Operative Techniques in Otolaryngology (2005) 16, 264-269

ELSEVIER

Operative Techniques in Otolaryngology

Hypopharyngeal airway surgery in the pediatric patient with obstructive sleep apnea syndrome

Jerome E. Hester, MD,[a] Nelson B. Powell, MD,[a,b] Robert W. Riley, DDS, MD[a,b]

From the [a]Department of Otolaryngology, Stanford School of Medicine, Palo Alto, California; and the [b]Department of Behavioral Sciences, Division of Sleep Disorders Medicine, Stanford School of Medicine, Palo Alto, California.

KEYWORDS
Pediatric sleep apnea;
Hypopharyngeal airway;
Genioglossus advancement;
Hyoid myotomy;
Maxillary mandibular advancement

Although standard treatment of pediatric sleep apnea has been directed at the nasal and retropalatal levels, some patients will have persistent obstruction at the base of the tongue. Surgical approaches that treat this area, many of which have been proven effective in the adult population, can be considered to treat these patients.

Standard treatment for the obstructive sleep apnea syndrome or the upper airway resistance syndrome in the pediatric age group has focused on the nasal and retropalatal levels in the past.[1] Certainly, these therapies have provided reasonable success rates, especially in the preadolescent age group.[2] However, as the awareness and subsequent diagnosis of the pediatric obstructive sleep apnea syndrome increases, identification of those individuals who have either persistent or recurrent obstruction will also increase. In some patients, this obstruction will likely involve the hypopharyngeal airway. At this time, the frequency of obstruction at this level in the adolescent age group is unknown.

Certainly, there must be concern regarding the pediatric age group when surgical changes are introduced into the upper or lower jaws. Consideration of alteration in the growth of the jaws is a relative risk until full development and growth have occurred. Typically, 90% of craniofacial development is present by age 12 years.[3] In addition, care to avoid damage to unerupted dentition must be taken. Therefore, unless extraneous circumstances are present, genioglossus advancement and bimaxillary advancement would usually not be considered until late adolescence. Before this time, recent studies suggest that the use of orthodontia, rapid maxillary expansion, or distraction may be useful.[4-6]

The mechanisms to identify the severity and location of obstruction have been described in the adult population.[7] In those adolescents with suspected hypopharyngeal obstruction, a complete physical examination and medical history are followed by fiberoptic nasopharyngoscopy and a cephalometric x-ray. These examinations not only help define the patient's anatomy but also assess the presence of other potential causes, such as neoplastic or developmental etiologies. Although medical comorbidities are less common than in adults, these are fully evaluated preoperatively, including a referral to the appropriate specialist as indicated. Laboratory data, including a complete blood count and comprehensive metabolic survey, are obtained.

All procedures are performed in the operating room with an anesthesiologist trained in difficult airways and the anesthetic treatment of sleep apnea. The surgeons are present at the time of induction. Postoperatively, all patients are admitted for observation with oxygen saturation monitoring. Those individuals who undergo multilevel surgery or those with preexisting medical morbidities are admitted to the intensive care unit. The use of intravenous narcotics is only allowed in the intensive care unit setting and, even then, only with strict instruction to the nursing staff to avoid them in the presence of signs of sedation. Benzodiazepines are also

Address reprint requests and correspondence: Jerome E. Hester, MD, Suite #317, 750 Welch Road, Palo Alto, CA 94303.
E-mail address: jhester@sleepsurgery.com.

1043-1810/$ -see front matter © 2005 Elsevier Inc. All rights reserved.
doi:10.1016/j.otot.2005.07.001

Table 1 Comparison of surgical techniques

	Genioglossus advancement	Hyoid myotomy and suspension	Maxillary mandibular advancement
Indications	• Persistent OSA after traditional soft tissue surgery and examination documenting base of tongue obstruction	• Persistent OSA after traditional soft tissue surgery and examination documenting base of tongue obstruction	• Persistent OSA after completing palatal surgery and genioglossus advancement • Severe OSA (RDI >40) after palatal surgery • Untreated OSA with craniofacial deformity amenable to bimaxillary surgery
Contraindications	• Unerupted dentition • Inadequate mandibular height	• Preoperative dysphagia	• Preadolescent
Special instruments	• Sagittal saw • Titanium screw	• "0" nonabsorbable suture on large curved needle	• Rigid fixation system
Tips and pearls	• Careful placement of osteotomy to avoid root tips, incorporate tubercle, and stay above mandibular border by 10 mm	• Absolute hemostasis • Placement of drain • Keep dissection medial to lesser cornu	• Aggressive advancement • Meticulous attention to fixation and occlusion

