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Original article

Combining anterior palatoplasty with barbed suspension pharyngoplasty in the treatment of obstructive sleep apnea

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Abstract

Background: Surgery is an alternative treatment to positive airway pressure therapy for obstructive sleep apnea (OSA) patients. Various palatal surgical techniques have been developed. However, medical literature has limited accounts on the use of a combination of these techniques to improve outcomes.
Objective: The aim of this study was to assess the efficacy of a combination of anterior palatoplasty (AP) and barbed suspension pharyngoplasty (BSP) in treating adult OSA.
Methods: Data of 24 OSA patients who underwent a combination of AP and BSP between July 2020 to May 2024 were retrospectively reviewed. The surgical outcomes, including apnea-hypopnea index (AHI), lowest oxygen saturation (LSAT), snoring scores, Epworth Sleepiness Scale (ESS), and post-operative complications were collected and compared between pre-operation and post-operation periods.
Results: Twenty-four patients which showed retropalatal or oropharyngeal obstruction were included in our study, with thirteen patients (54.2%) undergoing post-operative polysomnography with a mean follow-up time of 5.8 ± 2.2 months. The median (Q1–Q3) AHI decreased non-significantly from 27.3 (19.8–53.2) to 20.2 (14.4–37.0) events/h ($P = 0.216$) post-operatively. The median (Q1–Q3) snoring scores significantly improved from 6.0 (4.0–8.0) to 3.0 (0.0–4.0) ($P < 0.001$) and ESS decreased from 11.0 (9.2 –14.8) to 6.5 (4.0 –9.8) ($P < 0.001$). LSAT did not change significantly in this study. There were no serious post-operative complications.
Conclusion: The technique combining AP and BSP was safe and significantly improved snoring scores and reduced daytime sleepiness in OSA patients with retropalatal and oropharyngeal obstruction. Improvement in AHI was observed in some patients.

Keywords: Apnea-hypopnea index, obstructive sleep apnea, palatoplasty, pharyngoplasty.

Obstructive sleep apnea (OSA) is a common sleep-disordered characterized by repetitive narrowing or collapse of the upper airway. [1] The disorder is associated with many health problems, including cardiovascular disease, cognitive impairment, a low quality of life, and high risk of motor vehicle accidents. The underlying pathophysiology is multifactorial and varies considerably between individuals. [1] Positive airway pressure (PAP) is the gold standard treatment for moderate to severe OSA. However, there are many people who cannot tolerate or accept use of the machine, and in such cases, upper airway surgery is an alternative. Various surgical techniques have been proposed for correction of the various collapsible sites, of which new palatal surgical procedures are the most commonly proposed as the soft palate is the most common site of obstruction. [2, 3] The conventional uvulopalatopharyngoplasty (UPPP) method has been associated with significant complications, including velopharyngeal incompetence, bleeding, and nasopharyngeal stenosis. Its long-term success rate is less than 50%. [4] The Expansion sphincter pharyngoplasty (ESP) is a highly successful technique with minimally invasive approach. [5] It involves repositioning the palatopharyngeus muscle to the

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palatine muscle near the pterygoid hamulus. [6, 7] Currently, there are many palatal surgical techniques aimed at improving surgical outcomes and decreasing complications. [6,8]

Anterior palatoplasty (AP), developed by Pang *et al.* [9], is a modified cautery-assisted palatal stiffening operation (modified CAPSO). This procedure involves removal of the middle part of the soft palate tissue to create scarring and stiffen the soft palate. [10] Additionally, a part of the redundant uvula may also be trimmed. This technique reduces the apnea-hypopnea index (AHI), Epworth Sleepiness Scale (ESS), snoring sound, and increases lowest oxygen saturation (LSAT) in patients with snoring and mild to moderate OSA. [4, 9-12] Anterior palatoplasty is a simple, effective, and inexpensive procedure with minimal complications. [4, 9]

