Predicting Outcomes after Uvulopalatopharyngoplasty for Adult Obstructive Sleep Apnea: A Meta-analysis

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Abstract

Objective. Uvulopalatopharyngoplasty (UPPP) remains one of the most common surgical treatments for patients with obstructive sleep apnea. However, the results after UPPP are unpredictable. The purpose of this meta-analysis is to identify predictors of success after UPPP.

Data Sources. A literature search was performed utilizing PubMed, EMBASE, SCOPUS, and the Cochrane Library.

Review Methods. The keywords and medical subject heading terms used were uvulopalatopharyngoplasty and UPPP. Studies were included if UPPP was used as a single surgical procedure for the treatment of obstructive sleep apnea and results were presented separately as responder (surgical success) and nonresponder (surgical failure). Exclusion criteria included pediatric patients and other surgical procedures (eg, nasal and hypopharyngeal) performed at the same time as the UPPP. Age, body mass index, preoperative apnea-hypopnea index, Friedman stage, and several cephalometric variables were compared between responders and nonresponders.

Results. A total of 1257 studies were screened, with 15 studies included in this meta-analysis. Our results demonstrate that Friedman stage I is a strong predictor for success after UPPP, while Friedman stage III and low hyoid position are negative predictors. Age, body mass index, preoperative apnea-hypopnea index, and several cephalometric measurements were not significant.

Conclusion. Friedman stage and hyoid position are important predictors for UPPP.

Keywords

obstructive sleep apnea, outcome predictor, meta-analysis, Friedman anatomic stage

Obstructive sleep apnea (OSA) is a serious, potentially life-threatening disorder characterized by repetitive upper airway collapse or narrowing during sleep.1,2 OSA is known to be associated with physical, psychological, neurocognitive, and behavioral sequelae if left untreated.1,2 The primary treatment for OSA is continuous positive airway pressure (CPAP).1 However, only 40% to 60% of patients are compliant with CPAP therapy, and many seek alternate treatments such as surgery.2 Unfortunately, the outcomes of most upper airway operations for OSA are disappointing with mixed results, except for maxilla-mandibular advancement.2 However, recent studies suggest that the success rate for OSA surgery can be improved if patients are carefully selected.3

A variety of operations are commonly used to treat OSA.3 Uvulopalatopharyngoplasty (UPPP) is one of the most common surgical treatments for OSA, which primarily addresses obstruction at the level of the soft palate.4 Maxilla-mandibular advancement shows the highest rates of success; however, the operation is associated with significant morbidity and can be technically challenging.2,3 Tongue base resection or genioglossus advancement is generally performed to address hypopharyngeal obstruction.5,6

UPPP was introduced by Fujita et al in 1981.7 When conservative treatments such as CPAP, weight loss, and dental
appliances are insufficient or intolerable, UPPP remains the primary surgical procedure for many otolaryngologists. The majority of outcomes data in the literature regarding the surgical management for OSA are based on UPPP. A variety of outcome predictors for UPPP have been identified in the literature, including preoperative apnea-hypopnea index (AHI), body mass index (BMI), age, Friedman stage based on tonsil size and palate position, and cephalometric variables. However, the results are not always consistent.

The aim of this study was to systematically review the evidence regarding the key clinical questions of efficacy for UPPP in the treatment of OSA and to identify predictors of surgical success.

Methods

Literature Sources and Study Identification

A comprehensive literature search was performed utilizing PubMed, EMBASE, SCOPUS, and the Cochrane Library. The keywords and medical subject heading terms used were uvulopalatopharyngoplasty and UPPP. The comprehensive search was performed on February 1, 2015. Two reviewers, working independently, screened all abstracts and titles for candidate studies and discarded studies not related to UPPP. No language restriction was applied. After the initial screening, the manuscripts were fully reviewed for eligibility, and disagreements were resolved by consensus.