Abbreviations: OSA, obstructive sleep apnea; RDI, Respiratory Disturbance Index.

contraindicated in this group. Table 1 compares the procedures discussed herein.

Mandibular osteotomy with genioglossus advancement

Mandibular osteotomy with genioglossus advancement relies on the firm attachment of the genioglossus muscle to the genial tubercle. Advancement of the segment of the mandible places the muscle under tension, which limits its posterior displacement during sleep.[8] In addition to the preoperative evaluation described previously, a Panorex radiograph (Imaging Sciences, Int, Inc, Hatfield, PA) is obtained to document the anatomy of the anterior teeth, mandibular height, course of the inferior alveolar nerve canal, and any pathologic process.

The procedure may be performed with the patient under general anesthesia or, in appropriate cases, under intravenous sedation. The incision is intraoral in the anterior gingival buccal sulcus, taking care to leave a cuff of mucosa to facilitate closure and maintain the integrity of the sulcus postoperatively. Dissection is performed submucoperiosteally to expose the inferior border of the mandible. The location of the genial tubercle is identified by the radiographs and then palpated in the floor of the mouth (Figure 1A). The osteotomy is then outlined using a sagittal saw through the outer cortex. The outline is typically 9 × 18 mm, and centered 5-mm inferior to the root apices and 10-mm above the inferior border of the mandible, incorporating the previously identified geniotubercle. A titanium screw is placed in the center of the osteotomy to facilitate manipulation of the fragment. The cuts are then completed through the inner cortex, taking care to maintain parallel walls. The fragment is then displaced medially into the floor of the mouth. Hemostasis is obtained using electrocautery or, where indicated, Gelfoam (Pharmacia Corp, Kalamazoo, MI). The mandibular fragment is advanced and rotated slightly (Figure 1B). The outer cortex and marrow are removed, and a titanium screw is placed inferiorally to fixate the fragment. A pear-shaped bur may then be used to contour the fragment (Figure 1C). The wound is then closed with absorbable suture.

Overall, complication rates are low.[9] It is possible to have mild-to-moderate edema or ecchymosis in the floor of the mouth. This typically resolves but needs to be monitored closely. The patient should be counseled that hypesthesia or paresthesia of the anterior chin or lower teeth likely will be present but should resolve over a few weeks to months. Injury to the tooth roots and mandibular fracture generally can be avoided by correct placement of the osteotomy.

Hyoid myotomy suspension

The hyoid is integrally associated with the hypopharyngeal airway. Anterior advancement results in widening the posterior airway space.[10] For this reason, the hyoid advancement was initially described as a traditional component of phase I surgery in the Riley-Powell surgical protocol in those individuals with documented hypopharyngeal involvement.[11] However, it has been our observation that in many patients, the advancement provided by the genioglossus procedure alone, or more recently, when combined with radiofrequency, may provide adequate treatment of the hypopharyngeal airway. In addition, the hyoid advancement does leave an external scar,