Barbed pharyngoplasty was first described by Mantovani M, *et al.*[13, 14], as the Barbed Roman Blinds technique [13, 14], and has been applied to other techniques, such as barbed reposition pharyngoplasty (BRP) by Vicini C, *et al.*[15] Barbed suspension pharyngoplasty (BSP) is a new modified technique developed by Barbieri M, *et al.*[7] to increase palatal tension and augment the anterolateral suspension forces to the soft palate. [7] This non-resective surgical procedure involves placing the bidirectional barbed suture through the fibromuscular tissue of the soft palate and posterior tonsillar pillars, before securing them to the posterior nasal spine and pterygomandibular raphe. [7] This technique is knotless, requires short operating time, and is safe with a low rate of complications. [2] Previous reports have shown effective improvement in AHI, daytime sleepiness, and snoring sound in patients with mild to severe OSA. [7, 8, 16] The surgical results were comparable to those of ESP combined with AP in the study of Babademez MA, *et al.* [3]

There are few reports on using combined combination of the surgical techniques of anterior palatoplasty and barbed suspension pharyngoplasty to improve surgical outcomes. These two techniques are commonly performed in our hospital for patients with retropalatal obstruction. This study aimed to assess the treatment outcomes of combined surgical techniques in adult patients with OSA, regarding AHI, LSAT, snoring score, ESS, and post-operative complications.

Materials and methods

Study design

Data for this retrospective cohort study were collected from hospital medical records dated between July 2020 and May 2024. This study was approved by the Institutional Review Board of the Faculty of Medicine, Chulalongkorn University (IRB no. 0033/66).

The inclusion criteria for patients in this study were as follows: aged ≥ 18 years, diagnosed with OSA (AHI ≥ 5 events/h), refused or poorly compliant with PAP therapy, underwent pre-operative drug-induced sleep endoscopy (DISE) using the VOTE classification [17], which showed retropalatal or oropharyngeal obstruction, and underwent combined anterior palatoplasty with barbed suspension pharyngoplasty in the Department of Otolaryngology, King Chulalongkorn Memorial Hospital, Thai Red Cross Society. Patients who had revision palatal or oropharyngeal surgery, retroglossal or laryngeal complete obstruction according to DISE, significant craniofacial anomalies, or no clinical follow-up after surgery were excluded from the study.

The basic patient data collected included age, gender, body mass index (BMI), past medical history, Friedman tongue position (FTP), tonsil grading, and the Friedman staging system. Also recorded were the report of polysomnography level 1 scoring by trained sleep technicians and reviewed by sleep physicians. This included pre-operation and post-operation measurements of AHI, LSAT, ESS, and snoring score using a Visual Analog Scale (VAS) ranging from 0–10 (0 = no snoring, 10 = extremely loud and annoying). Additionally, data on post-operative length of stay, pain score (VAS from 0–10: 0, no pain; 10, maximum pain), and early and late complications were collected.

Surgical procedures

Surgery was performed under general anesthesia by the second author (NC). The patient was positioned on their back with neck extension. A McIvor mouth gag was used to expose the oropharynx. After extracapsular tonsillectomy was performed, an anterior palatoplasty incision was marked with a pen at the midline of the soft palate forming a rectangular shape measuring 7–10 mm in width and 40–50 mm in length (depending on the patient's anatomy) **(Figure 1A)**. Bilateral pterygomandibular raphe and posterior nasal spine were also marked. Xylocaine 1.0% with 1:200,000 units of epinephrine was injected into the

