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Genioglossus advancement and hyoid myotomy: short-term and long-term results

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Abstract
Successful results of genioglossus advancement and hyoid myotomy with suspension (GAHM) in the treatment of obstructive sleep apnoea (OSA) have been reported. However, there have been few studies of long-term results. Forty-six patients with hypopharyngeal obstruction underwent GAHM. Patients had a mean age of 40.1 ± 4.2 years and a mean body mass index (BMI) of 28.9 ± 2.1 kg/m^2. The mean follow-up was 39.4 ± 5.7 months with a range of 37 to 46 months. The mean pre-operative RDI, short-term RDI, and long-term RDI were 47.9 ± 8.4, 14.2 ± 3.9, 18.6 ± 4.1, respectively. The mean post-operative LSAT, short-term LSAT, and long-term LSAT were 81.2 per cent ± 2.9 per cent, 88.8 per cent ± 2.7 per cent and 87.2 per cent ± 3.1 per cent, respectively. The change in BMI was significantly different in the patients with, and without, recurrence (2.1 ± 0.3 *vs* 0.4 ± 0.2 kg/m^2, <0.05). Thirty (65.2 per cent) patients had long-term clinical success, and six (16.7 per cent) patients with short-term success failed long-term. GAHM appears to be an effective procedure and results in long-term success. However, patients with weight gain are at risk of recurrence.

Key words: Sleep Apnoea, Obstructive, surgery

Introduction

Obstructive sleep apnoea (OSA) is a common problem which affects two to four per cent of middle aged adults.[1] Patients who cannot comply with medical therapy then become at risk for the serious medical consequence of OSA. Mortality data suggested that there is an increased mortality in untreated patients with more than 20 periods of apnoea per hour of sleep.[2] Several surgical procedures have been developed to treat OSA. Uvulopalatopharyngoplasty (UPPP) was the procedure especially designed to address the palatal abnormalities seen in many OSA patients.[3] The surgical response of an isolate UPPP was quoted to be 40.7 per cent.[4] Although UPPP eliminated the obstruction at the palatal level, persistent obstruction remained at the hypopharynx.[5]

Because OSA is composed of patients with a wide spectrum of disease severity, upper airway obstruction of many patients, occurring during sleep, can appear at multiple sites. Results of genioglossus advancement and hyoid myotomy with suspension for hypopharyngeal obstruction have been reported. Riley *et al.*[6] showed successful results, which were based on severity, and ranged from approximately 75 per cent in patients with mild to moderate OSA to 40 per cent in patients with severe OSA. The treatment outcomes of pharyngeal surgery addressing both oropharyngeal and hypopharyngeal areas of collapse have now been validated by many centres.[7–9] However, there was little information on long-term results. The purpose of this study was to compare the short-term versus long-term results in patients undergoing this procedure.

Materials and methods

For 18 months, 320 consecutive patients were evaluated for treatment of snoring and sleep apnoea at Vajira Hospital. Patients were advised to bring their bed partners to the evaluation. The initial visit included a complete history, physical examination, and otolaryngologic examination. Fibre-optic pharyngoscopy with Muller's manoeuvre was performed at the level of the nasopharynx and the base of the tongue. Initial body weights and heights were obtained, and body mass index (BMI) was calculated. A lateral cephalometric radiograph and panoramic radiograph of the mandible were also obtained.

After a diagnosis of OSA was made, patients were advised on various treatment options for their diseases. When appropriate, patients were encouraged to lose weight, avoid sleeping supine if their problem was positional, lengthen their bedtime, and avoid alcohol and tobacco. Continuous positive airway pressure (CPAP), oral appliances, and

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TABLE I
CEPHALOMETRIC MEASUREMENTS

Variable	Pre-operative	Post-operative	*p* value
SNA (degree)	82.1 ± 1.5	82.2 ± 1.6	NS
SNB (degree)	80.5 ± 2.2	80.2 ± 3.4	NS
PNS – P (mm)	45.2 ± 3.3	42.9 ± 2.7	<0.01
MP – H (mm)	19.5 ± 4.1	22.4 ± 1.9	<0.001
PAS (mm)	5.2 ± 1.3	9.2 ± 1.4	<0.001

SNA = sella-nasion-point A angle; SNB = sella-nasion-point B angle; PNS – P = length from posterior nasal spine to uvula; MP – H = length between mandibular plane and hyoid bone; NS = not significant

surgical options were reviewed with each patient. Patients who had failed to respond to the conservative treatments were counselled about the benefits and risks of surgical procedures.