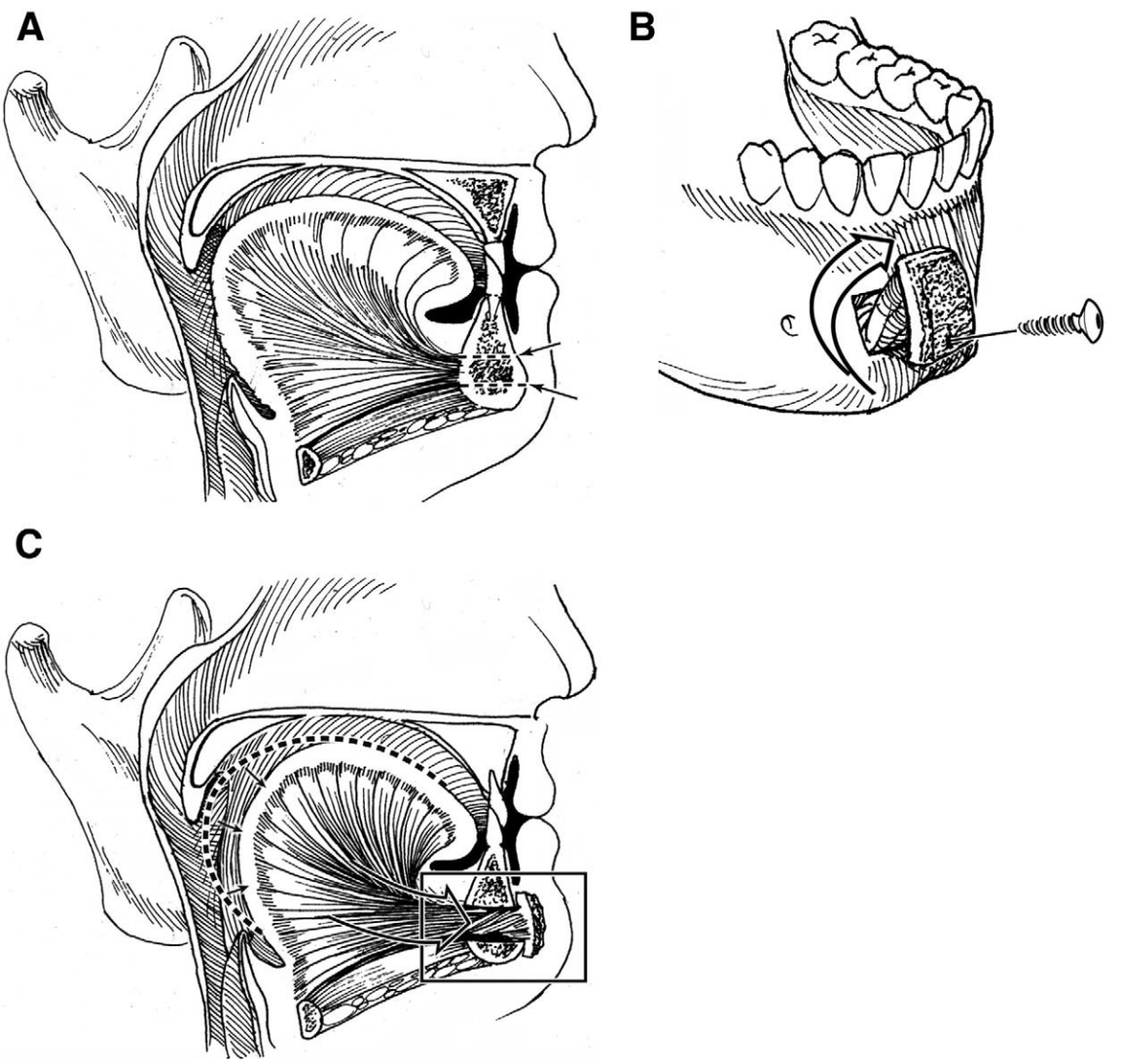

Figure 1 (A) Identification of the geniotubercle. (B) Advancement and fixation of the mandibular fragment and genioglossus. (C) Final position of the advancement.

which may be of particular concern in the adolescent population.

The procedure is performed through a horizontal incision typically placed in a neck crease. Dissection is continued to identify the hyoid (Figure 2A). Hemostasis is absolutely maintained. Removing the infrahyoid musculature isolates the body of the hyoid. The suprahyoid musculature is left intact. Further mobility can be obtained by transecting the stylohyoid ligament (Figure 2B). The hyoid itself is then advanced and stabilized by passing permanent sutures around the hyoid and through the superior aspect of the thyroid cartilage, which has been carefully cleared of soft tissue (Figure 2C). The wound is then closed in a layered fashion, and a passive drain is placed.