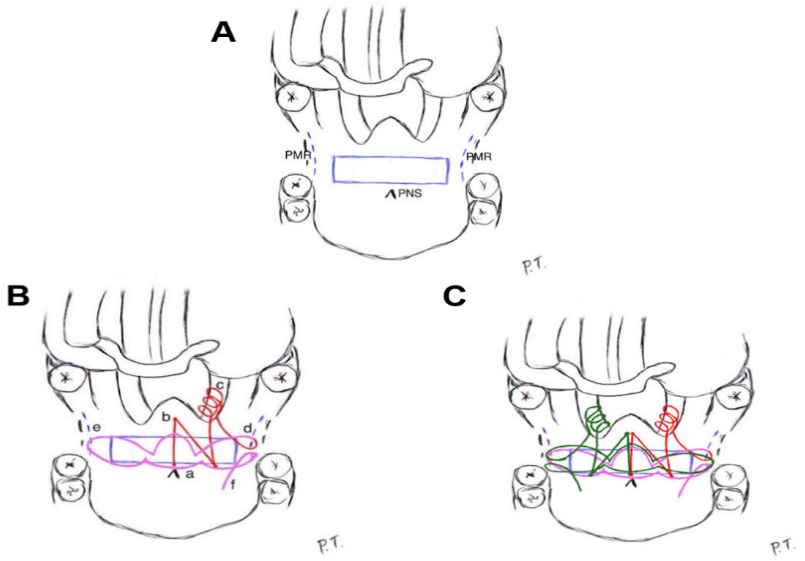

Figure 1. Drawing of operative procedures. **(A)** Anterior palatoplasty incision at midline soft palate (rectangular shape). PNS: posterior nasal spine; PMR: pterygomandibular raphe; **(B)** Suture route of right side BSP. a: posterior nasal spine; b: base of the uvula; c: palatopharyngeus muscle; d: right pterygomandibular raphe; e: left pterygomandibular raphe. The same procedures were performed on the left side; and **(C)** Suture route at the end of the procedure.

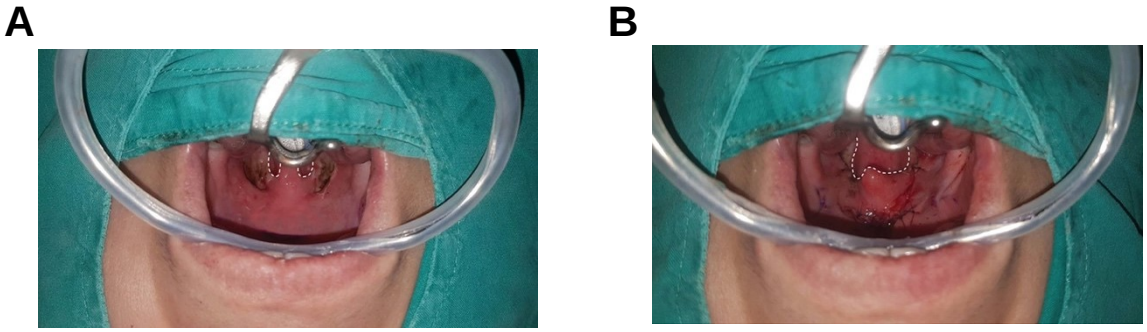

Figure 2. Intraoperative view **(A)** before and **(B)** after AP and BSP.

soft palate. Monopolar cautery was used to remove the previously marked soft palate mucosa, exposing the muscular layer. The redundant mucosa of the uvula tip was excised. Suspension pharyngoplasty was performed using bidirectional barbed sutures (Startafix™ Spiral PDO 2 – 0, 14*14 centimeters). The first stitch was inserted from the midline at the level of posterior nasal spine to the base of the uvula submucosally. The suture proceeded antero-laterally toward the superior part of the tonsillar bed. The upper part of the palatopharyngeus muscle was stitched in three passages, before the suture ran toward pterygomandibular raphe of that side to apply traction. The remaining barbed suture was sutured along the soft palate to the contralateral pterygomandibular raphe and was finally cut **(Figure 1B)**. The described procedure was performed starting at the opposite side of the oropharynx to create a mirrored line of sutures **(Figure 1C)**. The previous anterior palatoplasty incision was sutured using absorbable monocryl 3-0, and the superior part of the anterior and posterior tonsillar pillars were sutured together with a single stitch **(Figure 2)**. Finally, triamcinolone acetonide was injected into the tonsillectomy bed.

Additionally, simultaneous nasal surgery was performed if there was significant nasal obstruction. If hypertrophic inferior turbinates were present, radiofrequency turbinoplasty would be performed. If there was a significant deviated nasal septum, nasal septoplasty would be performed.

