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State-of-the Art in Reconstructive Palatal Surgery Techniques for Obstructive Sleep Apnea

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Abstract

Purpose of Review Palatal surgery serves as an alternative treatment modality to address the retropalatal airway obstruction in obstructive sleep apnea (OSA) patients, whereas the continuous positive airway pressure is considered the gold standard treatment. This article aims to review innovative palatal surgeries in terms of key surgical features and clinical outcomes.

Recent Findings Historical, conceptual, and technique evolutions, as well as preliminary outcomes of newer palatal surgeries, are briefly summarized. Palatal surgery has evolved to the concept of hybrid reconstruction, which emphasizes more on tissue preservation, physiology driven, and functional restoration of the retropalatal airspace. Surgically assisted rapid palatal expansion (SARPE) is introduced to OSA patients with a narrower nasal floor.

Summary Palatal surgery and SARPE demonstrate clinical effectiveness in OSA patients. A bi-palatal procedure involving both the soft tissue (soft palate) and skeletal surgery (hard palate) may be feasible for selected OSA patients.

Keywords Obstructive sleep apnea · Sleep surgery · Palatal surgery · Surgically-assisted rapid palatal expansion · CPAP

Introduction

Obstructive sleep apnea (OSA) is a prevalent and potentially life-threatening disease associated with cardiovascular events, neurocognitive impairments, stroke, obesity, and other morbidities. Whereas the continuous positive airway pressure (CPAP) is considered the gold standard treatment managing the upper airway collapse in OSA, surgical interventions serve as alternatives to alleviate the upper airway obstruction in selected patients who cannot comply with or are not willing to receive the CPAP therapy. Among different approaches of sleep surgeries addressing OSA, uvulopalatopharyngoplasty (UPPP) and its modified derivatives are the predominant ones to tackle airway obstruction on the level of velopharynx and oropharynx [1, 2•].

Single palatal or multiple-level procedures for OSA have demonstrated effectiveness and safety in terms of reduction in apnea-hypopnea index (AHI), other OSA-specific outcomes, and surgical complications [3•, 4–6]. In the light of the evolution of palatal surgeries in the past decades, customized and integrated treatment plans were achievable for OSA patients. Considering the growing body of literature on palatal surgeries in recent years, the purpose of this article was to summarize historical and conceptual evolutions and state-of-the-art surgical advancements in palatal surgery for OSA.

Historical Evolution of Palatal Surgery for OSA

At the early stage of developing palatal surgery, resection of the soft palatal triangle was firstly introduced to relieve snoring in the 1950s [7, 8•, 9•], and amputation of uvula was implemented to reduce the amplitude of uvular vibration in the 1960s [8•, 9•, 10]. In the 1970s, tracheostomy was proposed for Pickwickian syndrome (obesity hypoventilation syndrome), OSA, and severe daytime sleepiness. However, the application of tracheostomy was limited and almost replaced by the CPAP due to troublesome complications such as tracheal granuloma or tracheitis [11, 12]. UPPP introduced by Fujita et al. in the 1980s became the pivotal concept of

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modern soft palatal surgery that enlarged and stabilized the oropharyngeal airway by resection of palatine tonsils and reposition of the soft palate and uvula [13]. Simmons et al. presented the procedure of palatopharyngoplasty by removing as much soft palate and resecting uvula for OSA [14]. This, unfortunately, became the stereotype of UPPP in sleep medicine physicians and incurred criticism because of high complications and jeopardizing the use of CPAP. In the1990s, laser-assisted uvulo-palatoplasty (LAUP), applying CO2 laser to vaporize the free edge of the uvula and lateral aspects of the soft palate to stiffen the soft palate, was initially used for the treatment of snoring and alternative to UPPP [15, 16•]. Powell et al. introduced radiofrequency (RF) treatment to the submucosa of the soft palate for mild sleep-disordered breathing [17]. Both LAUP and RF procedures provided alternatives to relieve snoring and served as adjuncts to other sleep surgeries. In the 2000s, two office-based procedures were introduced to reduce fluttering of the soft palate either by direct insertions of pillar palatal implants [18] or by mucosal fibrosis caused by cautery-assisted palatal stiffening operation (CAPSO) [19].