Selection Criteria and Data Abstraction

The primary inclusion criteria were studies in which UPPP was used as a single surgical procedure for the treatment of OSA. Results were included that presented responders (surgical success) and nonresponders (surgical failure) separately. Definitions of responders were occasionally different among studies; however, what their definitions did have in common was a >50% reduction of preoperative AHI after UPPP. Patients who did not meet these goals were classified as “nonresponders.” As an exception, we did include studies in which the results were not presented as responders and nonresponders when the raw data of individual patients were presented. We classified the patients into the responder group if the preoperative AHI decreased >50% after UPPP or into the nonresponder group if they did not meet responder criteria. We then calculated the mean value and standard deviation of age, BMI, preoperative AHI, and cephalometric parameters for responders and nonresponders separately.

Studies were excluded if other surgical procedures, such as nasal or hypopharyngeal surgery, were performed at the same time as the UPPP or if the surgical results were not clearly defined. Studies that included pediatric patients (<18 years) were also excluded. Prior tonsillectomy and concomitant tonsillectomy were not considered inclusion or exclusion criteria. There were no language restrictions; all abstracts and included manuscripts identified by the search were included.

Statistical Analyses

Age, BMI, preoperative AHI, Friedman stage, and several cephalometric variables were compared between responders and nonresponders. Mean values and standard deviations were used for age, BMI, preoperative AHI, and cephalometric variables (Figure 1). For Friedman stage, patient numbers were given for all stages. The results were reported with 95% confidence intervals (95% CIs) of the standardized mean difference (SMD) for age, BMI, preoperative AHI, and cephalometric variables, with 95% CI of the odds ratio (OR) for Friedman stage. All P values were 2-tailed. Heterogeneity was defined when the P value of the Cochran’s Q statistic test was <0.1 or the value of I² was >50%. When a significant heterogeneity among the outcomes was found, the random effects model according to Dersimonian-Laird was used for merging data. Those outcomes without heterogeneity were analyzed with the fixed effects model based on the inverse variance approach. We used a funnel plot and Egger’s test simultaneously to detect publication bias. Analysis was performed with Comprehensive Meta-analysis 2.0 (Biostat, Englewood, New Jersey). The statistical details are summarized in Table 1.

Results

A flowchart illustrating the study selection process is found in Figure 2. Based on our search terms, 1257 relevant studies were screened and evaluated. Of these, 1156 were excluded per review of the abstracts. The most common reasons for
study exclusion were the absence of postoperative polysomnography data and other surgical methods performed in addition to UPPP. Of these, 78 articles underwent full review, and 15 studies met the inclusion and exclusion criteria (Table 2).

From the studies that met our inclusion and exclusion criteria,8,10-16,18-22 we collected data on number of patients in each study, age, BMI, preoperative AHI, Friedman stage, and several cephalometric variables (see Appendixes 1 and 2 at www.otojournal.org/supplemental). In total, data from 693 patients were recorded and utilized for statistical analysis.8-22

The follow-up periods varied among studies, ranging from 4 to 96 months.

