Positional Dependency and Surgical Success of Relocation Pharyngoplasty among Patients with Severe Obstructive Sleep Apnea

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Abstract

Objective. To examine the effect of positional dependency on surgical success among patients with severe obstructive sleep apnea (OSA) following modified uvulopalatopharyngoplasty, known as relocation pharyngoplasty.

Study Design. Case series with planned data collection.

Setting. Tertiary referred center.

Subjects and Methods. Standard nocturnal polysomnography was used to compare the apnea-hypopnea index (AHI) in different sleep positions before and after relocation pharyngoplasty in 47 consecutive patients with severe OSA (AHI, 59.5 ± 18.2 events/hour; Epworth Sleepiness Scale [ESS] scores, 12.2 ± 4.4) who failed continuous positive airway pressure therapy. Positional (dependency) OSA was defined when the supine:non-supine AHI ratio was >2, otherwise it was defined as nonpositional OSA. Surgical success was defined as a ≥50% reduction in AHI and a postoperative AHI of ≤20 events/hour. Polysomnographic parameters, ESS, and surgical success following surgery were recorded.

Results. Of the 47 patients, 27 (57%) had positional OSA and 20 (43%) nonpositional OSA. The nonpositional OSA patients had higher AHI and ESS scores than the positional OSA patients (P = .002 and .104, respectively). Relocation pharyngoplasty significantly improved AHI and ESS scores in both positional and nonpositional OSA groups 6 months postoperatively (P < .05). The overall surgical success rate was 49%; however, positional OSA patients had a significantly higher success rate than nonpositional OSA patients (67% vs 25%, P = .008).

Conclusion. The presence of positional dependency at baseline was a favorable outcome predictor of surgical success among severe OSA patients undergoing relocation pharyngoplasty.

Keywords

obstructive sleep apnea, positional dependency, sleep position, relocation pharyngoplasty, outcome

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Obstructive sleep apnea (OSA) is characterized by repeated episodes of complete or partial upper airway obstruction during sleep,1 which can be caused by anatomic narrowing or decreased neuromuscular control. Many risk factors have been identified for OSA, including male gender, aging, obesity, redundant soft tissue, and maxillofacial abnormalities.2 These factors are also affected by changes in body position during sleep,3 as OSA patients reportedly have more obstructive events in the supine than in the lateral position.4 Essentially, the effect of gravity on the soft palate and tongue in the supine position during sleep is the main reason for the anatomical and physiological changes observed in this posture.5

Fluctuations in polysomnography in different sleep positions may confound surgical outcomes.6 Uvulopalatopharyngoplasty (UPPP), the most widely used OSA surgery,7 significantly
decreases the apnea-hypopnea index (AHI) in the lateral sleep position, especially in nonpositional OSA patients. However, positional dependency does not seem to affect the success rate of UPPP for OSA. Moreover, the influence of positional dependency on surgical outcome of other modifications of UPPP, such as extended uvulopalatal flap, modified uvulopalatal flap with lateral pharyngoplasty, and relocation pharyngoplasty, have seldom been reported. Relocation pharyngoplasty involves advancing and tensing the soft palate and splinting of the lateral pharyngeal wall especially at inferior pole of the tonsillar fossa that stabilize the soft palate and tongue base and consequently resists gravity and reduces their collapse during supine position. Accordingly, we hypothesized that this surgical technique may treat positional OSA patients more effectively than nonpositional OSA patients.

Since nonpositional OSA patients are less frequently encountered and more severe than positional OSA patients in those with OSA overall (44% vs 56%), severe OSA patients may be good study subjects to assess the effects of positional dependency. Accordingly, we aimed to test the hypothesis that positional dependency at baseline among severe OSA patients is associated with a favorable outcome after relocation pharyngoplasty.

Methods

Ethical Considerations

This study was conducted in a tertiary referral center, the Sleep Center of Chang Gung Memorial Hospital in Taoyuan, Taiwan. This retrospective chart review study was approved by the Institutional Review Board of the hospital prior to commencement of the study.

