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Surgery of the Palate and Oropharynx

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Obstructive sleep apnea/hypopnea syndrome (OSAHS) is a clinical entity resulting from obstruction, usually at multiple levels, of the upper airway during sleep. The current mainstay of management of OSAHS is continuous positive airway pressure (CPAP). CPAP, however, is not always an effective means of treatment of OSAHS, not only because it does not correct obstruction, but also because, in order to have a significant impact in OSAHS and its long-term repercussions at the cardiovascular level, it requires compliance from the patient, which, according to some studies, is lower than 50% over long-term follow-up [1]. As otolaryngologists, we have the responsibility of helping the group of patients who cannot or will not accept CPAP as a permanent form of management. Surgical management of OSAHS first became an area of study when, in 1981, Fujita and colleagues [2] introduced what is now considered the first procedure specifically designed to address obstruction of the upper airway for the treatment of OSAHS, the uvulopalatopharyngoplasty (UPPP). In spite of initial success, it became apparent that UPPP had limited effectiveness in curing OSAHS, as defined by reduction in the apnea-hypopnea index (AHI) by 50% to a final absolute value less than 20. A meta-analysis conducted by Sher and colleagues [3] in 1996 reported data indicating that the procedure only had a 40% success rate in achieving cure in all patients undergoing UPPP for the treatment of OSAHS. Furthermore, a later study conducted by Senior and colleagues

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[4] not only confirmed this figure, but actually described patients who worsened, both from the objective (polysomnogram) and subjective (daytime sleepiness symptoms and snoring) viewpoints following UPPP. This led to further investigation of the etiology of OSAHS, and it became clear that the causes for OSAHS were as multifaceted as the syndrome itself. It also became apparent that an effective system to identify the cause of upper airway obstruction in OSAHS patients—and the appropriate candidates for surgical intervention—was necessary, not only to improve outcomes, but to avoid treatment failures and complications.

On the other hand, manometric upper airway analysis studies by Woodson and Wooten [5] showed that, aside from straightforward causes of obstruction such as craniofacial abnormalities, morbid obesity, and pan-airway obstruction, patients who present with persistent or recurrent OSAHS after UPPP have a residual retropalatal segment that keeps on causing obstruction in up to 75% of cases. These findings were confirmed by Metes and colleagues [6], who reported that after performing sleep nasendoscopy in patients who had surgical treatment failure, 50% presented with persistent retropalatal obstruction. So it is not only the appropriate selection of patients that is important in achieving the desired results, but also selection of the correct surgical procedure and adequately performing it.

Disease severity versus clinical staging: predictors of a successful outcome

Because of a significant failure rate of UPPP in curing OSAHS, it is evident that a selection process is necessary to identify appropriate candidates who benefit from the surgery to be performed. Without clinical studies, many otolaryngologists empirically treated patients who had mild disease, and avoided patients who had severe disease. Because OSAHS may be caused by multilevel obstruction, it is logical that mild as well as severe disease may be caused by hypopharyngeal obstruction. It became evident that the success rate of UPPP is not related to the severity of the disease. Localized obstruction at the level of the palate and tonsils may be mild, moderate, or severe. Patients who have obstruction localized to the oropharynx would be excellent candidates for UPPP. Studies by Friedman and colleagues [7] have shown that severity is not a prognostic factor in determining success after the procedure. In fact, patients who have mild disease can be very poor candidates, and patients who have very severe disease have an excellent chance of being cured with UPPP. An anatomically-based staging system is thus able to identify areas of obstruction, and helps in tailoring the appropriate surgical treatment for each individual. It also helps identify the patients who have OSAHS who may not report clear-cut symptoms, and helps predict the success rate of the intervention, creating realistic expectations in both patient and surgeon. The severity of disease is a secondary factor, which plays a role in determining the need for treatment.

Parameters of the Friedman staging system

Tongue position

To assess the position of the tongue in relationship to the palate, the patient is asked to open his mouth wide without protruding the tongue. The procedure is repeated about five times, so that the observer can assign the most accurate position of the tongue. This tongue position is based on previous observations by Mallampati and colleagues [8], who suggested that the position of the tongue was an indicator of the ease or difficulty of endotracheal intubation by conventional techniques. This palate position was originally modified by Friedman and colleagues, and studied with respect to OSAHS. Originally named the ''modified Mallampati palate position,'' it was eventually renamed the ''Friedman tongue position,'' because it really assesses the position of the tongue with respect to the palate. Modifications by Friedman and colleagues [9] were subsequently incorporated, yielding a staging system that is based on an assessment of the patient's tongue in a neutral position (inside the mouth).