Table 1. Statistical Details.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Enrolled Studies, n</th>
<th>Cochrane’s Q (P Value)</th>
<th>Pooling Estimates Model</th>
<th>Overall Effect Size: Responders vs Nonresponders, 95% CI (P Value)</th>
<th>Publication Bias (P Value, Egger Test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>7</td>
<td>3.086 (.543) 0.000</td>
<td>Fixed effect</td>
<td>–0.324 to 0.171 (.543)</td>
<td>None (.087)</td>
</tr>
<tr>
<td>Body mass index</td>
<td>11</td>
<td>12.139 (.276) 17.624</td>
<td>Fixed effect</td>
<td>–0.313 to 0.082 (.252)</td>
<td>None (.949)</td>
</tr>
<tr>
<td>Preoperative AHI</td>
<td>12</td>
<td>22.671 (.020) 51.479</td>
<td>Random effect</td>
<td>–0.577 to 0.004 (.054)</td>
<td>None (.481)</td>
</tr>
<tr>
<td>Friedman stage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>3</td>
<td>1.698 (.428) 0.000</td>
<td>Fixed effect</td>
<td>2.316 to 8.468 (.001)</td>
<td>None (.660)</td>
</tr>
<tr>
<td>II</td>
<td>3</td>
<td>9.599 (.008) 79.165</td>
<td>Random effect</td>
<td>0.797 to 13.745 (.099)</td>
<td>None (.247)</td>
</tr>
<tr>
<td>III</td>
<td>3</td>
<td>12.475 (.002) 83.968</td>
<td>Fixed effect</td>
<td>0.040 to 0.663 (.011)</td>
<td>None (.438)</td>
</tr>
<tr>
<td>Cephalometry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SNA</td>
<td>3</td>
<td>3.107 (.211) 35.639</td>
<td>Fixed effect</td>
<td>–0.464 to 0.199 (.432)</td>
<td>None (.765)</td>
</tr>
<tr>
<td>SNB</td>
<td>3</td>
<td>2.470 (.291) 19.017</td>
<td>Fixed effect</td>
<td>–0.248 to 0.415 (.623)</td>
<td>None (.668)</td>
</tr>
<tr>
<td>ANB</td>
<td>4</td>
<td>0.228 (.973) 0.000</td>
<td>Fixed effect</td>
<td>–0.558 to 0.024 (.072)</td>
<td>None (.287)</td>
</tr>
<tr>
<td>MP-H</td>
<td>4</td>
<td>5.575 (.350) 10.309</td>
<td>Fixed effect</td>
<td>–0.658 to –0.136 (.003)</td>
<td>None (.675)</td>
</tr>
<tr>
<td>PAS</td>
<td>4</td>
<td>1.563 (.668) 0.000</td>
<td>Fixed effect</td>
<td>–0.041 to 0.623 (.085)</td>
<td>None (.515)</td>
</tr>
<tr>
<td>PNS-U</td>
<td>5</td>
<td>2.668 (.615) 0.000</td>
<td>Fixed effect</td>
<td>–0.154 to 0.434 (.351)</td>
<td>None (.378)</td>
</tr>
</tbody>
</table>

Abbreviations: 95% confidence interval, 95% CI; ANB, angle between maxilla and mandible; MP-H, distance from the hyoid to the mandibular plane; PAS, posterior airway space; PNS-U, length of the soft palate; SNA, maxillary protrusion angle; SNB, mandibular protrusion angle.

*For Friedman stage, 95% CI of the odd ratio; for all else, 95% CI of the mean.

**P < .05.

Figure 2. Flow diagram of study selection.

Quality of Included Studies

All included studies were retrospective case series. There were no randomized trials identified in the literature search. The primary methodological limitation of the included studies was related to the lack of an explicit statement that participants were recruited consecutively. Additional information on the quality of the included studies is found in Appendix 3 (online).

Outcome Measures

Age, BMI, and Preoperative AHI. Seven articles (263 patients)8-10,12,18,21,22 were used to analyze age, 11 (422 patients)8,10-13,16-19,21,22 to analyze BMI, and 12 (437 patients)3-13,16-19,21,22 to analyze preoperative AHI (Table 2). For age and BMI, data were merged according to a fixed effects model, while those of preoperative AHI were merged according to random effects model (Figure 3). Age (SMD: –0.077, range: –0.324 to 0.171, P = .543), BMI (SMD: –0.115, range: –0.313 to 0.082, P = .252), and preoperative AHI (SMD: –0.287, range: –0.577 to 0.004, P = .054) were smaller among responders than nonresponders. However, the differences failed to reach statistical significance for all 3 variables. The P value of Egger’s test was >0.05 for all 3 variables, and a funnel plot of these variables (not shown here) showed roughly symmetric distribution from midline, suggesting no publication bias.

