Anterior Palatoplasty for Obstructive Sleep Apnea: A Systematic Review and Meta-analysis

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Abstract

Objective. The aim of this study was to determine the general outcomes and surgical success rates of anterior palatoplasty (AP) in patients with obstructive sleep apnea (OSA).

Data Sources. A systematic review of the literature and meta-analysis of published data were performed by searching the Cochrane, SAGE, MEDLINE, and Google Scholar databases, from January 1, 2007, to March 27, 2017, using relevant keywords.

Review Methods. The search scanned for studies with patients who had undergone AP (with or without tonsillectomy) as a single-stage, single-level surgical intervention for treatment of OSA. Two independent reviewers (M.B. and O.K.) inspected titles and abstracts of the studies according to established criteria. The full texts were then reviewed to extract the clinical and polysomnographic data. The primary outcome was the surgical success rate, defined as a reduction in the apnea-hypopnea index (AHI) of 50% or greater and an AHI of less than 20 postoperatively. The PRISMA statement was followed.

Results. After systematic evaluation of potentially relevant articles, 14 studies were downloaded, and 6 studies, consisting of 170 patients, met the study criteria. A fixed effects model was used to analyze the data. The surgical success rate of AP was 60.6%. No serious complications were reported in the literature.

Conclusion. The results of the present meta-analysis support AP as a moderately effective surgical method for the treatment of OSA. Comparative and randomized controlled prospective studies showing long-term results, with pre- and postoperative data, should be conducted to demonstrate the exact outcomes and reliability of this surgical technique.

Keywords

anterior palatoplasty, snoring, obstructive sleep apnea, surgical success, meta-analysis

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follows: a horizontal rectangular strip of mucosa and submucosa with dimensions of $4 \times 1$ cm (about 40-50 mm in length and 7-10 mm in width) is excised from the soft palate at 1 cm above the attachment of the uvula to the upper palatal pillar. The stripped area is then sutured with 10 to 15 Vicryl sutures, which pulls the soft palate anteriorly and superiorly. If prominent palatal arch webbing is evident, parauvular vertical cuts can be made on either side of the uvula. The muscle layer is completely protected in all versions of this procedure. The main structure of uvula is preserved; however, a minimal uvulectomy can be performed, especially in patients with elongated uvulas.

Previous reports showed that the AP technique provides an acceptable solution for snoring, and some authors have published their surgical outcomes. The major concern regarding AP is whether this surgical procedure can successfully treat OSA. Moreover, the severity of OSA is considered an important handicap for AP, as successful performance of AP alone in moderate or severe disease was deemed difficult, according to some authors.

A literature search revealed several reports from different centers regarding surgical outcomes of AP, but no meta-analysis is available that shows the general AP success rate. The purpose of the present study was to review the clinical and polysomnographic results of AP surgery and to conduct a meta-analysis to reveal the general success rate of the AP surgical procedure.

**Data and Methods**

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement was followed during this review.

**Search Strategy and Study Selection**

A literature search was independently performed by 2 researchers (M.B., O.K.) who searched the Cochrane, SAGE, MEDLINE, and Google Scholar databases from January 1, 2007, to March 27, 2017. The search terms used were *anterior palatoplasty, palatal surgery, pharyngoplasty, uvulopalatoplasty, snoring, sleep apnea, obstructive sleep apnea, sleep apnea syndrome, surgical*, and *surgery*. The final update of the review was performed on March 27, 2017.

**Data Extraction and Analysis**

**Inclusion criteria.** The inclusion criteria stipulated studies published in English specifying AP for the treatment of snoring and OSA. The following were included: (1) studies including AP surgery alone for treatment of OSA (with or without tonsillectomy) and (2) reports of preoperative and postoperative quantitative outcomes for the apnea-hypopnea index (AHI) identifying surgical success rate. If pre- or postoperative AHI data were missing but the general success rate was given, those studies were also included.