Meticulous hemostasis, the use of a drain, and the placement of a light pressure dressing for 24 hours markedly reduce the chance of seroma or hematoma. Perioperative antibiotics are used. By keeping the dissection medial to the lesser cornu, injury to the superior laryngeal nerve can be avoided. Dysphagia may occur postoperatively but is generally only significant in the elderly.

Maxillary mandibular advancement

It is very important that the treating physician acknowledge the limitations of even a complete diagnostic work-up in delineating the level and severity of obstruction. Ignoring this limitation may lead the surgeon to recommend a more aggressive treatment plan than may be otherwise indicated. Certainly, recent reports documenting increased success using bimaxillary advancement as a first stage have been used as evidence that this is a reasonable approach.[12] However, we believe it should be reserved in most patients for those who have completed the phase I protocol and have persistent disease.[13]

Besides the standard preoperative evaluation or all patients, careful attention is paid to the patient's occlusion. One goal of the procedure should be to maintain the

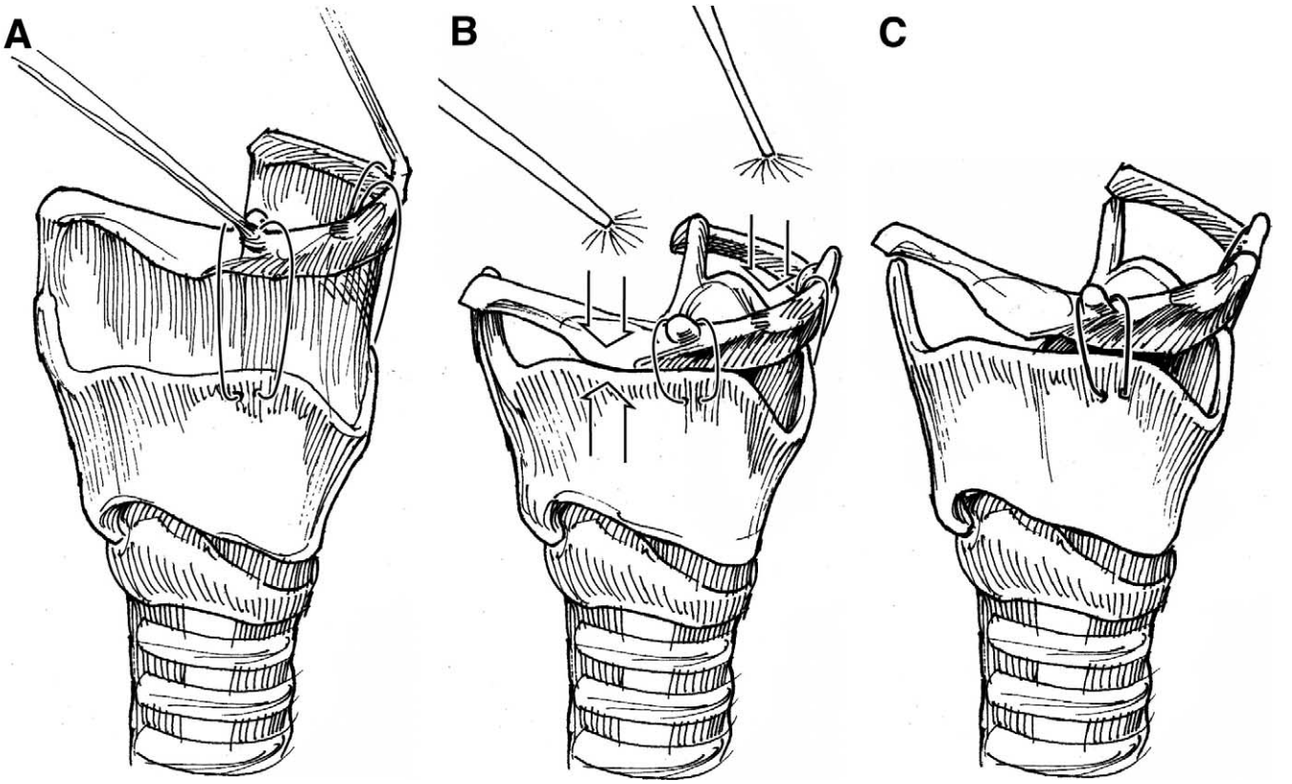

Figure 2 (A) Isolation of the hyoid and thyroid cartilage. (B) Advancement of the hyoid. (C) Fixation of the hyoid to the superior aspect of the thyroid cartilage.