After the surgery, antibiotics were prescribed for 1 – 2 weeks. Pain relief medications, including fentanyl, dexamethasone, parecoxib, and/or nefopam hydrochloride injections were prescribed as needed. Acetaminophen syrup, etoricoxib, and benzydamine hydrochloride throat spray were prescribed for home medication.

Statistical analysis

Continuous demographic and clinical variables, including AHI, LSAT, ESS, snoring score, and pain score, were presented as mean ± standard deviation (SD) or median and interquartile range (IQR), whereas categorical variables were presented as frequencies and percentages. If the variables exhibited a normal distribution, a paired *t*-test was used to compare pre-operative and post-operative values. If not, the Wilcoxon signed-rank test was used. In this study, a two-tailed $P < 0.05$ was considered statistically significant. IBM SPSS Statistics version 23.0 was used for the statistical analysis.

Results

Twenty-four patients were included in the study. The mean age was 44.7 ± 14.0 years, and 70.8% of cases were male. The mean BMI was 25.6 ± 5.0 kg/m^2. Common comorbidities were allergic rhinitis (45.8%), hypertension (37.5%), and dyslipidemia (33.3%). Two patients had a history of insomnia and were treated. The patients' Friedman tongue position was in grade 2-3, and the Friedman staging system was in stage 2-3. Pre-operatively, 5 patients (20.8%) were affected by mild OSA, 10 (41.7%) by moderate and 9 (37.5%) by severe OSA. The main obstructive sites, as identified by DISE, were the retropalatal and oropharyngeal regions (**Table 1)**.

Almost all patients had significant nasal obstructions; thus, nasal surgery was performed in 23 patients (95.8%). Radiofrequency ablation of inferior turbinate was performed in all these cases, and concomitant nasal septoplasty was performed in 12 cases (50.0%). The mean hospitalization was 2.5 ± 1.1 days

Only thirteen cases (54.2%) had post-operative polysomnography, with a mean follow-up polysomnography of 5.8 ± 2.2 months. The median (Q1–Q3) clinical follow-up time was 8.7 (6.2–19.0) months.

The observed reduction in the median (Q1–Q3) AHI from the pre-operation value of 27.3 (19.8–53.2) events/h to the post-operation value of 20.2 (14.4–37.0) events/h was not statistically significant

Table 1. Baseline characteristics of the study population (n = 24).

Demographic/ anthropometric variable	Mean ± SD or n (%)
Age (years)	44.7 ± 14.0
Gender	
Male	17 (70.8)
Female	7 (29.2)
BMI (kg/m^2)	25.6 ± 5.0
Comorbidities	
Allergic rhinitis	11 (45.8)
Hypertension	9 (37.5)
Dyslipidemia	8 (33.3)
Diabetes mellitus	2 (8.3)
Insomnia	2 (8.3)
Friedman tongue position	2.6 0.5
Tonsil grading	1.4 0.6
Friedman staging system	2.5 0.6
Apnea hypopnea index (events/hour; median (Q1-Q3))	27.6 (17.3– 45.6)
Mild OSA	5 (20.8)
Moderate OSA	10 (41.7)
Severe OSA	9 (37.5)
DISE findings (VOTE classification)	
Velum	2.0 ± 0.2
Oropharynx	1.0 ± 0.8
Tongue base	0.8 ± 0.4
Epiglottis	0.2 ± 0.4

BMI, body mass index; DISE, drug-induced sleep endoscopy; OSA, obstructive sleep apnea; Q1; quartile 1; Q3; quartile 3; SD, standard deviation.

($P = 0.216$). There was a non-significant change in mean LSAT from the pre-operative (85.5 ± 5.0%) to the post-operative (85.3 ± 7.0%) period ($P = 0.940$). In contrast, the median ESS significantly improved from 11.0 (9.2–14.8) to 6.5 (4.0–9.8) ($P < 0.001$). There was also a statistically significant reduction in the median snoring score from 6.0 (4.0–8.0) points to 3.0 (0–4.0) points ($P < 0.001$) **(Table 2)**.