**Exclusion criteria.** Articles that did not meet the following criteria were excluded: repeatedly published literature, language other than English, no data regarding number of patients with surgical success, diseases other than OSA, surgeries other than AP, patients who underwent adjunctive procedures or multilevel surgery at the same time as AP (tonsillectomy was not excluded), patients who underwent additional OSA surgery at any time after AP but before postsurgical polysomnography (as this can affect polysomnographic results), radiologic studies, or animal experiments (Figure 1).

**Main outcome measurements.** The primary outcome was the surgical success, defined as a greater than 50% reduction in the AHI to fewer than 20 events/h. If the success criteria were more restrictive than this, those studies were also included (ie, a greater than 50% reduction in the AHI to postoperative AHI $<15$ events/h or a greater than 50% reduction in the AHI to postoperative AHI $<10$ events/h). The secondary outcomes were visual analog scale (VAS) scores for snoring, the Epworth Sleepiness Scale (ESS) scores, the lowest oxygen saturation ($\text{minO}_2$), the mean oxygen saturation ($\text{meanO}_2$), and the oxygen desaturation index (ODI).
Statistical analysis. The meta-analysis was performed using the Comprehensive Meta-Analysis Software for Windows Version 3 (Biosoft Inc., Englewood, New Jersey, USA). The proportional meta-analysis was calculated according to the surgical success rates of the included studies. When \( P > 0.5 \) and \( P < 0.05 \), heterogeneity was considered statistically significant. According to the significance of the heterogeneity, the fixed effects model was used to analyze data. The outcome variables were proportion (%) and 95% confidence interval (CI), which were calculated to evaluate the efficacy of the AP surgery.

Quality assessment of included studies. The National Institute for Health and Clinical Excellence (NICE) quality assessment tool was used to evaluate the included studies. The 8 items were investigated for each study according to the NICE checklist: (1) Was the case series collected in more than 1 center (ie, multicenter study)? (2) Is the hypothesis/aim/objective of the study clearly described? (3) Are the inclusion and exclusion criteria (case definition) clearly reported? (4) Is there a clear definition of the outcomes reported? (5) Were data collected prospectively? (6) Is there an explicit statement that patients were recruited consecutively? (7) Are the main findings of the study clearly described? (8) Are outcomes stratified (eg, by abnormal results, disease stage, patient characteristics)? The total quality score for each study was calculated.

Risk of bias. For assessment of bias, the Cochrane Collaboration’s recommendation was followed. The risk of bias for the studies was evaluated using prespecified questions appropriate to each study design. Discrepancies were resolved by both authors (M.B., O.K.) through discussion.

Results

Overview of the Included Studies

Only studies with surgical success data, without multilevel or additional surgery, were included in this meta-analysis. The excluded studies are listed in detail in Figure 1. Since tonsillectomy is generally performed as a component of velopharyngeal OSA surgeries, cases that had undergone concurrent tonsillectomy were not excluded. Other reviews and meta-analyses were excluded to avoid possible duplications. Of the 308 articles found through the database searches, 294 studies were excluded. After evaluation of the remaining 14 studies carefully as full texts, 6 studies finally met the criteria for inclusion in the present meta-analysis.7, 8, 11-14 In accordance with the purpose of this study, primary snoring cases were not included. The total number of patients was 170. Four studies had available data regarding sex information, identifying 100 male patients (86.2%) and 16 female patients (13.8%). The mean age and the mean body mass index (BMI) for each study are shown in Table 1. The minimum and maximum follow-up periods were 3 months and 33.5 months, respectively. The highest and lowest surgical success rates were obtained in the studies by Marzetti et al11 (86%) and Adzreil et al14 (45.2%), respectively. The largest study sample was reached in the study by Ugur et al12 (n = 41), and the lowest number of patients was 8 in the study by Pang et al7 (Table 1). The preoperative and postoperative outcomes are shown in Table 2.