Mallampati [8] originally described the palate position with the tongue protruded, and he only had three levels. The modification included the tongue in neutral position, and had four levels. This relates to the actual position of the tongue during sleep, as opposed to a protruded tongue, which is certainly not related to the mechanism of sleep apnea.

Tongue position I (Friedman tongue position I, or FTP I), allows the observer to visualize the entire uvula, tonsils, and tonsillar pillars. FTP II allows visualization of the uvula, but not the tonsils. FTP III allows visualization of the soft palate, but not the uvula, and FTP IV allows visualization of the hard palate only (Fig. 1).

Tonsil size

The size of the tonsils also plays an important role in the staging and management of OSAHS patients. Tonsil size (TS) is graded from 0 to 4. TS 0 represents post-tonsillectomy patients. TS 1 implies tonsils hidden within the pillars. TS 2 represents tonsils that extend to the pillars. TS 3 refers to tonsils that extend beyond the pillars, but not all the way to the midline, whereas TS 4 tonsils (also known as ''kissing tonsils'') reach the midline (Fig. 2).

Body mass index

The relationship of body mass index (BMI), as calculated by the formula: weight (in kg)/(height (in m)^2, and the presence and severity of OSAHS has been previously established [10]. BMI can be graded based on accepted cutoff values. Grade 0 represents a BMI less than 20, grade I a BMI between 20 and 24, grade II a BMI between 25 and 29, grade III one between 30 and 39,

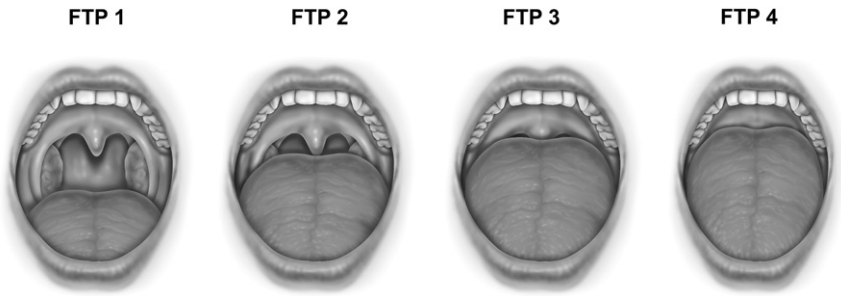

Fig. 1. Friedman tongue position (FTP). (*From* Friedman M, Ibrahim H, Bass L. Clinical Staging for Sleep Disordered Breathing. Otolaryngol Head Neck Surg 2002;127:14; with permission. Copyright © 2002 The American Academy of Otolaryngology–Head and Neck Surgery Foundation Inc.)

and grade IV one 40 or greater. For the purpose of clinical staging, a cutoff of 40 for the BMI is considered to be an automatic inclusion criterion for stage IV. Most surgeons performing procedures for OSAHS agree that patients who have a BMI 40 or greater have a poor prognosis for cure after UPPP. BMI also substitutes for neck circumference, which is also an indicator of obesity.

Based on these parameters, patients can be divided in four anatomical stages, as shown in Fig. 3. Stage I is defined as those patients who have FTP I or II, TS 3 or 4, and BMI less than 40. Stage II disease is defined as FTP I or II, and TS 0, 1, or 2, or FTP III and IV with TS 3 or 4, and BMI less than 40. Stage III disease is defined as FTP III or IV, and TS 0, 1, or 2, with a BMI less than 40. All patients who have BMI 40 or greater, or significant craniofacial or anatomical abnormalities (eg, micrognathia, midface hypoplasia) are grouped in stage IV [9].

Anatomical staging: outcomes

In contrast to the objective cure rates identified by Sher and colleagues [3] of 40% in unselected OSAHS patients undergoing UPPP, appropriately selected Stage I candidates achieved an objective cure rate of more than

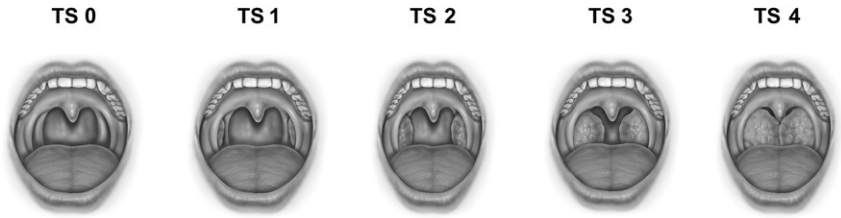

Fig. 2. Tonsil size (TS). (*Modified from* Friedman M, Ibrahim H, Bass L. Clinical Staging for Sleep Disordered Breathing. Otolaryngol Head Neck Surg 2002;127:15; with permission. Copyright © 2002 The American Academy of Otolaryngology–Head and Neck Surgery Foundation Inc.)