existing occlusion. However, in those individuals with a class II occlusion, the lower jaw may be corrected more aggressively to obtain normal occlusion. It is advised to have 2 units of autologous-packed red blood cells available at surgery. The patient is nasally intubated with the surgical team in attendance. Arch bars are typically placed to facilitate postoperative maintenance of occlusion. Alternatively, orthodontic bands can be placed preoperatively. The LeFort I maxillary osteotomy is performed first. The incision is made through the mucosa, and a submucoperiosteal flap is elevated. Full exposure from the nasal fossae to the root of the zygoma is important (Figure 3). Special care must be taken not to violate the nasal mucosa medially. The horizontal osteotomy is placed above the root apices using a sagittal saw. Pterygomaxillary separation is performed using a curved osteotome (Figure 4). The descending palatine arteries are identified and preserved if possible. If necessary, control of the vessels is obtained with surgical clips. Close attention to the maxilla is mandatory to identify any signs of vascular insufficiency. Immediate replacement of the maxilla is performed if any signs of ischemia are present. Aggressive advancement between 8 and 12 mm is then performed. Rigid fixation is accomplished with stainless steel 24-gauge wires and 4 titanium miniplates.

The mandible is then addressed through a posterior incision that allows identification of the external oblique ridge and lingula, and extends anteriorally to the canine. The periosteum is then elevated to expose both the medial and lateral surfaces. Identification of the lingula on

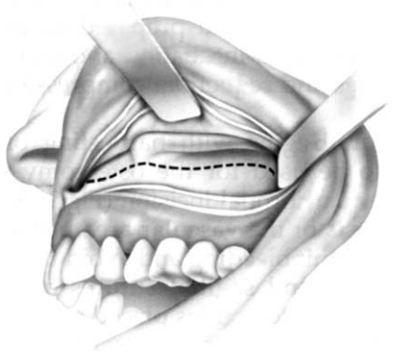

Figure 3 Advancement and fixation of maxillary and mandibular osteotomies. (Reprinted with permission.[13])

Figure 4 Posterior view of the LeFort osteotomy. (Reprinted with permission.[13])

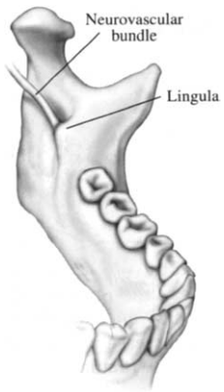

Figure 5 Identification of the lingual. (Reprinted with permission.[13])

the medial surface allows identification and protection of the neurovascular bundle (Figure 5). A pear-shaped bur is used to make a trough just above and just past the lingula. A reciprocating saw is used to cut through the outer cortex, from the midline cut to the lateral aspect of the alveolus. The cut extends to the mesial of the first molar. A vertical cut is then made from the inferior border to connect to the previous osteotomy (Figure 6). It is recommended that the inferior 5-7 mm of this cut would be bicortical, then superiorally includes only the outer cortex. The osteotomy is then completed carefully with osteotomes. The inferior alveolar nerve is then identified and preserved. Once these osteotomies have been completed bilaterally, the mandible is advanced and brought into occlusion using the previously made methylmethacrylate splint. Rigid fixation is obtained with percutaneous titanium screws and mandibular plates (Figure 7). All wounds are copiously irrigated and closed with absorbable suture. Intermaxillary fixation can be used postoperatively at the surgeon's discretion.