Patients

This comparative study included 47 consecutive patients who had severe OSA (AHI >30 events/hour) detected by polysomnography, were treated by relocation pharyngoplasty as a single primary surgery, and completed at least 6 months of follow-up between October 2007 and July 2011. Their daytime sleepiness was evaluated using a Mandarin Chinese version of the Epworth Sleepiness Scale (ESS). The principal procedures of relocation pharyngoplasty included tonsillectomy, extending supratonsillar resection, splinting of the lateral pharyngeal wall, and advancing the soft palate. Details of the procedure have been published elsewhere.

Outcome Measurements

Pre- and postoperative changes (after at least 6 months) in AHI and ESS scores were compared in supine and lateral sleep between the positional and nonpositional OSA groups. Differences in perioperative AHI, ESS scores, and success rates between the corresponding groups were also compared. The shifts in positional dependency after surgery were recorded, and changes of perioperative AHI in individual groups were compared. The effect of positional dependency on the surgical success was also assessed.

Surgical Procedure of Relocation Pharyngoplasty

The principal procedures of relocation pharyngoplasty included tonsillectomy, extending supratonsillar resection, splinting of the lateral pharyngeal wall, and advancing the soft palate. Figure 1 shows the principle surgical techniques and the improvement of the retropalatal and retroglossal spaces. Details of the procedure have been published elsewhere.

Statistical Analysis

Baseline demographic parameters, ESS scores, polysomnographic data, and success rates between the positional and nonpositional OSA group were compared. The effect of positional dependency on the surgical success was also assessed.
nonpositional OSA groups were compared by t test, Mann-Whitney U test, Fisher’s exact test, or odds ratios, as appropriate. Comparisons of changes in AHI 6 months postoperatively based on positional dependency were made by the paired t test, while AHI changes after relocation pharyngoplasty according to anatomic structures were compared by the Kruskal-Wallis test. Multilevel logistic regression analysis was applied to investigate significance of independent variables—age, sex, BMI, neck circumference, tonsil size, Friedman tongue position, and positional dependency. Data were expressed as mean ± standard deviation or means (95% confidence interval [CI]). Statistical analyses were performed using SPSS 17.0 statistical package for Windows (SPSS Inc, Chicago, Illinois). A two-tailed P value of less than .05 was considered statistically significant.

Results

There were 47 patients, including 44 men and 3 women, with a mean age of 38.8 ± 9.0 years. The mean AHI and ESS scores were 59.5 ± 18.2 events/hour and 12.2 ± 4.4 kg/m², respectively (Table 1). Of the 47 patients, 27 (57%) had positional OSA and 20 (43%) had nonpositional OSA. There were no significant differences in age, sex, neck circumference, BMI, tonsil size, tongue position, Friedman’s stage, percentage of supine position, and percentage of lateral supine position between the 2 groups. Although there was no difference in supine AHI, the nonpositional OSA patients had a significantly higher total AHI and lateral AHI than the positional OSA patients.

None of them had experienced severe surgical complications such as massive bleeding, airway obstruction, pulmonary edema, or death. All the subjects completed a follow-up polysomnography, and there was no difference in follow-up timing between the 2 subgroups (8.9 ± 7.2 vs 8.0 ± 6.7, P = .651). ESS scores reduced significantly in the entire patient group and in each subgroup (Table 2; all P < .001). However, the percentage reduction in ESS was not significantly different between the positional and nonpositional OSA groups (−28.9% ± 31.9% vs −40.6 ± 28.2%, P = .198). With regards to the pre- and postoperative values of AHI, supine AHI, and lateral AHI in the positional and nonpositional OSA groups, all AHI values improved significantly after relocation pharyngoplasty. The largest perioperative difference and change occurred in the lateral AHI in the nonpositional OSA group.

The overall success rate was 49%. Compared with the nonpositional OSA patients, the positional OSA patients had a significantly higher success rate (67% vs 25%, P = .008; effect size = 0.414).