Meta-analysis Results

The calculated overall success rate for AP was 60.6% in 170 patients, according to the fixed effects model (52.8-67.9 for 95% confidence intervals [CIs]; \( P = 0.008; z = 2.64; \) heterogeneity for significance = 0.86) (Figure 2). In addition to this main calculation, given that Pang developed the procedure, we performed an author bias analysis by excluding the 2 studies by Pang et al.7, 8 This subanalysis reduces the probability of author bias and possible duplication bias. For the remaining 4 studies (123 patients), the success rate was 56.3% (47.1-65.1 for 95% CIs; \( P = 0.177; z = 1.350; \) heterogeneity for significance = 0.107).

Complications

The complications were expressed in detail in 4 studies; complications included pain, lump sensation, nasal regurgitation, and bleeding (Table 1). No speech changes or velopharyngeal insufficiency were reported in the included studies. None of the patients experienced any type of airway obstruction postoperatively. None of the studies reported any requirement for tracheotomy.

Methodological Quality of Included Studies

The studies included in this meta-analysis were all case series. The NICE quality assessment tool demonstrated that the studies met between 5 and 7 of the 8 items (6, 7, 7, 6, 6, 5 points). No study met all 8 items.

Assessment of the Risk of Bias

The data presented in this meta-analysis were obtained from case series that constitute low or moderate risk of bias. We also have performed a proportional meta-analysis to calculate the overall success rate of AP without extraction of individual patient data from each study. None of the included studies gave individual patient data where inadequate reporting of studies could be rated as having an unclear risk of bias. Differential reporting of surgical success criteria among the included studies could be considered to represent reporting bias. The aforementioned author bias analysis should be noted.

Discussion

The results of this meta-analysis indicated a general success rate of AP of 60.6%. This is the effect of the single surgery, independent of the patients’ anatomical structure, requirement for a next-step surgery, presence of multilevel obstruction, or accuracy of indication. The presence of multilevel obstruction may impair the efficacy of AP; moreover, patients with OSA with multilevel obstruction cannot benefit sufficiently from AP when it is performed as a single surgery because AP alters only 1 portion of the upper airway. Readers should also view the meta-analysis results while considering the possibility of second-line surgery after AP.
### Table 1. Characteristics of the Included Studies.

<table>
<thead>
<tr>
<th>Study</th>
<th>Age, Mean ± SD, y</th>
<th>Sex</th>
<th>BMI, Mean ± SD, kg/m²</th>
<th>Follow-up, mo</th>
<th>Tonsillectomy</th>
<th>Complications</th>
<th>Total Subjects, No.</th>
<th>Successful Surgery, No.</th>
<th>Success Criteria</th>
<th>Surgical Success Rate, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pang et al⁷</td>
<td>NA</td>
<td>8 M, 0 F</td>
<td>NA</td>
<td>3</td>
<td>No</td>
<td>Pain; 2 weeks</td>
<td>8</td>
<td>6</td>
<td>AHI reduction ≥50%, final AHI &lt;15</td>
<td>75</td>
</tr>
<tr>
<td>Pang et al⁸</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>33.5</td>
<td>No</td>
<td>None</td>
<td>39</td>
<td>28</td>
<td>AHI reduction ≥50%, final AHI &lt;20</td>
<td>71.8</td>
</tr>
<tr>
<td>Marzetti et al¹¹</td>
<td>48.3 ± 10.2</td>
<td>NA</td>
<td>26.5 ± 2.4</td>
<td>6-9</td>
<td>Yes</td>
<td>Pain; 2 weeks; Difficulty in swallowing; 2 weeks</td>
<td>15</td>
<td>13</td>
<td>AHI reduction ≥50%, final AHI &lt;10</td>
<td>86</td>
</tr>
<tr>
<td>Ugur et al¹²</td>
<td>39.2 ± 7.6</td>
<td>35 M, 7 F</td>
<td>NA</td>
<td>24</td>
<td>No</td>
<td>n = 4; nasal regurgitation; 1.5 months</td>
<td>42</td>
<td>24</td>
<td>AHI reduction ≥50%, final AHI &lt;20</td>
<td>57.1</td>
</tr>
<tr>
<td>Bayir et al¹³</td>
<td>43.8 ± 7.1</td>
<td>31 M, 4 F</td>
<td>29.1 ± 3.6</td>
<td>5</td>
<td>No</td>
<td>None</td>
<td>35</td>
<td>20</td>
<td>AHI reduction ≥50%, final AHI &lt;20</td>
<td>57.1</td>
</tr>
<tr>
<td>Adzreil et al¹⁴</td>
<td>36.8 ± 8.5</td>
<td>26 M, 5 F</td>
<td>28.7 ± 3.5</td>
<td>3</td>
<td>Yes</td>
<td>n = 2; pain; no more than 2 weeks Bleeding 7-day postoperatively (from tonsil bed)</td>
<td>31</td>
<td>14</td>
<td>AHI reduction ≥50%, final AHI &lt;10</td>
<td>45.2</td>
</tr>
</tbody>
</table>

