patients suffered transient velopharyngeal insufficiency, and two patients complained of limited anterior excursion of the tongue. There were no episodes of airway compromise, no extrusions of the suture, and no cases of hypoglossal nerve injury.

Failure analysis

An effort was made to identify factors that may predict for failure to respond to multilevel pharyngeal surgery that includes tongue suspension. The

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(a)

(b)

(c)

FIG. 4(a)–(c)

Pre-operative (a) and post-operative (b) lateral cephalometric radiographs of a patient who has had a palatopharyngoplasty and tongue suspension demonstrate the modest improvement in the posterior airway space that is achieved. The appropriate location of the screw is seen in the panellipse radiograph (c).

patients who failed to respond to surgery had more severe disease (with a mean AHI of 58.9 *vs*. 32.4, $p<0.08$), and more significant upper airway collapsibility noted on the Müller manoeuvre (scores 3.7 *vs*. 3.0, 3.0 *vs*. 2.6, and 2.7 *vs*. 1.9 at the palate, lateral pharyneal walls and tongue base, respectively) than those who achieved a response to surgery, but none of these differences reached statistical significance. The mean age was similar in the two groups (48.8 years among responders *vs*. 49.8 years among non-responders), and the patients responding to surgery were actually somewhat more obese than those who failed to respond (BMI = 32.4 *vs*. 29.7), but these differences were not statistically significant.

Discussion

Moderate to severe OSA is usually associated with multilevel pharyngeal collapse. Therefore, multilevel surgery is required to overcome the collapse at these segments. Both soft tissue[1] and skeletal framework[2] approaches to multilevel surgery have been advocated[3,4] but each carries with it a significant degree of morbidity. DeRowe and his colleagues[6] have introduced a novel technique of tongue suspension designed to improve the retrolingual airway. This approach was subsequently described in greater detail by the same author,[10] and the results of a multi-institutional feasibility study have recently been published.[11] While the follow up of these patients is somewhat limited (one and two month post-operative subjective data, and two month post-operative polysomnographic data), the results were rather promising. Among the nine patients with sleep apnoea for whom post-operative polysomnograms were available, the AHI improved significantly from 33.2 to 17.9 ($p<0.005$), and the apnoea index improved from 10.5 to four. A statistically significant increase in delta sleep was also noted among all patients with post-operative polysomnograms (n = 20). Additionally, significant improvement in subjective measures of sleep quality, sleepiness, snoring, and overall health were noted. The results were particularly impressive because they were obtained in patients who had failed prior surgical intervention.

We have achieved a moderate degree of success by combining the tongue suspension procedure with palatopharyngoplasty in a small number of patients with greater than three months of follow-up. The anatomical improvement (as determined by Müller manoeuvre) was similar to that obtained after mandibular osteotomy with tongue advancement. The radiographic improvement in the PAS was minor, as might be predicted since the goal is to stabilize and support the posterior tongue, rather than to advance it. The polysomnographic success (67 per cent response to surgery) was intermediate between the results reported for palatopharyngoplasty in a meta-analysis by Sher *et al.*[9] (40.7 per cent) and the success achieved with multilevel pharyngeal surgery that incorporates a palatopharyngoplasty with hyoid myotomy-suspension and mandibular osteotomy-tongue advancement (85.7 per cent).[7] While the efficacy of palatopharyngoplasty with mandibular osteotomy-tongue advancement alone is not known, the surgical complexity and potential morbidity of that approach is considerable, and a less invasive technique is desirable.

The encouraging polysomnographic results seen so far in this small group of non-randomized patients treated with palatopharyngoplasty and tongue suspension will need to be confirmed in a larger cohort, and compared with other minimally invasive techniques for tongue base obstruction such as radiofrequency ablation.[12] Additionally, the long-term durability of the anatomic improvement will

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need to be demonstrated. However, this appears to be a promising new technique for the surgical management of OSA.

Conclusions

The tongue suspension procedure represents a minimally invasive technique for improving the nocturnal retro-lingual airway in patients with OSA. Anatomic, radiographic, polysomnographic, and subjective improvement were demonstrated in a consecutively-treated cohort of patients. It is easily performed by otolaryngologists, distinguishing it from other established techniques designed to address tongue base obstruction.

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