Conceptual Evolution of Palatal Surgery for OSA

Palatal surgery evolved conceptually over time regarding the diagnostics of obstruction sites of the upper airway in OSA, surgical purpose, treatment goal, and surgical techniques [9•]. It is crucial to locate and differentiate the phenotype of the obstructive site in surgical planning. Traditional methods of evaluating airway obstruction in patient's awake status included but not limited to physical examination (Friedman stage), nasopharyngoscopy with Muller's maneuver, and lateral cephalometric X-ray studies. Compared with awake methods, drug-induced sleep endoscopy (DISE) provided an armamentarium to stimulate the structural changes of the upper airway during pharmacologically induced sleep. Certal et al. reported that the surgical planning was changed in 50.24% of patients undergoing DISE evaluation, and changes were associated with obstruction on the level of hypopharynx and larynx [20]. Moreover, drug-induced sleep evaluations in combination with advanced image study, e.g., computed tomography, also demonstrated effectiveness in differentiating the palatal and base of tongue obstruction [21]. Discussions of the overall usefulness, cost-effectiveness of DISE, and other advanced sleep image studies were beyond the scope of this article; nevertheless, these newer methods served as a more physiologic approach to assess the dynamics of upper airway in OSA patients during simulated sleep status.

In terms of surgery purpose, palatal surgeries demonstrated to reduce major complications of OSA and improve OSA-specific symptoms as well [22, 23]. Higher prevalence of tinnitus, sudden sensorineural hearing impairment, and vertigo were noted in OSA patients [24–26], and the CPAP therapy showed effectiveness in managing vertigo and hearing loss in Meniere's disease [27]. Recent evidence revealed the association and shared pathomechanism between Alzheimer's disease (AD) and OSA [28, 29], and plasma concentration of Amyloid-β 1–40, known biomarker to be involved in the pathogenesis of AD, was found significantly higher in severe OSA patients [30]. One systemic review indicated that the CPAP treatment might be effective in improving cognitive function in OSA patients with AD [31]. These findings rendered OSA a potentially modifiable or preventable risk factor of AD, and implied treatment strategies of AD could involve OSA screening and sleep surgeries on selected patients.

The improvement of apnea-hypopnea (AHI) was often regarded as an indicator of the success rate of sleep surgery. However, treatment goals should also be emphasized on the patient's clinical symptoms and reductions of complications caused by OSA-associated morbidities. In general, term goals of sleep surgeries can be summarized in three aspects: post-operative AHI less than 15/h, significant improvements of clinical symptoms, and lower risk in biomarkers of cardiovascular disorders [32•].

Surgical techniques of palatal procedures evolved from the concept of resection/ablation to reconstruction in the past decades. Functional restoration of the upper airway patency in OSA was achieved by a physiological, reconstructive, and hybrid fashion, which included preservation of the mucosa, ablation of redundant adipose tissue, suspension of palatal muscles (palatopharyngeus muscle, superior pharyngeal constrictor muscle), and excision of palatine tonsils [9•]. To date, several different types of palatal- or pharyngoplasty have been proposed for OSA depending on the phenotype of obstruction site [33••, 34••, 35••, 36••, 37••, 38••].

Surgical Technique Advancements in Palatal Surgery for OSA

Several newer surgical techniques were introduced in the 2000s to address retropalatal obstruction in OSA, which mainly targeted on the lateral pharyngeal wall (LPW) collapse. It was worthwhile to briefly summarize key features of each surgical technique chronologically as well as its specific inclusion criteria and preliminary clinical effectiveness in managing OSA.

Chronologic Summary of Palatal Surgical Procedures by the Publication Year

- Lateral pharyngoplasty in 2003
- Z-palatoplasty in 2004
- Expansion sphincter pharyngoplasty in 2007

- Anterior palatoplasty in 2009
- Relocation pharyngoplasty in 2009
- Barbed Roman blinds technique in 2013
- Functional expansion pharyngoplasty in 2013
- Barbed anterior pharyngoplasty in 2014
- Barbed reposition pharyngoplasty in 2015
- The Alianza technique in 2017
- Suspension palatoplasty in 2018
- Barbed suspension pharyngoplasty in 2019
- Omni-suspension in 2020 (unpublished)

Lateral Pharyngoplasty

Cahali introduced this procedure to address the LPW collapse in OSA. Specific inclusion criteria involved at least two of the following: 1) lateral peritonsillar swelling, 2) tonsillar enlargement, and 3) a low-lying soft palate. This procedure was carried out by microdissection and sectioning of the superior pharyngeal constrictor muscle (SPC), which was followed by suturing this sectioned SPC laterally to palatoglossus muscle and palatopharyngeal Z-plasty to prevent the retropharyngeal collapse. In the preliminary report, this procedure significantly improved median AHI (from 41.2 to 9.5/h), daytime sleepiness, and quality of life [33••].