Abbreviations: AHI, apnea hypopnea index; BMI, body mass index; F, female; M, male; NA, not available.

### Table 2. Pre- and Postoperative Outcomes of the Included Studies.

<table>
<thead>
<tr>
<th>Study</th>
<th>Pre-AHI</th>
<th>Post-AHI</th>
<th>Pre-ESS (0-24)</th>
<th>Post-ESS (0-24)</th>
<th>Pre-VAS (Snoring) (0-10)</th>
<th>Post-VAS (Snoring) (0-10)</th>
<th>Pre-Mean O₂</th>
<th>Post-Mean O₂</th>
<th>Pre-Min O₂</th>
<th>Post-Min O₂</th>
<th>Pre-ODI</th>
<th>Post-ODI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pang et al⁷</td>
<td>12.3</td>
<td>5.2</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>88.3</td>
<td>92.5</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Pang et al⁸</td>
<td>25.3 ± 12.6</td>
<td>11 ± 9.9</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>81.4 ± 19.2</td>
<td>92.0 ± 16.9</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Marzetti et al¹¹</td>
<td>22 ± 12.5</td>
<td>8.6 ± 6.8</td>
<td>8.5 ± 3.7</td>
<td>4.9 ± 3.2</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>75.8 ± 20.0</td>
<td>10.7 ± 6.1</td>
<td>7.3 ± 5.3</td>
<td>NA</td>
</tr>
<tr>
<td>Ugur et al¹²</td>
<td>13.2 ± 7.1</td>
<td>7.3 ± 5.7</td>
<td>11.5 ± 5.0</td>
<td>8.3 ± 3.5</td>
<td>6.2 ± 8.3</td>
<td>3.4 ± 7.6</td>
<td>93.8 ± 1.3</td>
<td>94.0 ± 1.3</td>
<td>86.1 ± 3.8</td>
<td>87.8 ± 2.8</td>
<td>11.7 ± 9.0</td>
<td>6.7 ± 5.3</td>
</tr>
<tr>
<td>Bayir et al¹³</td>
<td>5-15 (n = 20)</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>86.1 ± 3.8</td>
<td>85.6 ± 4.2</td>
<td>12.1 ± 5.7</td>
<td>14.7 ± 9.9</td>
</tr>
<tr>
<td>Adzreil et al¹⁴</td>
<td>35 ± 23.9</td>
<td>16.6 ± 17.3</td>
<td>13.3 ± 4.5</td>
<td>6.3 ± 3.7</td>
<td>7.3 ± 0.9</td>
<td>2.7 ± 1.5</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

Abbreviations: AHI, apnea hypopnea index; ESS, Epworth Sleepiness Scale; meanO₂, mean oxygen saturation; minO₂, lowest oxygen saturation; NA, not available; ODI, oxygen desaturation index; VAS, visual analog scale.
The studies included in this meta-analysis were not evaluated in this manner, as our aim was not to assess the success rate of multilevel surgery, either single stage or multistage. As a general rule for OSA surgeries, all sites of airway obstruction should be identified before performing any surgery to modify obstructed pharyngeal airway segments and to obtain optimal surgical outcomes.\textsuperscript{15} AP on its own may be considered for treatment of OSA only if isolated velopharyngeal obstruction is observed in the upper airway.