As previously mentioned, these patients are monitored in the intensive care unit. Airway compromise can occur as a result of postoperative edema. The careful monitoring of blood pressure is important to help control this edema as

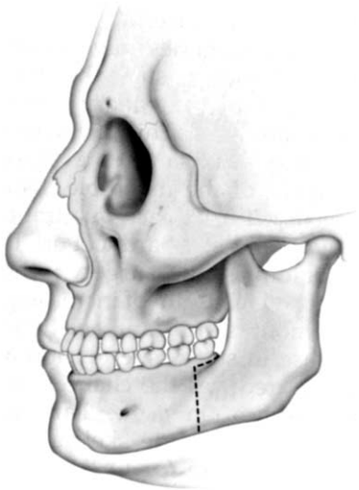

Figure 6 Outline of the vertical osteotomy. (Reprinted with permission.[13])

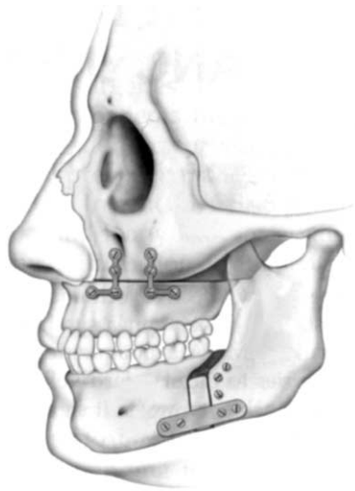

Figure 7 Final appearance of the advancement with rigid fixation. (Reprinted with permission.[13])

well as limit the chance of hemorrhage. Postoperative malocclusion or malunion can occur, but the use of rigid fixation, attention to occlusion intraoperatively, and maintenance of a soft diet for approximately 6 weeks limit these occurrences.

Conclusion

The identification of obstructive sleep apnea in the pediatric age group will increase as public and physician awareness increases. This result will lead to the treatment of those individuals with hypopharyngeal obstruction. Careful examination of these patients, and a stepwise approach to their problem should provide the safest and most efficacious method of treatment.

References

1. Mauer KW, Staats BA, Olsen KD: Upper airway obstruction and disordered nocturnal breathing in children. Mayo Clin Proc 58:349-353, 1983
2. Suen JS, Arnold JE, Brooks LJ: Adenotonsillectomy for treatment of obstructive sleep apnea in children. Arch Otolaryngol Head Neck Surg 121:525-530, 1995
3. Guilleminault C, Khramtsov A: Upper airway resistance syndrome in children: A clinical review. Semin Pediatr Neurol 8:207-215, 2001
4. Guilleminault C, Li K, Quo S, et al: A prospective study on the surgical outcomes of children with sleep-disordered breathing. Sleep 27:95-100, 2004
5. Pirelli P, Saponara M, Guilleminault C: Rapid maxillary expansion in children with obstructive sleep apnea syndrome. Sleep 27:761-766, 2004
6. Li K, Powell N, Riley RW, et al: Distraction osteogenesis in adult obstructive sleep apnea surgery: A preliminary report. J Oral Maxillofac Surg 60:6-10, 2002
7. Shepard JW Jr, Gefter WB, Guilleminault C, et al: Evaluation of the upper airway in patients with obstructive sleep apnea. Sleep 14:361-371, 1991
8. Riley RW, Powell NB, Li KK, et al: Surgical therapy for obstructive sleep apnea-hypopnea syndrome, in Kryger MH, Roth T, Dement WC

(eds): Principles and Practice of Sleep Medicine (ed 3). Philadelphia, PA, Saunders, 2000, pp 913-927

9. Troell RJ, Powell NB, Riley RW: Hypopharyngeal airway surgery for obstructive sleep apnea syndrome. Semin Respir Crit Care Med 19: 175-183, 1998
10. Riley RW, Powell NB, Guilleminault C: Maxillary, mandibular, and hyoid advancement for treatment of obstructive sleep apnea: A review of 40 patients. J Oral Maxillofac Surg 48:20-26, 1990
11. Riley RW, Powell NB, Guilleminault C: Obstructive sleep apnea syndrome: A review of 306 consecutively treated surgical patients. Otolaryngol Head Neck Surg 108:117-125, 1993
12. Hochban W, Conradt R, Brandenburg U, et al: Surgical maxillofacial treatment of obstructive sleep apnea. Plast Reconstr Surg 99:619-626, 1997
13. Hester JE, Powell NB, Riley RW, et al: Maxillary-mandibular advancement for obstructive sleep apnea. Oper Tech Otolaryngol Head Neck Surg 13:135-137, 2002