Changes in postoperative AHI in terms of anatomic structures showed that changes in supine AHI were significantly different among different tonsil size groups: severe OSA patients with the smallest tonsil size had the lowest reduction in supine AHI following relocation pharyngoplasty (Table 3). Following relocation pharyngoplasty, 5 of the 27 positional OSA patients were cured, and 17 of the remaining patients had positional dependency (77%, P = .014). In contrast, 15 patients of the nonpositional OSA group (75%) shifted to the positional OSA group after surgery (P < .001). That is, the proportion of positional dependency increased from 57% (27/42) at baseline to 86% (32/37) at 6 months postoperatively (P = .075).

Logistic regression analyses indicated that ≤37 years (odds ratio = 4.37, P = .034, 95% CI, 1.12-17.10) and

Figure 1. (A) Following tonsillectomy and removal of the supratonsillar mucosa and adipose tissue, splinting of the lateral pharyngeal wall being accomplished in 2-layer suturing. (B) The superior pharyngeal constrictor muscle being sewn to the anterior pillar and the posterior pillar flap being sewn on to the anterior pillar to stabilize the lateral pharyngeal wall. (C) Advancing and lifting of the soft palate and uvula after relocating the lateral pharyngeal wall to enlarge the retropalatal space.
positional dependency (odds ratio = 6.80, \( P = .007 \), 95% CI, 1.68-27.50) were significantly predictive of surgical success.

**Discussion**

The null hypothesis of the present study was supported; that is, severe OSA patients with positional dependency at baseline were more likely to be successfully treated with relocation pharyngoplasty compared with nonpositional OSA patients. Among the severe OSA patients, including both positional and nonpositional cases, the supine AHI, lateral AHI, and ESS scores were significantly reduced after relocation pharyngoplasty. Although the most significant reduction in AHI was noted in nonpositional OSA patients, their surgical success rate was significantly low 6 months postoperatively. However, the nonpositional OSA patients frequently became positional dependent cases following the operation. This suggests that severe nonpositional OSA patients may have a better chance of being effectively treated by relocation pharyngoplasty plus positional therapy.

The current study revealed that supine AHI was significantly higher than lateral AHI, which is consistent with previous studies in which apneic events occurring in the supine position were more severe than those in the lateral position.

**Table 1. Comparisons of baseline demographic and polysomnographic data between positional OSA and nonpositional OSA patients.a**

<table>
<thead>
<tr>
<th></th>
<th>Overall (n = 47)</th>
<th>Positional OSA group (n = 27 [57%])</th>
<th>Nonpositional OSA group (n = 20 [43%])</th>
<th>( P ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>38.8 ± 9.0</td>
<td>37.1 ± 7.6</td>
<td>41.0 ± 10.4</td>
<td>.168</td>
</tr>
<tr>
<td>Sex (male/female)</td>
<td>44/3</td>
<td>25/2</td>
<td>19/1</td>
<td>.741</td>
</tr>
<tr>
<td>NC (cm)</td>
<td>39.6 ± 2.4</td>
<td>39.1 ± 2.4</td>
<td>40.2 ± 2.3</td>
<td>.150</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>27.3 ± 3.0</td>
<td>27.4 ± 3.4</td>
<td>27.2 ± 2.5</td>
<td>.840</td>
</tr>
<tr>
<td>Tonsil size</td>
<td>2.2 ± 0.7</td>
<td>2.2 ± 0.6</td>
<td>2.3 ± 0.8</td>
<td>.608</td>
</tr>
<tr>
<td>Friedman tongue position</td>
<td>2.2 ± 0.6</td>
<td>2.3 ± 0.6</td>
<td>2.1 ± 0.6</td>
<td>.330</td>
</tr>
<tr>
<td>Friedman’s stage</td>
<td>1.9 ± 0.6</td>
<td>1.9 ± 0.6</td>
<td>1.9 ± 0.7</td>
<td>.842</td>
</tr>
<tr>
<td>ESS</td>
<td>12.2 ± 4.4</td>
<td>11.3 ± 5.0</td>
<td>13.3 ± 3.3</td>
<td>.104</td>
</tr>
<tr>
<td>AHI-overall (events/hour)</td>
<td>59.5 ± 18.2</td>
<td>52.5 ± 15.7</td>
<td>68.9 ± 17.4</td>
<td>.002</td>
</tr>
<tr>
<td>AHI-supine (events/hour)</td>
<td>63.4 ± 22.5</td>
<td>61.9 ± 17.1</td>
<td>65.4 ± 28.6</td>
<td>.629</td>
</tr>
<tr>
<td>AHI-lateral (events/hour)</td>
<td>33.7 ± 27.7</td>
<td>13.3 ± 13.1</td>
<td>61.4 ± 14.8</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Percentage of supine sleep position</td>
<td>68.4 ± 21.2</td>
<td>74.6 ± 17.3</td>
<td>60.0 ± 23.5</td>
<td>.062</td>
</tr>
<tr>
<td>Percentage of lateral sleep position</td>
<td>31.6 ± 21.2</td>
<td>25.4 ± 17.3</td>
<td>40.0 ± 23.5</td>
<td>.062</td>
</tr>
</tbody>
</table>