Friedman Stage. Three studies (361 patients) were used to analyze Friedman stage (Table 2).13,14,20 For stages I and III, data were merged according to a fixed effects model...
<table>
<thead>
<tr>
<th>Study</th>
<th>Patients, n</th>
<th>Follow-up, mo</th>
<th>Additional Criteria for Responders&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Presented Parameters</th>
<th>Main Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gislason&lt;sup&gt;8&lt;/sup&gt; (1988)</td>
<td>R, 22 NR, 12</td>
<td>6</td>
<td>None</td>
<td>Age, BMI, AHI, MP-H, PAS, PNS-U</td>
<td>60% of patients were successfully treated</td>
</tr>
<tr>
<td>Min&lt;sup&gt;9&lt;/sup&gt; (1995)</td>
<td>R, 7 NR, 8</td>
<td>6</td>
<td>And postoperative AHI &lt;20</td>
<td>Age, AHI</td>
<td>The Rs showed significantly higher preoperative oxygen saturation, lower preoperative AHI, and BMI than the NRs.</td>
</tr>
<tr>
<td>Janson&lt;sup&gt;10&lt;/sup&gt; (1997)</td>
<td>R, 11 NR, 13</td>
<td>48-96</td>
<td>And postoperative AHI &lt;10</td>
<td>Age, BMI, AHI</td>
<td>Preoperative AHI was lower among Rs than NRs, while BMI was not different between them.</td>
</tr>
<tr>
<td>Langin&lt;sup&gt;11&lt;/sup&gt; (1998)</td>
<td>R, 7 NR, 13</td>
<td>10</td>
<td>Or postoperative AHI &lt;10</td>
<td>BMI, AHI, MP-H, PAS, PNS-U</td>
<td>Postoperative enlargement of airway at oropharyngeal level is associated with a good outcome after UPPP.</td>
</tr>
<tr>
<td>Millman&lt;sup&gt;12&lt;/sup&gt; (2000)</td>
<td>R, 16 NR, 30</td>
<td>4</td>
<td>Or postoperative AHI &lt;10</td>
<td>Age, BMI, AHI, ANB, MP-H, PAS, PNS-U</td>
<td>Baseline AHI &lt;38, an MP-H &lt;20 mm, and the absence of retrognathia are predictors of improvement after UPPP.</td>
</tr>
<tr>
<td>Matsumoto&lt;sup&gt;13&lt;/sup&gt; (2002)</td>
<td>R, 14 NR, 29</td>
<td>&lt;6</td>
<td>None</td>
<td>BMI, AHI, SNA, SNB, ANB, MP-H, PNS-U</td>
<td>Maximum palate thickness was greater among Rs than NRs.</td>
</tr>
<tr>
<td>Friedman&lt;sup&gt;14&lt;/sup&gt; (2005)</td>
<td>R, 42 NR, 92</td>
<td>6-12</td>
<td>And postoperative AHI &lt;20</td>
<td>Friedman stage</td>
<td>Success rates for mild, moderate, and severe patients (based on preoperative AHI) were very similar (33.6%, 29.9%, and 36.6%, respectively). Friedman stage I had a success rate of 80.6%, stage II 37.9%, and stage III 8.1%.</td>
</tr>
<tr>
<td>Li&lt;sup&gt;15&lt;/sup&gt; (2006)</td>
<td>R, 86 NR, 24</td>
<td>12</td>
<td>And postoperative AHI &lt;10</td>
<td>Friedman stage</td>
<td>Success rates for mild (90%), moderate (73%), moderate-severe (81%), and severe (74%) patients were similar (P = .10). However, success rates for patients with anatomic stages I, II, III, and IV were 100%, 96%, 65%, and 20%, respectively (P &lt; .001).</td>
</tr>
<tr>
<td>Lee&lt;sup&gt;16&lt;/sup&gt; (2010)</td>
<td>R, 27 NR, 42</td>
<td>6</td>
<td>And postoperative AHI &lt;10</td>
<td>BMI, AHI</td>
<td>Mouth opening &gt;38° during videofluoroscopy is a poor prognostic factor.</td>
</tr>
<tr>
<td>Aneeza&lt;sup&gt;17&lt;/sup&gt; (2011)</td>
<td>R, 5 NR, 5</td>
<td>12-84</td>
<td>And postoperative AHI &lt;20</td>
<td>BMI, AHI</td>
<td>60% were successfully treated with UPPP in the long term. Daytime sleepiness was significantly reduced, while 11 of 14 (78.5%) were reported to develop long-term side effects of UPPP, the highest being velopharyngeal insufficiency (42.8%).</td>
</tr>
<tr>
<td>Xiong&lt;sup&gt;18&lt;/sup&gt; (2011)</td>
<td>R, 22 NR, 17</td>
<td>6</td>
<td>And postoperative AHI &lt;20</td>
<td>Age, BMI, AHI</td>
<td>Disease severity, glucose and lipid metabolism, and Friedman stage may be important predictors of surgical outcome of UPPP.</td>
</tr>
<tr>
<td>Tanyeri&lt;sup&gt;19&lt;/sup&gt; (2012)</td>
<td>R, 13 NR, 19</td>
<td>36-96</td>
<td>And postoperative AHI &lt;20</td>
<td>BMI, AHI</td>
<td>Weight gain decreases the success of UPPP over the years.</td>
</tr>
<tr>
<td>Shie&lt;sup&gt;20&lt;/sup&gt; (2013)</td>
<td>R, 50 NR, 67</td>
<td>6</td>
<td>And postoperative AHI &lt;20</td>
<td>Friedman stage</td>
<td>Treatment success was significantly lower in the obese group (24.6%) vs the nonobese group (62.5%).</td>
</tr>
<tr>
<td>Braga&lt;sup&gt;21&lt;/sup&gt; (2013)</td>
<td>R, 23 NR, 31</td>
<td>&gt;84</td>
<td>And postoperative AHI &lt;5</td>
<td>Age, BMI, AHI, SNA, SNB, ANB, MP-H</td>
<td>BMI, preoperative AHI, and cephalometric measurement showed no influence on surgical success.</td>
</tr>
<tr>
<td>Liu&lt;sup&gt;22&lt;/sup&gt; (2013)</td>
<td>R, 23 NR, 28</td>
<td>6-12</td>
<td>And postoperative AHI &lt;20</td>
<td>Age, BMI, AHI, SNA, SNB, ANB, MP-H, PAS, PNS-U</td>
<td>The preoperative distance from the posterior border of the uvula to the middle pharyngeal wall was significant predictor of UPPP surgical success.</td>
</tr>
</tbody>
</table>