Z-Palatoplasty

Friedman et al. presented this procedure specifically for OSA patients without tonsils, and inclusion criteria were as follows: 1) patients without tonsils or had a prior tonsillectomy, 2) Friedman OSA stages II or III, and 3) retropalatal narrowing. Key surgical techniques involved creation and separation of two adjacent soft palatal/uvular flap by removing of the mucosa and incising the uvula in the midline, and then the uvular flap on both sides was reflected and sutured back over the outlined palatal flap laterally. This technique created a retropalatal distance of 3 to 4 cm. The preliminary report showed that 68% of patients with Z-palatoplasty (ZPP) had surgical success, and ZPP demonstrated comparable effectiveness in managing snoring and other sleep symptoms [35••].

Expansion Sphincter Pharyngoplasty

Pang et al. developed expansion sphincter pharyngoplasty (ESP) to address LPW collapse in OSA with specific inclusion criteria as follows: 1) patients with smaller tonsils (size I and II), 2) BMI less than 30 kg/m^2, 3) Friedman clinical stage II or III, and 4) LPW. In addition to bilateral tonsillectomy, key features of this procedure were mobilization of two palatopharyngeal muscular flaps bilaterally by resecting its inferior end horizontally and creation of two soft palatal grooves by incision on the anterior pillar arch superolaterally on both sides until the palatini muscles were exposed. Finally, rotation and suturing of these palatopharyngeal flaps to the palatini muscles were done. The preliminary report showed that the patients following ESP had a significant reduction of mean AHI from 44.2 to 12.0/h and had a higher success rate compared with UPPP [34••].

Anterior Palatoplasty/Modified CAPSO

Pang et al. presented this technique mainly involving the anterior surface of the soft palate for patients with simple snoring or less severe OSA. Specific inclusion criteria were as follows: 1) smaller tonsil size (size I or II), 2) elongated uvula, and 3) simple snorer or patients with AHI less than 30/h. This procedure was carried out by uvulectomy, followed by vertical para-uvular cutting through both soft palatal arches. One horizontal rectangular mucosal stripping down to the muscular layer was made, and the wound edges were approximated by suturing, which lifted the soft palate anterosuperiorly. The preliminary report revealed significant reductions in mean AHI (from 25.3 to 11.0/h) and improved snore scores [39••].

Relocation Pharyngoplasty

Li et al. introduced this technique to alleviate the LPW collapse in OSA by advancing the soft palate and increasing the retropalatal space. Specific inclusion criteria included 1) webbing, thin and pliable posterior pillar, and 2) sagittal collapse of retropalatal space of 50% or more in Muller's maneuver. Key surgical techniques involved well identification of palatoglossus, palatopharyngeal, and SPC muscles after bilateral tonsillectomy. The palatopharyngeal muscle on each side was firstly rotated in a cephalic and lateral fashion, followed by sewing the SPC muscle to ipsilateral palatoglossus muscle laterally. Then, the posterior pillar on each side was sutured to the ipsilateral palatoglossus muscle posteroanteriorly and vertically. This procedure consisted of two layers of muscular suturing to stabilize the LPW and enlarge the retropalatal space. The preliminary report demonstrated significant improvements of mean AHI (from 43.4 to 15.7/h), sleep symptoms (daytime sleepiness and snoring), and rapid eye movement stage (mean REM 13.8 to 22.7%) [36••].