Abbreviations: OSA, obstructive sleep apnea; NC, neck circumference; BMI, body mass index; ESS, Epworth Sleepiness Scale; AHI, apnea-hypopnea index.

*aData are mean ± standard deviation.

**Table 2. Comparisons of changes of daytime sleepiness and disturbed respiratory events after relocation pharyngoplasty.**

<table>
<thead>
<tr>
<th></th>
<th>Preoperative</th>
<th>Postoperative</th>
<th>Mean difference</th>
<th>95% CI</th>
<th>Mean percentage of change</th>
<th>95% CI</th>
<th>( P ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall (n = 47)</td>
<td>ESS 12.2 ± 4.4</td>
<td>7.5 ± 3.6</td>
<td>-4.7</td>
<td>-5.8</td>
<td>-3.5</td>
<td>-33.9</td>
<td>-42.9</td>
</tr>
<tr>
<td></td>
<td>AHI-overall (h)</td>
<td>59.5 ± 18.2</td>
<td>22.6 ± 17.4</td>
<td>-36.9</td>
<td>-42.0</td>
<td>-31.8</td>
<td>-63.1</td>
</tr>
<tr>
<td></td>
<td>AHI-supine (h)</td>
<td>63.4 ± 22.5</td>
<td>27.6 ± 21.5</td>
<td>-35.8</td>
<td>-43.5</td>
<td>-28.1</td>
<td>-53.3</td>
</tr>
<tr>
<td></td>
<td>AHI-lateral (h)</td>
<td>33.7 ± 27.7</td>
<td>10.7 ± 16.7</td>
<td>-23.0</td>
<td>-30.8</td>
<td>-15.2</td>
<td>-57.2</td>
</tr>
<tr>
<td>Positional OSA group (n = 27)</td>
<td>ESS 11.3 ± 5.0</td>
<td>7.5 ± 3.7</td>
<td>-3.8</td>
<td>-5.2</td>
<td>-2.4</td>
<td>-28.9</td>
<td>-41.5</td>
</tr>
<tr>
<td></td>
<td>AHI-overall (h)</td>
<td>52.5 ± 15.7</td>
<td>16.4 ± 12.8</td>
<td>-36.1</td>
<td>-42.7</td>
<td>-29.5</td>
<td>-68.9</td>
</tr>
<tr>
<td></td>
<td>AHI-supine (h)</td>
<td>61.9 ± 17.1</td>
<td>17.9 ± 12.4</td>
<td>-44.0</td>
<td>-51.1</td>
<td>-36.8</td>
<td>-70.7</td>
</tr>
<tr>
<td></td>
<td>AHI-lateral (h)</td>
<td>13.3 ± 13.1</td>
<td>6.9 ± 12.6</td>
<td>-6.4</td>
<td>-11.0</td>
<td>-1.7</td>
<td>-45.2</td>
</tr>
<tr>
<td>Nonpositional OSA group (n = 20)</td>
<td>ESS 13.3 ± 3.3</td>
<td>7.5 ± 3.5</td>
<td>-5.8</td>
<td>-7.9</td>
<td>-3.7</td>
<td>-40.6</td>
<td>-53.8</td>
</tr>
<tr>
<td></td>
<td>AHI-overall (h)</td>
<td>68.9 ± 17.4</td>
<td>31.0 ± 19.6</td>
<td>-37.9</td>
<td>-46.8</td>
<td>-29.1</td>
<td>-55.2</td>
</tr>
<tr>
<td></td>
<td>AHI-supine (h)</td>
<td>65.4 ± 28.6</td>
<td>40.6 ± 24.4</td>
<td>-24.8</td>
<td>-39.6</td>
<td>-10.0</td>
<td>-29.8</td>
</tr>
<tr>
<td></td>
<td>AHI-lateral (h)</td>
<td>61.4 ± 14.8</td>
<td>15.8 ± 20.3</td>
<td>-45.5</td>
<td>-56.9</td>
<td>-34.1</td>
<td>-73.4</td>
</tr>
</tbody>
</table>