Forty-nine patients (15.3 per cent) that had a primary complaint of snoring and OSA were found to suitable for GAHM. All patients had both oropharyngeal and hypopharyngeal obstruction. Uvulopalatal flap (UPF) was an adjunct surgical procedure for oropharyngeal obstruction. All patients were evaluated pre-operatively and then post-operatively by polysomnography. OSA was diagnosed in patients who experienced daytime sleepiness or disturbed sleep and had more than five respiratory disturbances per hour of sleep on their polysomnogram. Polysomnography was performed in the sleep laboratory with full monitoring that included an EEG, electro-oculogram, chin and leg electromyograms, ECG (modified V_2 lead), airflow, thoracic and abdominal efforts, and pulse oximetry (Alice 3 System, Healthdyne; Atlanta, GA). The polysomnogram was analysed according to the standards of the American Thoracic Society.[10] Baseline information was collected. The patient's bed partner or observer used a 10 cm visual analog scale (VAS) to grade the severity of snoring prior to the procedure, and post-operative treatment. 'No snoring' occupied the far left portion of the scale, while 'severe snoring' occupied the far right of the scale. An Epworth sleepiness scale (ESS) which reflected the chance of dozing in specific situations as well as daytime sleepiness[11] was completed at baseline.

Patients with a respiratory disturbance index (RDI) greater than 40 and lowest oxygen saturation (LSAT) less than 80 per cent were advised to use CPAP at least two weeks prior to surgery, and continue CPAP post-operatively until a polysomnogram was performed to document outcome.

Genioglossus advancement and hyoid myotomy

GAHM was performed essentially as decried by Riley *et al.*[6,12] An incision was made just to the labial side of the gingivolabial sulcus. The mandibular bone was exposed down to the inferior margin. Mandibular osteotomy was done using a 2-hole saggital saw blade. The fragment was advanced and rotated 90 degrees. The outer table was removed and the fragment was secured to the lower edge of the mandible using a lag-screw technique with an 11 mm × 2.0 mm screw in a 1.5 mm drill hole. The wound was drained with a Penrose drain and sutured. A horizontal anterior cervical neck incision was made over the hyoid bone. The hyoid was released from its inferior attachments and advanced anteriorly and inferiorly over the thyroid cartilage. An 1-0 Ticron suture was passed around the hyoid approximately 1 cm lateral to the midline, it was then passed through the thyroid ala, approximately 1 cm from the notch. A second suture was placed starting at the level of the lesser cornu and ending 2 cm from the thyroid notch. This sequence was repeated on the opposite side. The wound was irrigated and drained with a Penrose chain.

Uvulopalatal flap

UPF was performed as described originally by Powell *et al.*[13] The mucosa, submucosa with glands, and fat on the lingual surface of the uvula and soft palate were removed with a scalpel. The uvular tip was amputated and bleeding was controlled with bipolar electrocoagulation. The uvula was reflected back toward the soft palate and fixed into its new position with multiple sutures of 3-0 polyglyclic acid.

A visual analog scale for pain was completed once daily for 10 days after the procedure. The patients were asked to rate pain on a continuous scale from 0 (none) to 10 (excruciating or intense pain). Data on the patients were compared from the pre-operative stage to the short-term and long-term post-operative assessment and analysed by the Student *t* test, repeated measure, and Mann-Whitney U test.

Results

Forty six (94 per cent) patients completed the questionnaires and polysomnographic studies at both the short and long-term follow-up examination and were included in the analysis. The patients were examined between 37 and 46 months after the operation (mean ± SD = 39.4 ± 5.7 months). Ages ranged from 35 to 52 years (40.1 ± 4.2 years). Forty-three (93.5 per cent) patients were married and three (6.5 per cent) were single or divorced; 38 (82.6 per cent) were male. BMI was calculated (weight in kilograms divided by the square of the height in metres). BMI at the time of surgery ranged from 26.5 to 31.2 km/m^2 (28.9 ± 2.1 kg/m^2), at short-term 26.6 to 31.9 kg/m^2 (29.2 ± 3.1 kg/m^2), and at long-term 27.1 to 32.1 kg/m^2 (31.1 ± 2.7 kg/m^2).