Barbed Roman Blinds Technique

Mantovani et al. introduced this procedure, which was evolved from the surgical technique "velo-uvulo-pharyngeal lift (Romans Blinds Technique)," to address the LPW in OSA [40, 41]. This procedure was characterized by complete preservation of oropharyngeal muscular structures, and the use of knotless barbed sutures suspended and stabilized the muscular structure of the soft palate to the anchoring points at the pterygomandibular raphe. Key features of barbed Roman blinds technique (BRBT) included multiple transmucosal sutures passing from the hard palate mucosa (1 cm in front of the posterior nasal spine) to each side of the periuvular end of the palatopharyngeal muscle, followed by lifting each periuvular end to the hamulus of the pterygoid. Then, spiral suturing along the pterygomandibular raphe in a cephalic-caudal fashion was done, and repetitive needle passages encircling the palatopharyngeal muscle were anchored toward the ipsilateral pterygomandibular raphe. The preliminary report revealed significant reductions of the mean AHI (from 36 to 13.7/h) and improvements of daytime sleepiness [42••].

Functional Expansion Pharyngoplasty

Sorrenti and Piccin presented the functional expansion pharyngoplasty (FEP) procedure, a physiologically modified ESP [34••], to stabilize the LPW and advance the soft palate in OSA by repositioning the palatopharyngeal muscle superolaterally. Key surgical features were as follows: 1) well identification of the palatopharyngeal muscle, 2) creation of the rotational muscular flap by transecting at the inferior third of PPM, and 3) reposition of the flap superolaterally to the hamulus of pterygoid. The preliminary report demonstrated effectiveness in reducing mean AHI from 33.3 to 11.7/h [43••].

Barbed Anterior Pharyngoplasty

Salamanca et al. introduced a modified anterior pharyngoplasty for simple snoring and mild OSA by anchoring the soft palate to adjacent anatomical structures with barbed suture technique [39••, 40, 41]. Key surgical features were as follows: 1) rectangular soft palatal mucosa/submucosa removal, 2) intramuscular sutures along the soft palatal wound tightening the underlying levator palatini, palatoglossal, and/or palatopharyngeal muscles, 3) submucosal sutures connecting the wound to the palatine aponeurosis and the hamulus of pterygoid on both sides, and 4) further sutures anchoring and stabilizing the soft palate in the BRBT fashion. The preliminary report showed improvements in mean AHI (from 8.9 to 3.8/h) and snoring scores [44••].

Barbed Reposition Pharyngoplasty

Vicini et al. demonstrated the barbed reposition pharyngoplasty (BRP) for OSA featured by multiple lateral knotless suturing loops to stabilize the LPW and increase the retropalatal space. The BRP was initially carried out by the identification of the palatopharyngeal and palatoglossus muscles following bilateral tonsillectomy. After marking at the center of the palate and pterygomandibular raphe, the procedure was achieved by making knotless suturing around the upper part of the raphe on each side, which displacing the palatopharyngeal muscle anterolaterally and suspending the posterior pillar to the raphe. Initial report showed the effectiveness and feasibilities of the BRP as one step of multi-level sleep surgeries for OSA by improving mean AHI (from 43.65 to 13.57/h) and daytime sleepiness [37••].

The Alianza Technique

Mantovani et al. introduced this procedure by combining the BRBT and the barbed anterior pharyngoplasty (BAP) for a concentric retropalatal collapse in mild-to-moderate OSA. Key surgical features included 1) creation of a semilunar periuvular palatal wound and tonsillar fossa mucosectomy, 2) sutures encircling and connecting the exposed periuvular palatal muscle from the level of posterior nasal spine medially to the pterygoid hamulus laterally, 3) spiral downward suturing along the cephalic two-thirds of the pterygomandibular raphe anchoring the palatopharyngeal muscle superolaterally, and 4) repetition of spiral suturing between the pterygomandibular raphe and the pterygomandibular raphe cranially. The preliminary report revealed significant improvements in mean AHI, daytime sleepiness, and the snoring score [45••].

Suspension Palatoplasty

Li et al. presented this procedure to address the anteroposterior airway collapse in OSA. Specific inclusion criteria were as follows: 1) smaller tonsils (size I or II) and 2) nearly total/total anteroposterior or coronal type of velopharyngeal airway obstruction. Key features of this technique included exposures of the pterygomandibular raphe and the palatopharyngeal muscle after removals of tonsils and supratonsillar fat. Then, the velopharyngeal airway was enlarged anteroposteriorly and stabilized by repetitive suturing the palatopharyngeal muscle to the pterygomandibular raphe (suspension) on both sides. The preliminary report showed effectiveness in managing selective OSA patients by significantly reducing the mean AHI from 39.8 to 15.1/h, improving sleep symptoms, and increased retropalatal airspace on perioperative endoscopy and cephalometric X-ray [38••].