Abbreviations: OSA, obstructive sleep apnea; ESS, Epworth Sleepiness Scale; AHI, apnea-hypopnea index; CI, confidence interval; LB, lower bound; UB, upper bound.
position. Positional OSA is common in mild to moderate OSA patients, whereas nonpositional OSA occurs more frequently in patients with severe OSA. In our study, the positional OSA patients had a significantly lower AHI than the nonpositional OSA patients. Pevernagie et al reported that positional and nonpositional OSA patients were different in shape, with an elliptical (long axis oriented, lateral) shape in the positional OSA group and a circular shape in the nonpositional OSA group. When positional OSA patients sleep in the lateral position, the A-P diameter remains constant, and the long lateral diameter resists gravity and prevents a complete collapse of the upper airway.

Almost all previous studies assessing surgical outcomes have focused on changes in total severity in OSA patients who had undergone conventional UPPP. To date, this is the first study to investigate the influence of positional dependency on surgical outcomes of relocation pharyngoplasty. Our findings showed that relocation pharyngoplasty significantly improved not only total AHI but also supine and lateral AHI (Table 2). This is different from previous studies in which UPPP was found to eliminate obstructive events in the lateral sleep position. It is possible that the discrepancy is due to different surgical techniques between UPPP and relocation pharyngoplasty, since UPPP includes tonsillectomy (part of the lateral pharyngeal wall) leading to enlargement of the pharyngeal lateral dimension. However, direct suture of the tonsillar fossa after removal of the tonsils pulls the tongue backwards via the palatoglossus muscle, which narrows the retroglossal dimension. In contrast, relocation pharyngoplasty involves plicating the superior pharyngeal constrictor muscle to rebuild a firm tonsillar fossa that decreases the posterior displacement of the tongue, which causes obstruction in the supine position (Figure 2).

As mentioned previously, if nonpositional OSA occurs more frequently in more severe OSA patients than positional OSA, it is reasonable to assume that nonpositional OSA patients may be treated less effectively by upper airway surgery compared with positional OSA patients. In addition, reducing AHI following relocation pharyngoplasty may shift some nonpositional OSA patients to positional OSA patients. The present study supports these hypotheses, and we suggest that relocation pharyngoplasty enhances the positional effect in OSA patients. Therefore, although the surgical failure rate seems to be particularly high in the severe nonpositional OSA patients compared to the positional OSA patients, the nonpositional OSA patients can be further treated with mandibular advancement devices or positional therapy.

It seems reasonable that relocation pharyngoplasty changes the velopharyngeal shape from elliptical (dimension: A-P) to coronal (dimension: lateral > A-P), which is more resistant to gravity in the lateral sleep position. Therefore, positional therapy may be valuable as an adjunctive treatment after relocation pharyngoplasty in severe OSA patients. Positional therapy is a less frequent form of therapy. Traditionally, patients are advised to stitch a tennis ball into the back of their pajamas; however, this advice is rarely followed and adherence is poor because it is uncomfortable. Maurer et al reported the use of a specially designed vest to prevent the supine position in a small group of patients, and the results showed that 9 (75%) patients were cured. We suggest that multimodality treatment involving surgery and positional therapy could be a new trend because it improves outcomes after limited surgery.