Abbreviations: AHI, apnea-hypopnea index; ANB, angle between maxilla and mandible; BMI, body mass index; MP-H, distance from the hyoid to the mandibular plane; NR, nonresponder; PAS, posterior airway space; PNS-U, soft palate length; R, responder; SNA, maxillary protrusion angle; SNB, mandibular protrusion angle; UPPP, uvulopalatopharyngoplasty.<br><sup>a</sup>Except ≤50% reduction of AHI.
because they were not heterogeneous, while data of stage II were merged according to a random effects model (Figure 4). The ratio of stage I was significantly greater among responders versus nonresponders (OR: 4.429, range: 2.316-8.486, \( P < .001 \)), while that of stage III was significantly smaller (OR: 0.164, range: 0.040-0.663, \( P = .011 \)). Ratio of

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**Figure 3.** Comparison of age, BMI, and preoperative AHI between responders and nonresponders. Mean values are not significantly different between the 2 groups. AHI, apnea-hypopnea index; BMI, body mass index.
stage II was greater among responders but failed to reach statistical significance (OR: 3.310, range: 0.797-13.745, $P = .099$). The $P$ value of Egger’s test was $>.05$ for all 3 variables, and the funnel plot of these variables (not shown here) showed roughly symmetric distribution from midline, suggesting no publication bias.

**Cephalometric Variables.** Six studies (248 patients) were used to analyze cephalometric variables (Table 2). For all variables, data were merged according to a fixed effects model (Figure 5). Among 6 variables (Figure 1), only MP-H (distance from the hyoid to the mandibular plane) showed a significant difference between responders and nonresponders. MP-H was statistically smaller among responders versus nonresponders (SMD: $-0.397$, range: $-0.658$ to $-0.136$, $P = .003$). ANB (angle between maxilla and mandible) and PAS (posterior airway space) just failed to reach $P < .05$. ANB (SMD: $-0.267$, range: $-0.558$ to $0.024$, $P = .072$) was smaller among responders versus nonresponders, while PAS (SMD: $0.291$, range: $-0.041$ to

![Figure 4](image)