Barbed Suspension Pharyngoplasty

Barbieri et al. developed this technique to enlarge the retropalatal airspace anterolaterally in OSA. Key surgical features involving the bidirectional knotless suturing in the BRP and the suspension procedure in suspension palatoplasty (SP) [37••, 38••] were as follows: 1) anterolateral barbed suturing from the midline at the level of posterior nasal spine to the upper part of tonsillar bed with two passages of the needle to strengthen the tension of displacement, 2) anchoring of the palatopharyngeal muscle to the anterior pillar by multiple stitches, 3) suspension stitch passing into the pterygomandibular raphe, and 4) multiple stitches made in the palatal muscle through the uvular base. The study demonstrated significant improvements in AHI and daytime sleepiness as well as a comparable success rate with the BRP technique [46••].

Omni-Suspension

> "Radial expansion of the velopharyngeal airway by suspending the palatopharyngeal muscle to the ipsilateral pterygomandibular raphe
> in multiple directions"

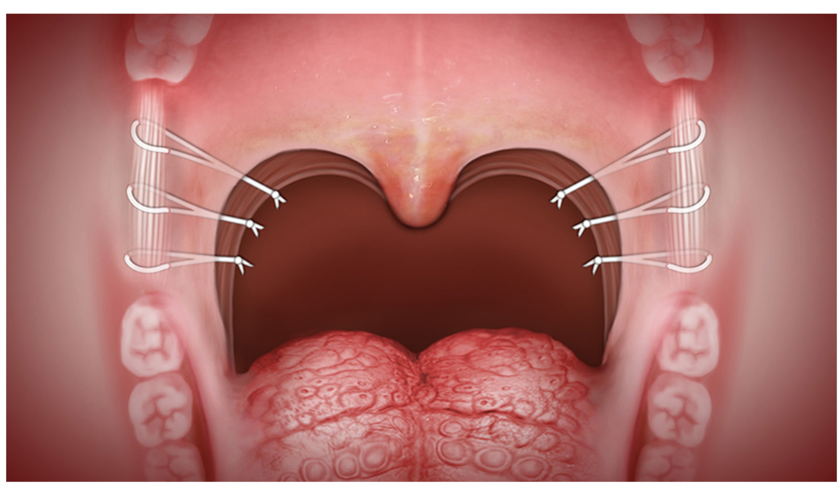
Li et al. developed this technique for OSA patients with complete concentric airway collapse of the velopharynx identified on DISE, and it could be applied as a part of multi-level surgery for severe OSA. This surgical technique was referred to as a radial expansion of the velopharyngeal airway by suspending the palatopharyngeal muscle in multiple directions. Key features of this procedure included mucosa-preservation tonsillectomy, reconstruction of the tonsillar fossa, palatal muscle suspension, and uvuloplasty. The pivotal step was suspending and stabilizing the palatopharyngeal muscle to the ipsilateral pterygomandibular raphe in a cephalic-caudal fashion by submucosal and bundle suturing. The velopharyngeal space was expanded in both anteroposterior and lateral directions (Fig. 1). The preliminary result (unpublished) revealed significantly improved AHI and daytime sleepiness and demonstrated minimal complications in OSA patients following this procedure.

Safety and Effectiveness of Palatal Surgery for OSA

Despite the lack of longitudinal studies of each specific aforementioned surgical technique, several studies utilizing a systematic methodology were conducted to evaluate the overall effectiveness and safety of palatal surgery for OSA. One study, which included 14,633 patients based on the national database, revealed the single-level operation of UPPP alone had less postoperative bleeding than multi-level operation involving tongue/hypopharyngeal surgeries. The multivariate modeling also showed that the multi-level operation had greater odds of the need for postoperative CPAP [1]. Similarly, another study, including 2674 patients, indicated there was a significant difference in complication rate between UPPP alone and multi-level operation (1.6% and 4.3%, respectively) [47•]. Besides, a multicenter study assessing long-term complications of palatal surgery for OSA indicated that the highest postoperative complaint was throat lumping (11.5%) followed by throat phlegm (10.1%), throat dryness (7.8%), and throat scar feeling (3.7%). Within the same study, postoperative difficulty in swallowing was reported as 0.5%, and there were no velopharyngeal insufficiency or voice alternations [5].