	Friedman Palate Position	Tonsil Size	BMI
Stage I	1	3, 4	<40
	2	3, 4	<40
Stage II	1, 2	1, 2	<40
	3, 4	3, 4	<40
Stage III	3	0, 1, 2	<40
	4	0, 1, 2	<40
Stage IV	1, 2, 3, 4	0, 1, 2, 3, 4	>40
All patients with significant craniofacial or other anatomic deformities.			

BMI = Body Mass Index.

Fig. 3. Modified Friedman staging system for patients with obstructive sleep apnea/hypoapnea syndrome. (*From* Friedman M, Ibrahim H, Joseph N. Staging of Obstructive Sleep Apnea/ Hypopnea Syndrome: A Guide to Appropriate Treatment. Laryngoscope 2004:114;455; with permission.)

80.6%, in a series of 134 patients [9]. Successful treatment of OSAHS with UPPP was most likely achieved in stage I patients because of the predominant palatal and tonsillar component. Stage II and III patients were least likely to achieve a cure after UPPP, with an overall objective cure rate of 37.9 and 8.1%, respectively. Stage III patients have a predominant base of the tongue obstructive component, thus making single level surgery useless. Supporting these findings is the fact that objective cure rates in stage II and III patients significantly improved to 74% and 43.8%, respectively, when radiofrequency tongue base reduction (TBRF) was performed in conjunction with UPPP to address the obstructive hypopharyngeal component [11].

Surgical techniques

Submucosal uvulopalatopharyngoplasty

UPPP is designed to eliminate palatal and pharyngeal redundancy by resection of excess loose palatal and pharyngeal mucosal and submucosal tissue, in addition to tonsillectomy. The original procedure described by Fujita and colleagues [2], as well as many other modifications, recommends

excision of redundant mucosa, with a single-layer closure under tension. A widely accepted surgical principle is that epithelial surfaces should never be closed under tension. Repositioning of tissues should be accomplished at a muscular or subepithelial level, so that epithelium can be closed with minimal or no tension. The tense mucosal closure in traditional UPPP has resulted in two common sequelae: (1) dehiscence of the suture line, and (2) severe postoperative pain, lasting as long as 2 weeks in some cases. Likewise, epithelial tension may also be responsible for common complications that contribute to failure of the procedure and require surgical correction.

Many authors writing about UPPP have actually redescribed the original procedure with important technical modifications. Submucosal UPPP focuses on the importance of epithelial preservation and tension-free closure of the epithelium, and on the preservation of the majority of the mucosa of the soft palate and the anterior and posterior pillars. Elimination of palatal and pharyngeal tissue redundancy (the palatoplasty and the pharyngoplasty components, respectively) is accomplished by subepithelial and muscular stretching and closure. Epithelial closure is accomplished without tension.

The tonsils, if present, can be excised using any technique, but the authors prefer the cold steel technique to minimize trauma to the anterior and posterior pillars. The tonsil is grasped with curved Allis forceps and pushed laterally to help identify the capsule. This allows for assessment of the lateral extent of the tonsil, and exposes the proper plane of dissection. An incision through the anterior pillar and the posterior pillar is made, preserving as much tissue as possible. If necessary, excess anterior pillar can be trimmed at closure. Posterior pillar resection results in posterior pull of the palate, which decreases the retropalatal space. The dissection is performed using Metzenbaum scissors or a Hurd dissector, dividing the tonsil capsule from the superior constrictor muscle. Constant traction of the tonsil is maintained, allowing the tissue to separate as it is dissected. The removal of the tonsil proceeds within its anatomic boundaries, and the musculature of the tonsil fossa is left intact. Dissection is performed inferiorly, toward the base of the tongue, and a snare is applied to complete the dissection. If done carefully, at the end of tonsillectomy, the tonsillar fossa is dry and the muscle fibers are still covered by fascia.