**Figure 4.** Comparison of Friedman stage between responders and nonresponders. Odds ratio of Friedman stage I is significantly greater among responders, while that of Friedman stage III is greater among nonresponders.
Figure 5. Comparison of cephalometric measurements between responders and nonresponders. Mean value of MP-H is significantly greater among nonresponders than responders. SNA, SNB, ANB, PAS, and PNS-U are not different between the 2 groups.
0.623, \( P = .085 \)) was greater. SNA (maxillary protrusion angle; SMD: \(-0.133\), range: \(-0.464\) to 0.199, \( P = .432\)), SNB (mandibular protrusion angle; SMD: \(0.083\), range: \(-0.248\) to 0.415, \( P = .623\)), and PNS-U (length of the soft palate; SMD: 0.140, range: \(-0.154\) to 0.434, \( P = .351\)) were not significantly different between the 2 groups. The \( P \) value of Egger’s test was >.05 for all 6 variables, and the funnel plot of these variables (not shown here) showed roughly symmetric distribution from midline, indicating no publication bias.

**Discussion**

This meta-analysis included 15 studies evaluating the outcomes of UPPP for patients with OSA. The data suggest that Friedman stage I is a strong predictor for success after UPPP, while Friedman stage III and low hyoid position are negative predictors. Age, BMI, preoperative AHI, and other cephalometric measurements were not significant predictors of success after UPPP. Among all potential outcome predictors, only a few could be included in this meta-analysis due to significant heterogeneity in study design and results.

Guidelines recommend CPAP as the primary treatment option for OSA.\(^1\) Surgery is considered for those who are noncompliant with CPAP or cannot tolerate its use.\(^1,2\) However, it has been difficult to predict which patients will have successful surgical results, and the dogma that preoperative AHI can predict surgical results is controversial. Other studies have found that anatomic stage based on tonsil size and palate position is much more important for surgical outcome than preoperative AHI. For example, Li et al\(^{15}\) found no differences in surgical success rates after UPPP for mild (90%), moderate (73%), moderate-severe (81%), and severe OSA (74%; \( P = .10\)). However, when evaluating the same patients based on anatomic stage, they found that success rates for patients with anatomic stage I, II, III, and IV were 100%, 96%, 65%, and 20%, respectively (\( P < .001\)).

Friedman et al\(^{14}\) also showed similar results. Success rates for UPPP based on the preoperative polysomnography data were not statistically significant, whereas anatomic classification by the Friedman staging system (based on tongue position, tonsil size, and body mass index) could predict a better surgical outcome. Fukuda et al\(^{23}\) evaluated outcomes after UPPP based solely on tonsil size. Tonsils were graded 1 to 3, with grade 3 representing tonsils in contact with each other. The surgical success rates based on tonsil grades 1, 2, and 3 were 10%, 43%, and 80%, respectively, which was statistically significant. Many investigators believe that tonsillectomy can play a bigger role than palatal surgery in UPPP. There is also evidence that the effect of UPPP is very limited for the patients with prior tonsillectomy.\(^{24}\) Our meta-analysis confirmed that anatomic stage is a strong outcome indicator for UPPP. Patients with Friedman stage I anatomy are more likely to be surgical responders when compared with patients with unfavorable anatomy, or Friedman stage III.

UPPP is considered to be most effective for patients with obstruction at the level of the soft palate.\(^6\) A number of studies suggest that patients with obstruction at the level of the hypopharynx do not typically respond well to UPPP. Aboussouan et al\(^{22}\) evaluated patients with OSA with only velopharyngeal collapse based on the Müller test and found a success rate of 78% after UPPP, while those with hypopharyngeal collapse have a success rate of 36%. Li et al\(^{26}\) demonstrated that preoperative AHI decreased from 48.6 to 18.7 after UPPP for the patients with only oropharyngeal obstruction based on sleep endoscopy, while preoperative AHI decreased from 53.0 to 34.0 for those with hypopharyngeal obstruction. Friedman et al\(^{27}\) found that OSA patients with Friedman stage II or III improved significantly after UPPP when combined with tongue base radiofrequency ablation, while patients who had only UPPP failed to improve. Han et al\(^{28}\) reported that preoperative AHI did not decrease significantly when tongue base obstruction was observed, frequently based on overnight upper airway pressure. The evidence suggests that patients with hypopharyngeal obstruction are not the best candidates for UPPP. However, this meta-analysis could not examine this potential variable due to heterogeneity and insufficient data among the included studies.