Regarding the effectiveness of palatal surgery for OSA, one systematic review and meta-analysis showed that multilevel operation provided a substantial improvement in pooled mean AHI (from 39/h to 18.3/h) in addition to daytime sleepiness and quality of life [3•]. Another 17-year meta-analysis study indicated significant mean AHI reductions for the anterior palatoplasty (24.7/h) and the lateral/expansion pharyngoplasty (19.8/h) [4]. On the other hand, the effectiveness of palatal surgery was also associated with the clinical stage of the patient [6]. Friedman et al. concluded the clinical stage based on the position of the palate, tonsil size, and body mass index (BMI) as related to the success rate of palatal surgery. Stage I patients had the highest success rate

Fig. 1 Palatopharyngeus muscle is suspended to pterygomandibular raphe in anterior, medial, and lateral directions



(80.6%), followed by stage II (37.9%) and stage III (8.1%) [48]. Li et al. proposed the other anatomy-based stage system consisting of tongue-palate position, tonsil size, BMI, and craniofacial anomalies, and they found that success rates for stage I, II, III, and IV patients were 100%, 96%, 65%, and 20%, respectively. On the contrary, there was no significant relationship between the polysomnography-based (severity) stage and the success rate [49]. One meta-analysis conducted by Choi et al. also demonstrated that Friedman stage and hyoid position were predictors for clinical outcome following UPPP, whereas other factors such as age, BMI, preoperative AHI, and other parameters on cephalometry were not significantly associated [50•].

Since multiple obstructive sites were commonly encountered in OSA patients, multi-level operation predominantly involving palatal surgery was an effective treatment modality; however, it was necessary to inform that a multi-level approach might potentially have a higher complication rate during patient counseling and factor in anatomical/clinical stage of the patient when it comes to surgical planning.

Hard Palatal Surgeries for OSA

In addition to the deviated nasal septum and hypertrophic inferior turbinates, increased nasal airflow resistance in OSA patients can also be caused by maxillofacial deformities [51]. Maxillary transverse deficiency (MTD) is characterized by a narrower width of the maxilla relative to the mandible owing to growth discrepancies. MTD often presents with a higher arched palate and a smaller oral cavity, which contribute to nasal airway obstruction and potential pharyngeal airway obstruction as a result of posterior displacement of the tongue [52•]. Compared with pediatric patients, orthopedic maxillary expansion (OME) is less feasible for skeletally matured adults with MTD due to several unfavorable complications such as palatal tissue necrosis, extrusion or instability of the expansion device [53–55]. As a result, surgically assisted rapid palatal expansion (SARPE) combining orthodontics and surgical procedure negates the undesirable side effects of OME and provides a substantial transverse enlargement of the maxillary base. With the widening of the nasal floor and the nasal valve contributed by this procedure, subjective nasal breathing symptoms and nasal airflow resistance in adult OSA patients can be alleviated [56•, 57, 58•].

Several indications of SARPE have been reported as follows: 1) constricted maxillary arch and posterior crossbite, 2) malalignment of maxillary dentition, 3) cleft palate associated maxillary hypoplasia, 4) wide black buccal corridors, and 5) failed OME due to resistance [58•]. Since maxillary expansion procedures widen the nasal floor and improve nasal valve perimeters, it is reasonable to apply SARPE as an adjunct or single intervention to address nasal airway obstruction in selected OSA patients. One systematic review and meta-analysis enrolled six studies utilizing maxillary expansion for OSA, and it showed improvements in mean AHI (decreased from 24.3 to 9.9/h), mean LSAT (increased from 84.3 to 86.9%), and sleep symptoms/daytime sleepiness [52•, 59•, 60].