After removal of both tonsils, the uvula is grasped with an Allis forceps and retracted anteriorly for optimal approach to the posterior surface of the soft palate. A curvilinear horizontal incision is made on the mucosa at the base of the uvula posteriorly, preserving almost the entire posterior soft palate mucosa (Fig. 4A). Using a cold knife, the mucosa is separated from the muscle, releasing the posterior soft palatal mucosa (Fig. 4B). A trapezoid incision is outlined at the anterior mucosa of the soft palate (Fig. 4C). This level is identified preoperatively in the awake patient, just below the ''dimpled'' area. The incision is carried bilaterally and horizontally across the soft palate, until the anterior pillar starts sloping downward. The uvula and the submucosal tissue of the lower edge of the soft palate are excised

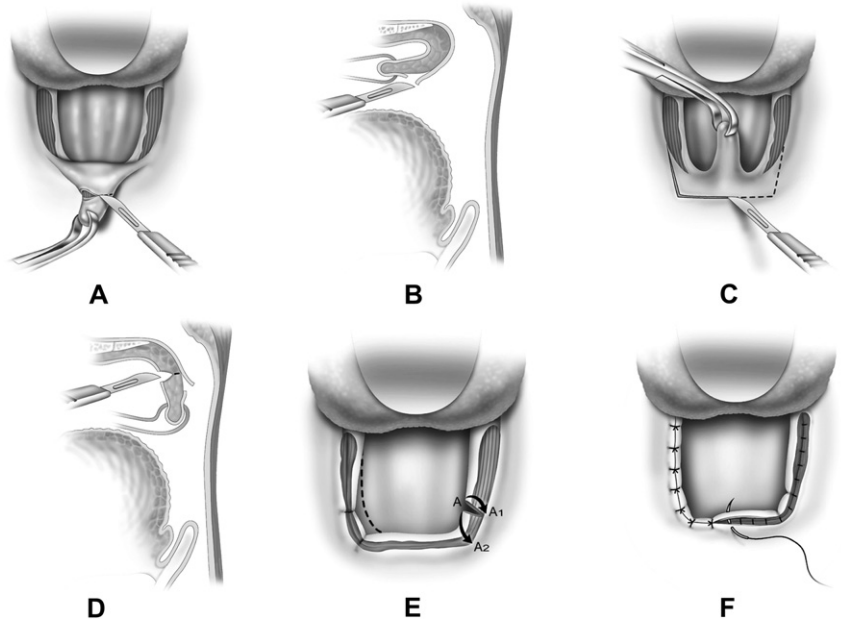

Fig. 4. Submucosal uvulopalatopharyngoplasty. (*Modified from* Friedman M, Landsberg R, Tanyeri H. Submucosal uvulopalatopharyngoplasty. Op Tech Otolaryngol Head Neck Surg 2000;11:26–9.)

(Fig. 4D). Based on Fairbanks' technique [12], an incision dividing the superior third from the inferior two thirds of the posterior pillar is performed (Fig. 4E). The posterior pillar is then advanced anterolaterally, toward the corner of the palatal-pharyngeal junction, which ultimately gives a squared appearance to the resected palate. By including contiguous muscle fibers in this advancement, a more lateralizing effect is achieved, which expands the airway in the anterior-posterior (because of the forward pull) and lateral dimensions. Elimination of pharyngeal redundant folds is achieved by approximation of the submucosa and muscular tissue of the tonsillar fossa and the soft palate, using interrupted 2-0 Vicryl (Ethicon, Sommerville, New Jersey) sutures through the exposed pharyngeal musculature (Fig. 4F). These sutures also prevent the formation of a dead space, where a seroma or hematoma might develop. The mucosal flap edges are then loosely approximated, taking care not to undermine, using 3-0 chromic sutures [13].

Z-palatoplasty

The Z-palatoplasty (ZPP) technique was developed as a more aggressive technique for patients who have stage II and III disease. This includes all patients who have had previous tonsillectomy, as well as patients who have small tonsils and those who have unfavorable tongue positions. The

goal of ZPP is to widen the space between the palate and the posterior pharyngeal wall, between the palate and the tongue base, and to either maintain or even widen the lateral dimensions of the pharynx. This is accomplished by changing the scar contracture tension line to an anterolateral vector, and by widening the anteroposterior and lateral oropharyngeal air spaces at the level of the palate. By splitting the soft palate and retracting it anterolaterally, an effective anterolateral pull is created, which actually continues to widen the airway as healing and contracture occur. None of the palatal musculature is resected, in spite of the aggressive palatal shortening, thereby addressing and minimizing the risk for permanent velopharyngeal insufficiency (VPI). This procedure is performed with adjunctive TBRF, which addresses the hypopharyngeal airway.