Patients with mild to moderate OSA who cannot tolerate CPAP treatment can be possible candidates for AP surgery if they have (1) redundant soft palate, (2) smaller tonsils (grades 0-2), (3) primarily anteroposterior velopharyngeal collapse based on endoscopic evaluation and a modified Muller’s maneuver, and (4) modified Mallampati scores of 1 to 2. AP can also be offered to patients who are simple snorers with primarily retropalatal flutter and small tonsils.\textsuperscript{8} AP surgery affords the opportunity to reconstruct the upper airway with minimal resection of the mucosa and submucosa while avoiding all muscle structures. Moreover, uvula preservation is an important feature of this technique (minimal uvulectomy can be performed). From this point of view, the AP technique can be considered minimally invasive palatal surgery.

Patients with severe OSA are not considered candidates for AP because of the difficulty of reducing AHI levels in these patients using this technique. The severest mean preoperative AHI level was reported in the study of Adzreil et al\textsuperscript{14}; therefore, the lowest success rate was obtained in that study among those included in this meta-analysis. However, the studies by Pang et al\textsuperscript{8} and Marzetti et al\textsuperscript{11} included patients mostly with moderate OSA, and they obtained 72% and 86% success rates, respectively. We believe that patients with moderate to severe OSA who have a vertical phenotype of the velopharynx, small tonsils, and anterior-posterior narrowing of the retropalatal segment can be more suitable candidates for transpalatal advancement pharyngoplasty techniques.

The postoperative period is an important factor when assessing surgical success. The study by Adzreil et al\textsuperscript{14} showed that patients with mild OSA had the best success rate at 3 months postoperatively, followed by those with moderate OSA and severe OSA. Although the general success rate was 45.2% in that study, the patients with mild OSA showed 66.7% success at 3 months postoperatively. The authors also mentioned that the initial success rate of 45.2% dropped further to 32.3% at 1 year postoperatively and the efficacy of AP declined with time, subjectively and objectively, as shown by worsening VAS, ESS, and AHI scores. The aim of surgery for OSA should be to reduce the patient’s complaints to a minimum for as long as possible. A general problem with OSA surgeries is that the level of patient satisfaction and polysomnographic parameters are much better in the early postoperative period than in the late postoperative period. From this perspective, the study by Pang et al,\textsuperscript{8} with the longest follow-up, presents more promising results with its relatively better success rate of 72% at 33.5 months postoperatively.

The fibrotic scar generated by AP pulls the velum superiorly and anteriorly. This reconstruction increases retropalatal cross-sectional area, and it reduces vibration of the velum. The technique can be performed under general anesthesia, or it can be performed as an office-based procedure under local anesthesia in an outpatient clinic. The cost and time effectiveness is also remarkable, as the procedure is quick, is inexpensive, and requires no special equipment. The technique itself is tolerable and is nondestructive, so patients may undergo additional surgery, such as nasal surgery, tonsillectomy, or tongue base surgery, at the same sitting with AP. In this meta-analysis, our aim was to assess the single effect of AP surgery, so we did not include studies of patients who underwent AP concurrently with other surgical procedures (except for tonsillectomy). In 2 studies in this meta-analysis, the authors performed concomitant tonsillectomy with AP.\textsuperscript{11,14} Their success rates were 86% and 45%, respectively; however, their definition of success criteria was relatively more restricted, as a reduction in the AHI of $\geq$50% and postoperative AHI $\leq$10 events/h. We also suggest that, when indicated, tonsillectomy can be performed with AP.