The most common early post-operative complication was dysphagia (occurring in 17 patients, 70.8%). This symptom usually disappeared within a few weeks. Other complications included foreign body sensation (5 patients, 20.8%), velopharyngeal insufficiency (5 patients, 20.8%), abnormal taste sensation (5 patients, 20.8%), and thread extrusion (2 patient, 8.3%). These symptoms mostly improved and resolved within 1–3 months post-operation. Patients who had velopharyngeal insufficiency were advised to adopt mindful eating until clinical resolution. There was one case with abnormal taste sensation that persisted up to the last follow-up date at 12 months. No post-operative bleeding and nasopharyngeal stenosis were observed. The mean post-operative pain scores at days 1, 7, and 14 were 4.4 ± 2.6, 4.6 ± 2.1, and 2.4 ± 2.1, respectively **(Table 3).**

Table 2. Pre-operative and post-operative parameters.

	Pre-operative	Post-operative	*P*-value
AHI (n = 13) (mean ± SD)	41.0 ± 36.2	26.6 ± 19.8	0.216[a]
Median	27.3	20.2	
Q1–Q3	19.8–53.2	14.4–37.0	
LSAT (n = 13) (mean ± SD)	85.5 ± 5.0	85.3 ± 7.0	0.940[b]
Median	85.0	86.5	
Q1–Q3	81.0–90.5	81.0–90.5	
ESS (n = 24) (mean ± SD)	11.7 ± 4.2	6.9 ± 3.9	< 0.001[a]*
Median	11.0	6.5	
Q1–Q3	9.2–14.8	4.0–9.8	
Snoring score (n = 24) (mean ± SD)	6.1 ± 1.9	2.6 ± 1.9	< 0.001[a]*
Median	6.0	3.0	
Q1–Q3	4.0–8.0	0.0–4.0	
BMI (n = 24) (mean ± SD)	25.5 ± 5.0	25.1 ± 4.3	0.114[b]

AHI, apnea-hypopnea index; BMI, body mass index; ESS, Epworth sleepiness scale; LSAT, lowest oxygen saturation; Q1; quartile 1; Q3; quartile 3; SD, standard deviation
P-values estimated by [a] Wilcoxon signed-rank test or [b] Paired *t*-test.
*$P < 0.05$ was considered statistically significant.

Table 3. Early and late post-operative complications.

Complications (n = 24)	Early (< 1 month) (n, %)	Late (> 1 month) (n, %)
Dysphagia	17 (70.8)	1 (4.2)
Foreign body sensation	5 (20.8)	2 (8.3)
Velopharyngeal insufficiency	5 (20.8)	3 (12.5)
Abnormal taste	5 (20.8)	3 (12.5)
Thread extrusion	2 (8.3)	1 (4.2)
Bleeding	0	0
Nasopharyngeal stenosis	0	0
Postop pain score (mean ± SD)		
Day 1	4.4 ± 2.6	
Day 7	4.6 ± 2.1	
Day 14	2.4 ± 2.1	

Discussion

The combined AP and BSP surgical techniques are simple, requires minimal equipment, preserves the pharyngeal musculature, and exhibits no major post-operative complications. This technique is suitable for OSA patients with velopharyngeal collapse. Pang KP, *et al.* reported that AP significantly reduced AHI from 25.3 ± 12.6 to 11.0 ± 9.9 at three-year follow-up in 39 patients with mild to moderate OSA (BMI < 33, Friedman stage II). [11] Barbed pharyngoplasty is another recent surgical technique that has also shown favorable results. Barbieri M, *et al.* reported that BSP significantly reduced median AHI from 25 (15.8–34.3) to 5 (2.5 m - 6.0) in 42 patients with mild to severe OSA (BMI ≤ 35, no hypopharyngeal/laryngeal collapse) following at least six months of post-operative PSG. [7] Both surgical techniques can improve post-operative AHI, LSAT, ESS, and snoring scores. [7, 9, 12, 16]