Two adjacent flaps are outlined in the palate (Fig. 5A). The anterior midline margin of the flap is halfway between the hard palate and the free edge of the soft palate, and the distal margin corresponds to the free edge of the palate and uvula. The lateral extent is posterior to the midline, and extends to the lateral extent of the palate. The mucosa from only the anterior aspect of the two flaps is subsequently removed (Fig. 5B). Fig. 5C illustrates how the preoperative uvula and palate hang close to the posterior pharyngeal wall, narrowing the retropharyngeal space. The two flaps are then separated from each other by splitting the palatal segment down the midline (Fig. 5D), extending them laterally, in a butterfly fashion (Fig. 5E), and dividing the palatoglossus muscle. A two-layer closure is then done, which brings the midline all the way to the anterolateral margin of the palate (Fig. 5F, G).

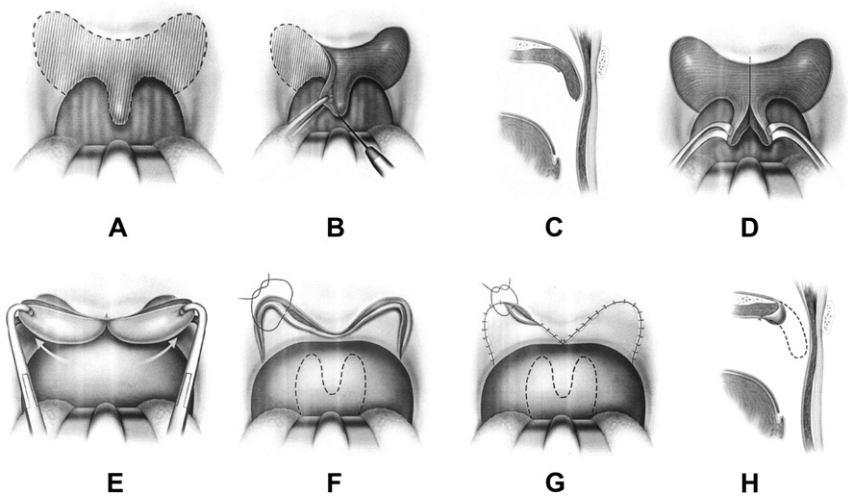

Fig. 5. Z-paloplasty. (*From* Friedman M, Ibrahim H, Vidyasagar R. Z-palatoplasty (ZPP): a technique for patients without tonsils. Otolaryngol Head Neck Surg 2004;131:89–100; with permission. Copyright © 2004 The American Academy of Otolaryngology–Head and Neck Surgery Foundation Inc.)

The primary closure is done at the submucosal level, which then enables a tension-free closure of the mucosa. A distance of at least 3 to 4 cm between the posterior pharynx and the palate is created. Fig. 5H illustrates the widening of the nasopharynx after the midline palatoplasty. The lateral dimension of the palate is usually increased to approximately 4 cm [14].

Palatal implants

The stiffening of the soft palate using the Pillar Palatal Implant System (Restore Medical, St. Paul, Minnesota) is an innovative technique introduced in clinical practice in 2003 for the treatment of snoring. It is a simple, office-based procedure with minimal morbidity. The Pillar implant technique can be performed in the office under local anesthesia, or as part of a combination of procedures in patients under general anesthesia in the operating room. The Pillar Implant System consists of an applicator (delivery tool) with a curved, 14-gauge needle at the tip, in which the implant is preloaded (Fig. 6A). The implant is a braided segment of polyester filaments intended for permanent implantation. It is about 18-mm long and 2-mm in diameter. The implant is deployed through the needle when the slider in the delivery tool is advanced. Each delivery tool contains one implant. This applicator is designed to perform a one-handed technique, although the free hand is used to palpate the correct location for implant insertion. The curved needle has three markings: a full insertion marking, a halfway depth marking, and a needle tip marking (Fig. 6B).