There was a significant reduction in the distance between the posterior nasal spine and soft palate (PNS-P) from 45.2 ± 3.3 mm to 42.9 ± 2.7 mm (p<0.01). There was an increase in posterior airway

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TABLE II
PATIENT CHARACTERISTICS

Characteristics	Non-responders	Responders	*p* value
Age (y)	41.2 ± 5.1	40.8 ± 3.8	NS
BM (kg/m^2)	30.5 ± 2.4	28.4 ± 1.8	<0.05
RDI	50.1 ± 9.1	46.7 ± 7.6	<0.01
LSAT (%)	80.9 ± 2.5	81.3 ± 3.1	NS

BMI = body mass index; RDI = respiratory disturbance index; LSAT = lowest oxygen saturation; NS = not significant

space (PAS) from 5.2 ± 1.3 mm to 9.2 ± 1.4 mm (p<0.001) and an increase in the distance between the mandibular plan and hyoid bone (MP-H) from 19.5 ± 4.1 mm to 22.4 ± 1.9 mm (p<0.001). There were no changes in skeletal measurements (SNA, SNB) (Table I).

The mean pre-operative RDI and short-term RDI were 47.9 ± 8.4 and 14.2 ± 3.9 respectively. The mean pre-operative LSAT and short-term LSAT were 81.2 per cent ± 2.9 per cent and 88.8 per cent ± 2.7 per cent, respectively. Response to the GAHM procedure was defined as a 50 per cent reduction in RDI and a final RDI of 20 or less. By these criteria, 36 of 46 (78.3 per cent) patients responded at short-term. The mean BMI was significantly higher in the non-responder group, 30.5 ± 2.4 kg/m^2 as compared to the responder group, 28.4 ± 1.8 kg/m^2 (p<0.05). The mean RDI was also significantly higher in the non-responder group, 50.1 ± 9.1 as compared to the responder group, 46.7 ± 7.6 (p<0.01). There was no statistically significant difference between responders and non-responders concerning age and pre-operative LSAT (Table II). No statistically significant difference in cephalometric measurements was seen between the responders and non-responders.

The mean long-term RDI was 18.6 ± 4.1 and the mean LSAT was 87.2 per cent ± 3.1 per cent. Thirty (65.2 per cent) patients had long-term clinical success (Figure 1). Six (16.7 per cent) patients with short-term success failed over the long-term. The short-term RDI was 14.5 ± 4.7 and increased to 30.1 ± 8.4. The LSAT decrease from 87.5 per cent ± 1.7 per cent to 81.8 per cent ± 3.9 per cent. There were no significant differences between the patients who subsequently relapsed and those who did not with regard to age, pre-operative BMI, RDI, and cephalometric measurements. The change in BMI was in patients with significantly different, and without relapse (2.1 ± 0.3 versus 0.4 ± 0.2 kg/m^2, p<0.01).

Significant improvement from the base line (8.5 ± 1.3) was observed in VAS at six months (1.7 ± 1.4, p<0.001) and long-term (2.7 ± 1.9, p<0.01). There was a significant difference between short-term and long-term results (p<0.05) (Figure 2). The average pre-operative VAS was 8.5, indicating moderate to severe snoring in this group of patients. Snoring was considered to be cured by the bed partner or observer if the VAS was less than half the base line.[14] Based on this criteria, the problem was eliminated in 93.5 per cent (43 of 46) of patients at six months. Thirty-five (81.4 per cent) patients reported continual success without relapse of snoring. Six patients who were subsequently defined as non-responders reported relapse of snoring from 1.7 ± 1.2 to 5.2 ± 2.3 (p<0.001).