![Figure 2. Meta-analysis of articles on cases undergone anterior palatoplasty. Differently sized squares indicate the sample size of each study. “Total fixed effects” indicates the overall success rate. CI, confidence interval.](image)
The reported complications in the included studies were pain, lump sensation (a feeling of scar tissue), nasal regurgitation, and bleeding. Most of these complications were easily overcome, but the lump sensation may persist beyond 2 years.\textsuperscript{12} Bleeding was reported to arise from the tonsil bed but not from the AP incision.\textsuperscript{14} No speech changes or velopharyngeal insufficiency were reported in the data from the included studies. The study by Karakoc et al,\textsuperscript{16} which was excluded from the present meta-analysis due to the absence of surgical success rate, showed no statistically significant difference between preoperative and postoperative assessments of nasalance scores in patients undergoing AP. Due to the risk of focal infection, bleeding, pain, and delayed healing, patients undergoing the AP procedure are recommended to continue with a soft diet for at least 1 week postoperatively.

None of the studies included in this meta-analysis reported data on the use of drug-induced sleep endoscopy (DISE). DISE is considered more reliable in detecting patients with hypopharyngeal obstruction and more capable of determining the need for multilevel surgery.\textsuperscript{17,18} The obstruction sites are more hidden during the awake examination with Muller’s maneuver, and DISE can demonstrate unexpected collapse patterns, especially at the hypopharyngeal level. The examination of patients with DISE allows surgeons to determine each level of obstruction in the upper airway, and it can prevent unnecessary operations. If the level of collapse is not identified prior to surgery, only a one-third chance remains that the correct area will be treated by a velopharyngeal surgery alone. This is quite a significant source of error for OSA surgeries. In the case of hypopharyngeal obstruction in any of the patients included in this meta-analysis, the surgical success rate might potentially be affected by this condition.

Six studies were included in this meta-analysis. Of these, 2 were reported by Pang et al,\textsuperscript{7,8} which seems acceptable because AP was first introduced by Pang and his coauthors. Overall, of the 170 patients who had undergone AP, only 47 patients were extracted from the studies by Pang et al; hence, the meta-analysis results reflect the general surgical outcomes of AP. When we excluded the 2 studies by Pang et al and reperformed the meta-analysis, the success rate was 56.3% for the remaining 4 studies. Even though the literature has many published articles related to AP, we stringently followed our exclusion criteria. Those studies indicating multilevel surgery or adjunctional surgery were strictly excluded. Another factor that might have affected the results was the observed differences among studies in terms of success criteria. Better surgical success is likely if the criteria established by the authors of the included studies defined postoperative AHI as \leq 20 events/h rather than AHI \leq 10 events/h. Conversely, the choice of criteria as a 50% reduction and postoperative AHI <10 events/h would decrease the success rate. Because of this methodologic difference, some studies may potentially cause bias. In addition, surgeons carrying out the different studies might perform AP technique differently on their patients, because the technique continues to develop and evolve. Finally, not all of the included studies give sufficient data regarding respiratory parameters. Our main purpose was to provide an overall success rate as a contribution for the likely upcoming literature reporting success rates for AP. We consider that this article could be a useful reference for these types of articles that seek to determine the overall success rate for AP.

Conclusion

The results of the present meta-analysis indicate that anterior palatoplasty is a moderately effective surgical method for the treatment of OSA, with a success rate of 60.6%. No serious/further complications following this procedure are reported in the literature. Due to a lack of comparative and randomized controlled studies, the current number of published reports is not sufficient to present strong evidence to confirm AP as a sufficient procedure for the treatment of OSA. Therefore, we recommend that several prospective studies should be conducted that can show long-term results, with preoperative and postoperative data, to demonstrate the exact outcomes and reliability of this surgical technique.

Author Contributions

Murat Binar, designed study, wrote article, analysis, drafting, revising, final approval checking, accountability for all aspects; Omer Karakoc, design of the work, analysis, drafting, revising, final approval checking, accountability for all aspects.

Disclosures

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Sponsorships: None.
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References