The oral cavity should be prepped with chlorhexidine gluconate (0.12% to 0.2%) rinse to decrease the chance of implant infection. The first step consists of injecting the soft palate with a mixture of 1% lidocaine/1:100,000 epinephrine solution. The injections are performed close to the insertion sites, which are located at the junction between the hard and soft palate, right at the midline and 2 to 3 mm laterally on each side (Fig. 6C). A total injection volume of 1 to 2 mL, (10–20 mg lidocaine) 10 minutes in advance, should achieve adequate anesthesia before inserting the implants. The area is injected for the entire length of the soft palate. The infiltration of the soft palate causes tissue swelling, which might lead to a superficial placement of the implant if the insertion site and soft palate are not adequately palpated prior to and during insertion. This increases the risk of implant extrusion when the swelling decreases. The insertion sites are marked with a marking pen. The exact location of the insertion site is determined by palpating the junction of the soft and hard palate with the index finger. The implants should be adjacent to the hard palate, and should effectively "extend" the hard palate, as well as shorten the soft palate. Palpation allows for proper placement, and helps avoid penetration through the nasopharyngeal mucosa. Once the sites have been marked, the midline implant is inserted first. The device needle is inserted into the soft palate, while the angle and depth are estimated with the index finger of the free hand. The needle is

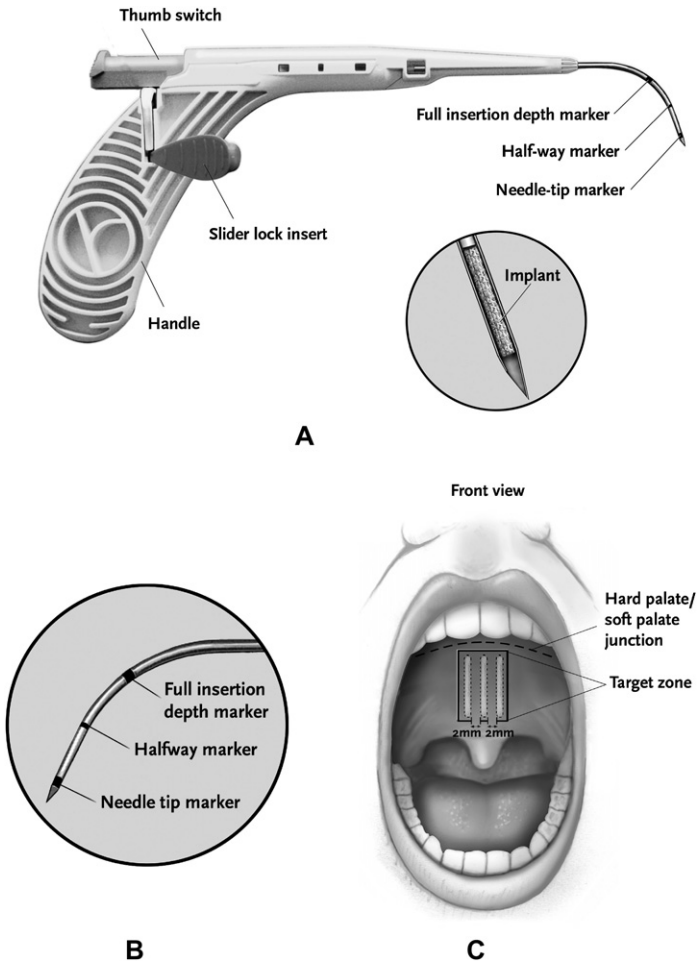

Fig. 6. Palatal implants. (*Courtesy of* Restore Medical, Inc., St. Paul, MN; with permission.)

advanced to the full insertion depth marker (which should remain visible), thus creating a tunnel in the soft palate muscles into which the implant is then deployed (Fig. 6D). At this point the device is unlocked by pressing the lock located beneath the slider, downwards. The slider is pushed halfway, until a click is heard. The needle is then withdrawn until the halfway depth marker, and the slider is pushed all the way in, thus deploying the implant into the soft palate. The position of the slider can be determined by looking at the windows on the side of the delivery tool (Fig. 6E). The needle is then withdrawn following the curvature of the needle, by moving the delivery tool in an arching fashion. If resistance is felt while delivering the implant, it usually means that the implant is pushing against the end of the previously created tunnel. Withdrawing the needle as the slider is pushed