In this study, the median post-operative AHI improvements were not statistically significant. As demonstrated in our graphical abstract **(Figure 3)**, only 13 out of 24 patients underwent the post-operative polysomnography, while all patients participated well with the post-operative clinical assessment. Due to the small number of participants, conclusions regarding the outcomes of the combined treatment should be taken with caution. Most cases in our study were Friedman stage 3, which may contribute to limited success with palatal surgery alone. Friedman M, *et al.* demonstrated that patients with stage 3 had success rates as low as 8.0% after UPPP. [18] These findings are consistent with those of previous studies. Choi JH, *et al.* reported success rates of 83.0%, 52.3%, and 31.8% for oropharyngeal OSA surgery in Friedman stages 1, 2, and 3, respectively. [19] Additionally, we found partial tongue base obstruction from DISE in 16 cases (66.7%). Subgroup analysis of patients undergoing post-operative PSG revealed distinct trends in AHI reduction between those with and without tongue base obstruction. Patients with tongue base obstruction (n = 9) showed an AHI reduction of -5.9 (95% CI: - 17.2 to 5.3, $P = 0.301$), whereas those without (n = 4) showed a reduction of -28.6 (95% CI: -63.1 to 5.9, $P = 0.104$). Neither change was statistically significance. A larger sample size is needed to determine the true effect. A recent

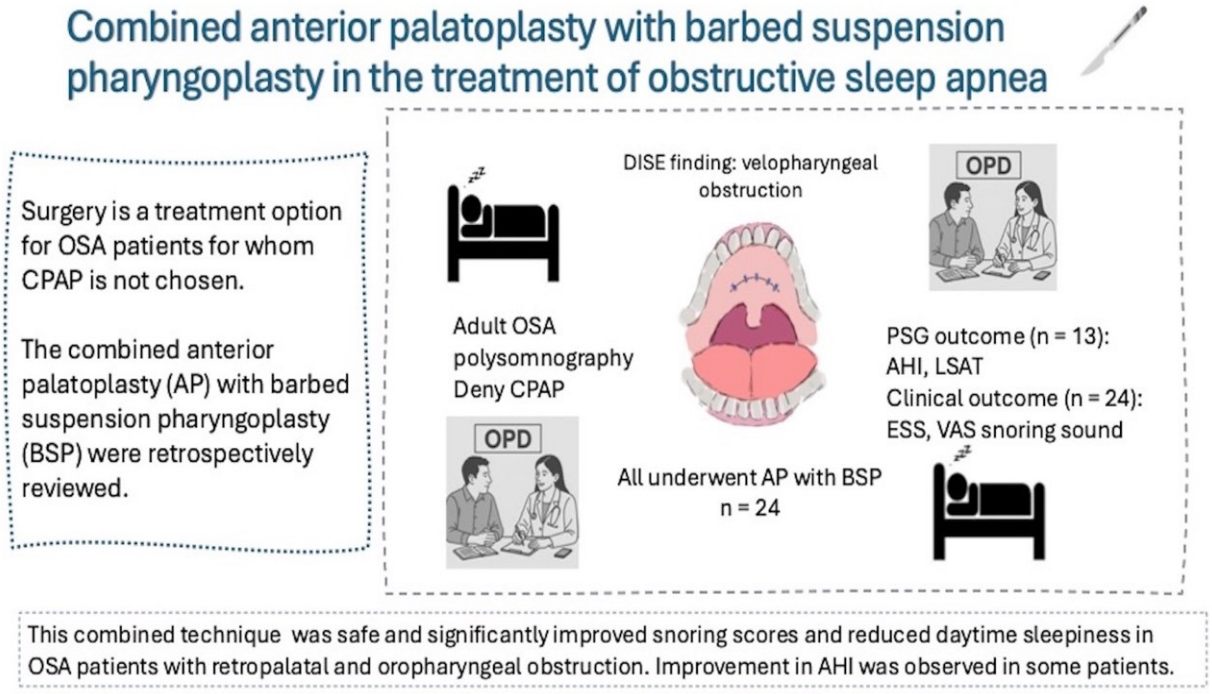

Figure 3. Graphical abstract illustrating the main concept and results of this study. AHI: apnea-hypopnea index; CPAP: continuous positive airway pressure; DISE: drug-induced sleep endoscopy; ESS: Epworth sleepiness scale; LSAT: lowest oxygen saturation; OSA: obstructive sleep apnea; VAS: visual analogue scale.