At the six months post-operative evaluation, all patients reported a marked improvement or reduction in their daytime sleepiness. The subjective data measured with the ESS (0 to 24) showed significant improvement. The mean pre-operative ESS scale was 15.9 ± 2.7 and the mean post-operative ESS scale was 6.2 ± 2.3 (p<0.01) at short-term and 7.3 ± 2.7 (p<0.01) at long-term. There was a significant difference between short-term and long-term results (p<0.05) (Figure 3). At the long-term post-operative evaluation, six patients who were subsequently defined as non-responders had recurrence of their daytime sleepiness from 6.7 ± 2.1 to 12.8 ± 1.2 (p<0.001).

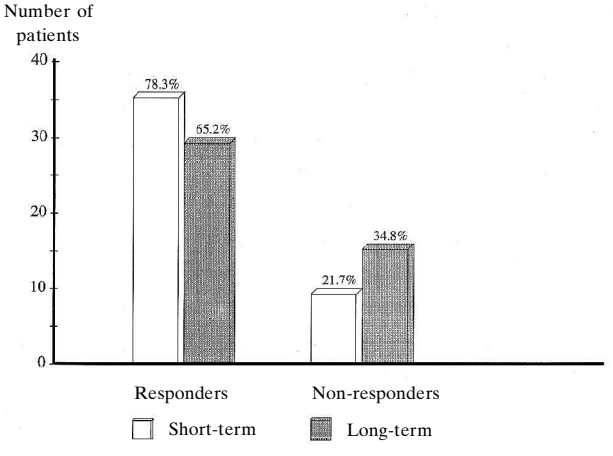

FIG. 1
Responders and non-responders at short-term and long-term.

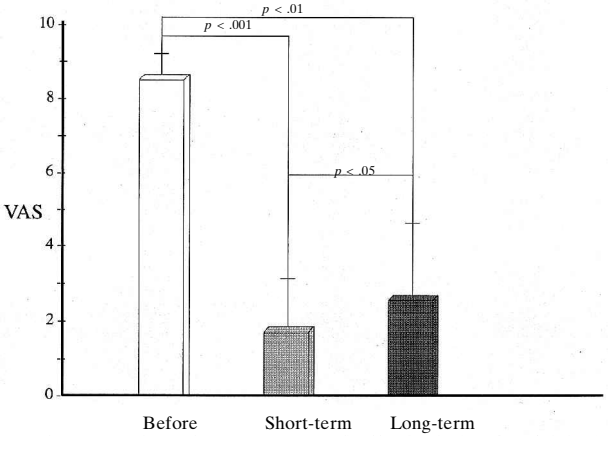

FIG. 2
Mean snoring scale (VAS) before and after surgery.

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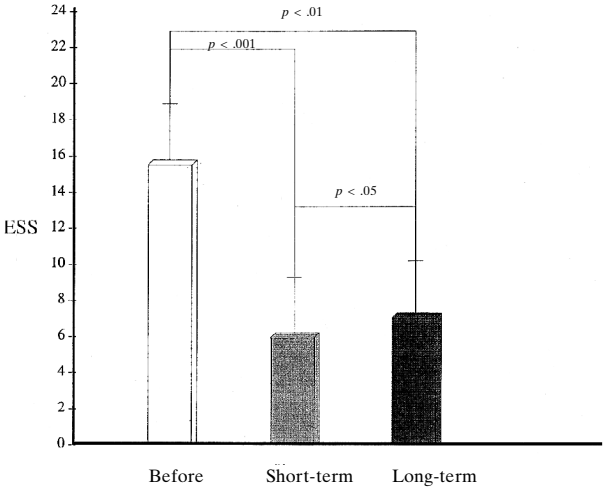

FIG. 3
Mean ESS scale before and after surgery.

Complications included dysphagia in 6.5 per cent (three of 46) and aspiration in 8.7 per cent (four of 46). These were self-limited and resolved in three weeks. There were no emergent airway complications in this study. Most patients (44 of 46) had mild-to-moderate pain (VAS⩽7) for five to seven days after procedures. UPF complications included transient nasal regurgitation 8.7 per cent (four of 46) and transient foreign body sensation 15.2 per cent (seven of 46) for one month. Bleeding, infection and nasopharyngeal stenosis were not encountered. Patients had mild-to-moderate pain (VAS ⩽7) and mild speech problems (VAS⩽4) for five to seven days after the procedure.