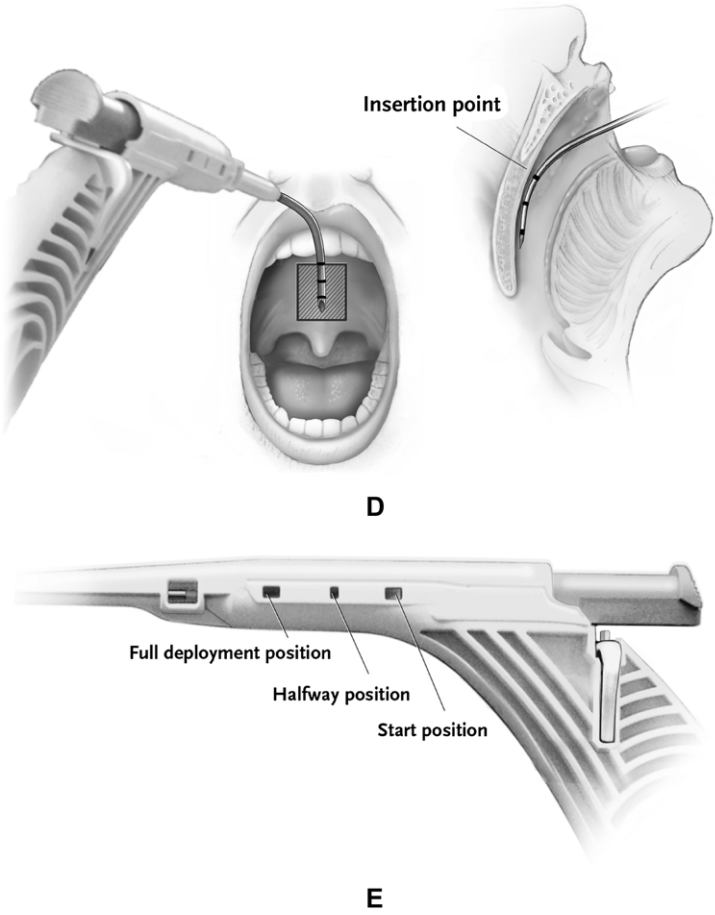

Fig. 6 (*continued*)

all the way in will usually result in adequate placement of the implant. The two lateral implants are inserted in the same fashion, as close as possible to the midline implant, about 2 mm apart. A good way of estimating this distance is by using the diameter of the needle (~ 2 mm). Three implants are usually inserted. After insertion, visual inspection is necessary to rule out incomplete or inadequate insertion of an implant, as well as persistent bleeding from the insertion sites.

Transpalatal advancement pharyngoplasty

Transpalatal advancement pharyngoplasty differs from other procedures addressing the palate and oropharynx in that instead of modifying or resecting soft tissue, it alters the actual bone (hard palate) and the soft tissue attachments of the posterior maxilla [15].

The indications for this procedure are persistent retropalatal obstruction after UPPP, and OSAHS in patients who have small tonsils and without excessively thick and long soft palate. A palatal incision begins at the central hard palate posterior to the alveolus and continues posteriorly, in a curvilinear fashion immediately medial to the greater palatine foramen (Fig. 7A). The tip or cephalic end of the flap needs to lie at least 1 cm proximal to the margin of the bone removal. The incision is then flared laterally over the palpable process of the hamulus to the buccal mucosa. A mucoperisoteal flap is elevated, exposing the hard palate and the proximal soft palate (Fig. 7B). In the midline, the palatal mucosa is often thin, and care must be taken during elevation to avoid tearing the tissue. Laterally and posteriorly, the submucosa of the flap is thicker fibroadipose tissue, and is bluntly dissected with the sharp edge of the mastoid curette. When the tensor aponeurosis is reached, the plane of elevation is superficial to the tendon and muscle. Only enough tensor is exposed to provide a grasp for subsequent sutures, usually 5 to 8 mm. Electrocautery is used so that the soft palate is separated from the hard portion of the palate and the nasopharynx is exposed (Fig. 7C). A posterior portion of the hard palate is removed. A Kerrison rongeur or drill removes a 1 cm margin of the hard palate. This includes