This study has limitations. First, because the proportion of prone sleeping position among the patients was very low (19%), positional OSA patients had a significantly lower AHI than the nonpositional OSA patients. Pevernagie et al reported that positional and nonpositional OSA patients were different in shape, with an elliptical (long axis oriented, lateral) shape in the positional OSA group and a circular shape in the nonpositional OSA group. When positional OSA patients sleep in the lateral position, the A-P diameter remains constant, and the long lateral diameter resists gravity and prevents a complete collapse of the upper airway.

### Table 3. Comparisons of changes of apnea-hypopnea index after relocation pharyngoplasty according to anatomical structures.

<table>
<thead>
<tr>
<th>Overall (n = 47)</th>
<th>Tonsil size</th>
<th>Friedman tongue position</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Overall (n = 47)</td>
<td>I (n = 6)</td>
</tr>
<tr>
<td></td>
<td>Mean percentage of change</td>
<td>LB</td>
</tr>
<tr>
<td>AHI (total)</td>
<td>–53.8</td>
<td>–71.7</td>
</tr>
<tr>
<td>AHI (supine)</td>
<td>–4.3</td>
<td>–66.6</td>
</tr>
<tr>
<td>AHI (lateral)</td>
<td>–77.9</td>
<td>–103.9</td>
</tr>
</tbody>
</table>

Abbreviations: AHI, apnea-hypopnea index; CI, confidence interval; LB, lower bound; UB, upper bound.
limited, the lateral position (both right and left) was also used to represent the non-supine position. This categorization can clearly elucidate changes in the airway lumen and shape in different sleeping postures. Second, this study was limited by its retrospective design. As such, there may have been bias in patient selection. The effect of rapid eye movement sleep that may significantly exacerbate the severity of OSA in patients with mild to moderate OSA has not been determined in the current study. Further, a difference existed in severity of OSA between the positional and nonpositional OSA groups; hence, explanation of the result should be made with caution. Third, the severity of OSA is currently defined by the AHI, but the use of single surrogate outcome may oversimplify the complexity of OSA treatment outcome. A large cohort with similar AHI and other surrogates for an ideal comparison is needed in further extended study.

Conclusions

The supine position produces a detrimental effect on sleep breathing such that OSA is generally more severe during sleep in the supine position. Among severe OSA patients, nonpositional OSA patients have a higher AHI than positional OSA patients, and the difference is mainly in the severity of lateral AHI. Relocation pharyngoplasty significantly improves daytime sleepiness, overall AHI, lateral AHI, and supine AHI. Positional OSA patients had a significantly higher success rate than nonpositional OSA patients, and positional dependency may be a significant factor to predict surgical success among severe OSA patients undergoing relocation pharyngoplasty. Finally, positional therapy may be a valuable adjunctive treatment after relocation pharyngoplasty.

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Author Contributions

Hsueh-Yu Li, conception and design, acquisition of data, analysis and interpretation of data, drafting the article, final approval; Wen-Nuan Cheng, conception and design, analysis and interpretation of data, drafting the article, final approval; Li-Pang Chuang, conception and design, acquisition of data, revising it critically for important intellectual content, final approval; Tuan-Jen Fang, conception and design, acquisition of data, revising the manuscript critically for important intellectual content, final approval; Li-Jen Hsin, conception and design, analysis and interpretation of data, revising the manuscript critically for important intellectual content, final approval; Chung-Jan Kang, conception and design, acquisition of data, revising the manuscript critically for important intellectual content, final approval; Li-Ang Lee, conception and design, acquisition of data, analysis and interpretation of data, revising the manuscript critically for important intellectual content, final approval.

Disclosures

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