Although variations of SARPE have been introduced, differences in surgical techniques depend on the surgeon's opinions of the major resistance determining anatomical site in the midface. The distraction-resistant sites in the midface and their corresponding releasing surgical techniques were briefly summarized as follows: 1) the zygomaticomaxillary junction (corticotomy through the zygomatic buttress to the maxillopterygoid junction), 2) the midpalatal suture (osteotomy), 3) midline hard palate (two paramedian palatal osteotomies), and 4) pterygoid plates (osteotomy). The nasal septum was often released from palate via osteotomy to prevent nasal airflow obstruction [56•]. In recent years, distraction osteogenesis maxillary expansion (DOME) and endoscopically-assisted surgical expansion (EASE) were presented to mitigate nasal airflow resistance in OSA, and these two procedures were briefly summarized in terms of specific patient selection criteria, key surgical features, and preliminary clinical outcomes [61••, 62••].

Dome

Liu et al. introduced this procedure in selected adult OSA patients with a high arched palate and narrow nasal floor. Inclusion criteria were as follows: 1) constricted palatal vault (measuring from 0.8 to 3 cm), (2) no tonsillar hypertrophy, and (3) Mallampati class 3 or 4. Key procedure features included 1) placement of maxillary expander with mini-implants, 2) paramedian Lefort I maxillary osteotomies, 3) maxillary expansion (0.25 mm/day) to achieve 8 to 10 mm expansion at the nasal floor within 1 month, and 4) realignment of occlusion. The preliminary report indicated significant improvements in mean AHI (from 30.9 to 14.2/h) and daytime sleepiness. In addition, the anterior and posterior nasal floor were significantly widened [61••]. This procedure also showed effectiveness in increasing the percentage of REM sleep [63], and it was associated with reduced nasal airflow velocity and inversely related to the negative pressure in the pharyngeal airway [64].

Ease

Li et al. presented this outpatient procedure to manage the narrowed nasal floor in selected OSA patients. Key surgical techniques included 1) insertion of the transpalatal distractor to the palate at the region of the first molar, 2) separation of the pterygomaxillary suture, 3) nasal endoscopy- assisted midpalatal osteotomy at the junction of nasal septum and nasal floor, 4) midpalatal osteotomy carried out from posterior nasal spine to the point within 2–3 mm of the anterior nasal spine, 5) maxillary expansion (0.3 mm/day) until the width of nasal floor achieved 7 mm or the patient experienced no further nasal symptoms improvements, and 6) realignment of occlusion. This procedure demonstrated significant improvements in mean AHI (from 31.6 to 10.1/h), daytime sleepiness, and nasal obstruction septoplasty effectiveness [62••].

The Concept of Bi-Palatal Surgery for OSA

The retropalatal airway obstruction in OSA can be attributed by soft tissue factor (collapsibility of the pharyngeal wall and flaccidity of the soft palate) and bony factor (confinement by the narrower width of the hard palate). A bi-palatal approach involving both the advancement of the soft palate and expansion of the hard palate not only addresses the issue of velopharyngeal obstruction but also alleviates the higher nasal resistance in OSA. Traditionally, soft and hard palatal surgery are carried out by otolaryngologists and oral and maxillofacial surgeons, respectively. For selected OSA patients with narrowing retropalatal airspace caused by the soft tissue and bony factor, it is reasonable to assume the feasibility of a simultaneous or two-stage bi-palatal operation. Further investigations will be needed for validations of the clinical effectiveness and safety of this procedure.

Conclusions

Palatal surgery remains one of the most effective procedures for selected OSA patients whenever the CPAP treatment is not tolerated. This article briefly summarized historical, conceptual, and surgical technique evolutions of palatal surgeries in the past decades. In terms of surgical techniques, palatal operations evolve conceptually from tissue resection/ablation of the obstructive anatomical site to the concept of hybrid reconstruction of the narrowed velopharyngeal airway, which adopts tissue preservation, physiology driven, and functional restoration approach. Palatal muscle suspension and other newer techniques have demonstrated effectiveness in managing the pharyngeal wall collapse, and the hard palatal expansion can address nasal airway obstruction caused by the narrower nasal floor. In the modern era of sleep surgery with advancements of diagnostics, surgical techniques and collaborations among specialists, a bi-palatal procedure involving both the soft tissue (soft palate) and skeletal surgery (hard palate), may be feasible for selected OSA patients.

Compliance with Ethical Standards

Conflict of Interest Hseu-Yu Li and Shih-Chieh Shen declare no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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- • Of importance
- •• Of major importance

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