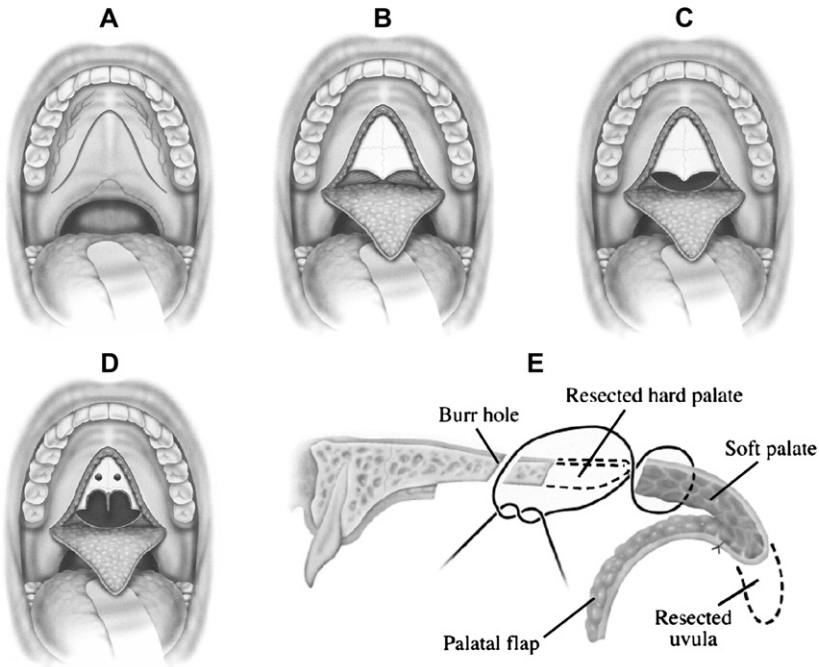

Fig. 7. Transpalatal advancement pharyngoplasty. (*From* Woodson BT. Transpalatal advancement pharyngoplasty for obstructive sleep apnea. Op Tech Otolaryngol Head Neck Surg 2000;11:36–40; with permission.)

the central palate, thus exposing the posterior nasal septum (Fig. 7D). Bleeding may be controlled with a suction Bovie. Palatal burr holes are placed at a 45° angle to the palate, extending from the oral surface of the palate into the nasal cavity (Fig. 7E). Particular care is needed if the palatal processes of the maxillary bone are thin. Several millimeters of bone need to remain to support the anchoring sutures. A tapered free needle then passes a doubled suture through the drill holes into the nasopharynx. The suture is grasped in the nasopharynx and is withdrawn from the mouth. Care must also be taken not to torque on the needles to prevent fracture of the palatal bones. Sutures are then secured medially and laterally in the tensor aponeurosis. A figure-of-eight suture is easier and less traumatic to place compared with a simple suture. The soft palate is mobilized using steady anterior traction with a finger or blunt instrument behind the palate. While an assistant retracts the palate anteriorly, the sutures are tied. Redundant mucosa may or may not need to be trimmed, and a tension-free closure is performed with fine absorbable sutures [16].

General guidelines of postoperative management

Early complication of airway obstruction can occur in the postoperative period, usually after extubation. This is especially true in patients who have hypopharyngeal obstruction. As with any intervention that involves resection of the soft palate and oropharyngeal structures, significant morbidity can be expected during the first 24 to 72 hours postoperatively, in the form of significant pain and dysphagia. For submucosal UPPP, ZPP, and transpalatal advancement pharyngoplasty, overnight admission to a monitored bed is generally recommended. The ability of the patient to tolerate at least a liquid diet, oral pain medications, antibiotics, and steroids determines the moment when the patient can be safely discharged home. This does not apply to the insertion of palatal implants, which is an outpatient, office-based procedure. Complications usually consist of bleeding, which can occur at any time until the healing process is completed. Airway compromise caused by significant edema in the immediate postoperative period, velopharyngeal insufficiency, pain/dysphagia, and globus sensation over the following months, as well as nasopharyngeal stenosis and abscess formation, are rare but possible complications. The common complications presented in patients who undergo palatal implant insertion are implant extrusion, requiring removal and subsequent replacement, and on rare occasions, implant infection, which also requires removal of the implant.

Summary: which procedure is the right procedure?

Oropharyngeal procedures may be performed as isolated procedures or combined with hypopharyngeal surgery. The choice of the surgical

procedure to be performed at the level of the oropharynx and palate for the treatment of OSAHS depends on the preoperative anatomical staging of the patient. Patients who have Friedman tongue position I will likely benefit from procedures addressing the palate. The severity of disease based on polysomnographic criteria, together with the experience and skill of the surgeon, will determine which technique is actually chosen. Palatal implant insertion is an appropriate procedure when the patient's presenting complaint is mainly snoring, and, after polysomnographic evaluation, the patient is diagnosed with mild sleep apnea (AHI $\leq$15). Mild to moderate (AHI greater than 6, less than 40) stage I patients are excellent candidates for either submucosal UPPP or ZPP. Severe OSAHS cases (AHI $\geq$40), or even patients who have been previously operated on and present with persistent or recurrent OSAHS, may benefit from ZPP or transpalatal advancement pharyngoplasty. The surgeon should be familiar with the rates of success for each one of the abovementioned procedures, and should also be comfortable managing these patients in the postoperative period, and addressing potential short- and long-term complications that might present. It is the surgeon's duty to inform the patient that the procedure might not achieve the desired results, and in fact, could potentially make the patient's condition worse. The need for further revision surgery must also be considered as a possibility by the patient.

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