A number of studies have argued that preoperative AHI is a predictor for outcomes after UPPP.\(^{4,10,29}\) For example, Dündar et al\(^{29}\) reported that preoperative AHI >40 indicated poor outcome. Around the same time, Janson et al\(^{10}\) also reported that the mean preoperative AHI for surgical responders was 25, while those for nonresponders was 48. However, Friedman et al\(^{14}\) and Li et al\(^{15}\) showed that preoperative AHI was not a meaningful indicator for surgical outcome. Our meta-analysis suggests that preoperative AHI was greater among nonresponders versus responders; however, the difference failed to reach significance (\( P = .054\)).

Generally, obesity is thought to reduce a diameter of upper airway, which can aggravate OSA severity and potentially worsen surgical outcomes. In Friedman’s anatomic staging system, Friedman defined stage IV as BMI >40 without considering other factors.\(^{40}\) However, there is still conflicting evidence regarding the association between obesity and surgical outcome. Boot et al\(^{31}\) Janson et al,\(^{10}\) and Braga et al\(^{27}\) reported that BMI was not associated with surgical outcome, while Dündar et al\(^{29}\) and Shie et al\(^{20}\) argued that high BMI was a poor predictor for surgical results. Our meta-analysis showed that BMI was not an outcome indicator for UPPP.

However, many surgeons do not operate on severely obese OSA patients, and most studies exclude patients with BMI >40. Therefore, it is difficult to determine if BMI is a meaningful prognostic factor based on the exclusion criteria from a number of the studies.

Anatomy-based parameters, or cephalometry, have been used to predict outcomes after UPPP. Many investigators have tried to find some measurable characteristics to predict surgical outcome. Petri et al\(^{32}\) reported that low hyoid position, increased cranio cervical angle, and short maxilla were predictors of poor surgical outcomes. Millman et al\(^{12}\) reported that the distance from the hyoid to the mandible
The study does have limitations that should be acknowledged. First, many studies have been published reporting surgical results after UPPP; however, only 15 met our criteria to be included in this meta-analysis. Most were eliminated because of heterogeneity of study design and result format. For example, we excluded studies when other surgical procedures were performed at the same time as UPPP. If these studies were included, then the sole effect of UPPP could not be estimated. In addition, a common format for study results is essential for merging data, so we gathered only the studies that presented their results as responders and nonresponders. These exclusion criteria did limit the number of studies that we included in this meta-analysis. Second, the overall quality of enrolled studies was low. All the studies for this meta-analysis were based on retrospective data, with no randomized trials. Third, although >50% reduction of AHI was one of the most commonly used measures of surgical success in the reviewed articles, definitions of surgical responders did differ among studies, as seen in Table 2. If the number of enrolled studies were sufficient, we would have been able to perform subgroup analysis based on postoperative AHI. However, the number of included studies was insufficient for this analysis. Fourth, due to limitations in the data, we were unable to report some of the exact cutoff values for various cephalometric outcomes. For example, the distance from the hyoid to the mandibular plane is longer among nonresponders, but the range could not be presented.

Conclusion

This meta-analysis demonstrates that anatomic factors such as Friedman stage and hyoid position are better able to predict outcomes after UPPP. Age, BMI, and preoperative AHI were not found to be predictors of surgical success. Sleep surgeons should carefully consider various anatomic factors prior to performing UPPP to improve surgical results.

Author Contributions

Ji Ho Choi, data search and collection, manuscript revision, final approval of the version to be published, agreement to be accountable for all aspects of the work; Seok Hyun Cho, data search and collection, manuscript revision, final approval of the version to be published, agreement to be accountable for all aspects of the work; Soo-Nyung Kim, data analysis, manuscript revision, final approval of the version to be published, agreement to be accountable for all aspects of the work; Jeffrey D. Suh, data interpretation, manuscript writing, final approval of the version to be published, agreement to be accountable for all aspects of the work; Jae Hoon Cho, study design, manuscript writing, final approval of the version to be published, agreement to be accountable for all aspects of the work.

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Supplemental Material

Additional supporting information may be found at http://otojournal.org/supplemental.

References