Discussion

Surgical treatments for OSA become particularly important when initial medical treatments have failed. The surgical concept for treatment of OSA is to enlarge the upper airway, thereby restoring its patency during sleep. Because the anatomical obstruction associated with OSA may occur at multiple sites, and in severe cases usually does, it is logical to focus the surgical attack on each of these sites. UPPP was the first operation especially designed to address the palatal abnormalities seen in many patients with OSA.[3] Subsequently, other procedures have been introduced, but UPPP remains the most commonly performed operation for OSA in adults. Sher *et al.*[4] reported a short-term UPPP success of 40 per cent in nonselected patients. When hypopharyngeal obstruction was identified, success was a low five per cent. UPPP failure may occur from persistent hypopharyngeal collapse.

Many different approaches have been developed with the intent of better treating hypopharyngeal obstruction. GAHM described by Riley *et al.*[6,12] was undertaken to enlarge the hypopharyngeal area. The genial tubercle, which is the anterior attachment of genioglossus muscle is mobilized by osteotomies and the hyoid with its attached musculature is drawn anteriorly over the thyroid ala, to expand the hypopharyngeal lumen and decrease the airway resistance. In this study, there was a significant widening of the PAS and the MP-H distance lengthened after the surgery.

- **The paper shows the results of a combined surgical approach at the velo- and hypopharyngeal level to try and stabilize the pharyngeal airway in patients with obstructive sleep apnoea who have failed nasal (NCAPAP) continuous positive airways pressure ventilation**
- **The paper demonstrates the authors have achieved a significant increase in the retro-glossal airway or PAS space as shown by significant benefit in terms of reduction of respiratory disturbance index (RDI) and the reduction in the Epworth sleepiness score (ESS)**
- **The authors demonstrate that weight gain and severe obstructive sleep apnoea are mitigators against success in surgical treatment of obstructive sleep apnoea which are basic truths and fundamentally important points to make**

The GAHM results in this study were comparable with the previous studies. It has a 78 per cent success rate of decreasing RDI by 50 per cent or more and post-operative RDI less than 20 events per hour. GAHM literature showed that short-term improvement in OSA occurred in 42 per cent to 75 per cent.[6–9] The findings in this study that the non-responders had significantly higher pre-operative BMI and RDI than the responders are in agreement with results of GAHM literature. Romirez and Loube[8] revealed in morbidly obese patients a 42 per cent success rate. Riley *et al.*[6] showed that patients with mild to moderately severe OSA had an approximately 75 per cent success rate but the surgical success declined to 42 per cent when patients had severe OSA.

The short-term results from GAHM treatment for OSA are encouraging. Ramirez and Lobe,[8] Utley *et al.*[7] and Troell *et al.*[15] showed a 42 to 64 per cent success rate in between three to 12 months after surgery. However, there is little information on long-term results of GAHM. UPPP for OSA has shown that increasing the length of follow-up time results in a drop in the success rate from 60 to 40 per cent.[16] In this study, there were significant differences between short-term and long-term (more than three years) results. Twenty-eight (65 per cent) patients had long-term success and six (16 per cent) patients with short-term success failed in long-term. The significant increase in BMI between the first and second post-operative recordings in the patients with relapse confirm that BMI was important. Patients with recurrence in the long-term also reported relapse of snoring and daytime sleepiness. There were no

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serious complications after GAHM in this study. There were, however, transient aspiration and transient dysphagia.

UPF reported by Powell *et al.*[13] achieved the same results as UPPP but with fewer post-operative complications. In this study, there was a significant reduction in the distance between the posterior nasal spine and soft palate after the operation. The reposition and stabilization of the uvula on the soft palate were responsible for wide opening of the retropalatal airway space. There was a minimal morbidity associated with the treatment. It was a safe and effective adjunct procedure for the treatment of palatal obstruction in OSA patients.

GAHM in the treatment of OSA results in long-term success. A regular follow-up with recommendation concerning weight control is also important for preventing a relapse after GAHM procedure.

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