systematic review and meta-analysis showed that anterior-posterior lingual collapse from DISE was associated with surgical failure. [20] In such cases, multi-level surgery with tongue surgery may be more suitable. Positional-related OSA was recorded in eight cases (33.3%). The increase in median supine sleep position (from 44.7% to 71.7%) after surgery might have contributed to the non-significant change in AHI and LSAT. Obesity might also impact surgical results. Previous studies reported that obesity (BMI ≥ 30 kg/m^2) can decrease the surgical success rate. [20, 21] In this study, there were five cases (20.8%) with a BMI greater than 30 kg/m^2. One of them (with a BMI of 34.4 kg/m^2) showed worsening in AHI and LSAT. Nevertheless, we found significant improvement in ESS and snoring scores. The shortening and stiffening of the soft palate after scar and fibrosis formation from the operation might explain the improvement in the snoring score. Additionally, this might improve patients' sleep by decreasing annoying snores and increasing supine sleep time, leading to a reduction in daytime sleepiness.

In this study, nasal surgery was performed simultaneously if the patients exhibited significant signs and symptoms of nasal obstruction. Nasal obstruction is a risk factor and a common occurrence in OSA. [22] Previous studies have indicated that nasal surgery alone in patients with OSA improves sleepiness symptoms but does not significantly affect the AHI. [23] The nasal and soft palate anatomy are key contributors to obstruction in OSA and, therefore, should be treated together in a single-stage procedure if possible. [16] This approach offers several advantages, including improved surgical efficacy, reduced cost, avoidance of delayed treatment, and elimination of the need for re-admission for multiple procedures. In this study, nasal surgery was performed in 23 patients (95.8%), indicating its high frequency at our center.

The most common complication in this study was dysphagia due to pain. These findings align with those of previous studies. [9, 12] The study by Pang KP, *et al.* found that pain was more intense when concurrent tonsillectomy was performed. [12] In this study, tonsillectomy was performed in all cases, and they mostly experienced improvement in pain within two weeks. We found other complications, including foreign body sensation, velopharyngeal insufficiency, abnormal taste, and thread extrusion. These symptoms usually subsided within 1 – 3 months. In a study with use of barbed suture technique alone, foreign body sensation was the main complaint and disappeared within two weeks to one month. [15] Taste disturbance might be explained by damage to a branch of glossopharyngeal nerve following tonsillectomy, or by injury to taste receptors during soft palate surgery. [24] In line with those of other studies on combined anterior palatoplasty and pharyngoplasty techniques, our results showed no late complication of nasopharyngeal stenosis. [8, 25]

Our study has some limitations. First, the operations were performed in a single center resulting in a relatively small sample size for statistically valid conclusions. Second, this was a retrospective study relying on archived hospital records, where the quality and consistency of the collected data may not be as good as that of a well-controlled prospective study. Third, post-operative polysomnography has some limitations, including high cost, distance, or inconvenience of accessing the sleep center, and some patients might have felt improvement in their condition and declined further polysomnography. Fourth, the inclusion of nasal surgery in our study might have slightly impacted the interpretation of velopharyngeal surgical results. Further prospective studies with larger sample size and longer follow-ups are needed for a better assessment of the value and outcomes of the combined treatment approaches.

Conclusion

A combination of anterior palatoplasty and barbed suspension pharyngoplasty can be regarded as a simple and safe surgical option for OSA patients with retropalatal and oropharyngeal obstruction. This technique has shown improvements in snoring sound and daytime sleepiness. While the AHI tended to improve in some patients, the improvements were not statistically significant.

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Conflicts of interest

All authors have completed and submitted the International Committee of Medical Journal Editors Uniform Disclosure Form for Potential Conflicts of Interest. None of the authors had any conflict of interest to disclose.

Data sharing statement

All data generated or analyzed in this study are included in this published article. Further details are available for non-commercial purposes from the corresponding author on reasonable request.

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