Evolving Therapies to Treat Retroglossal and Base-of-Tongue Obstruction in Pediatric Obstructive Sleep Apnea

Christopher T. Wootten, MD; Sally R. Shott, MD

Objective: To describe our experience treating retroglossal and base-of-tongue collapse in children and young adults with obstructive sleep apnea using combined genioglossus advancement (Repose THS; MedtronicENT, Jacksonville, Florida) and radiofrequency ablation of the tongue base.

Design: Retrospective institutional review board–approved analysis of 31 operations.

Setting: Tertiary pediatric medical center.

Patients: Thirty-one patients with a mean age of 11.5 years (age range, 3.1-23.0 years).

Interventions: Combined genioglossus advancement and radiofrequency ablation.

Main Outcome Measures: Preoperative and postoperative polysomnographic data were evaluated for each patient. Success of surgery was determined using the criteria of a postoperative apnea-hypopnea index of 5 or fewer events per hour, without evidence of hypoxemia (oxygen saturation as measured by pulse oximetry), and without prolonged hypercarbia (end-tidal carbon dioxide).

Results: Thirty-one patients who underwent genioglossus advancement were analyzed. Nineteen (61%) had Down syndrome. The overall success rate was 61% (19 of 31) (58% [12 of 19] success among patients with Down syndrome and 66% [7 of 12] success among patients without Down syndrome). Overall, the mean apnea-hypopnea index improved from 14.1 to 6.4 events per hour (P < .001); the mean nadir oxygen saturation as measured by pulse oximetry during apnea improved from 87.4% to 90.9% (P = .07).

Conclusions: Pediatric obstructive sleep apnea refractory to adenotonsillectomy that is due to retroglossal and base-of-tongue collapse remains difficult to treat. However, most patients in this analysis benefited from combined genioglossus advancement and radiofrequency ablation.


The spectrum of sleep-related breathing disorder ranges in severity from primary snoring to obstructive sleep apnea (OSA). Approximately 1% to 3% of all children have OSA, most of which is attributable to adenotonsillar hypertrophy. Patients who are severely affected may demonstrate craniofacial maldevelopment (adenoid facies), failure to thrive, delay in cognitive abilities, hypertension (pulmonary and systemic), or severe cardiovascular dysfunction, including cardiac failure from cor pulmonale.

Fortunately, because most pediatric OSA is caused by adenotonsillar hypertrophy, adenotonsillectomy alone is an effective and durable treatment. However, multilevel airway narrowing beyond enlarged tonsils and adenoids may occur and represents a source of treatment failure after adenotonsillectomy. Although these additional levels of narrowing (nasal, nasopharyngeal, retropalatal, retroglossal, and hypopharyngeal) may be found in otherwise healthy children, certain populations are predisposed to multilevel airway collapse. Included in this group are obese children, children with nasal obstruction of any etiology, children with neurologic impairments or familial factors, children with malacia or laryngotracheal or bronchial stenosis, and children with craniofacial anomalies, such as Pierre Robin sequence and Down syndrome.

The treatment of pediatric OSA beyond adenotonsillectomy is more complex. Managing OSA of anatomically diverse origins includes diagnosing which levels are responsible for the airway collapse and defining the severity of the col-
lapse. A polysomnogram (PSG) is used to assess the severity of the collapse. Although most clinicians do not routinely obtain a PSG in children with OSA and with classic signs and symptoms of adenotonsillar hypertrophy, multilevel collapse (especially after adenotonsillectomy) needs to be quantified using a PSG before proposing more invasive surgical treatments or continuous positive airway pressure (CPAP) management.

Diagnosing which levels are responsible for airway collapse can be difficult. Included in this workup are a detailed history and physical examination, including flexible nasopharyngoscopy to the level of the larynx. Recently, cine magnetic resonance (MR) imaging has provided a useful radiographic adjunct to the physical examination, because it allows the clinician to screen for and to observe airway collapse in 3 planes (axial, coronal, and sagittal). The Bernoulli principle indicates that collapse at one level may mask or enhance collapse at another location in the airway. Therefore, the exact nature of dynamic airway collapse may not be appreciated by a detailed history and physical examination, cine MR imaging, and flexible endoscopy performed in the office and in the operating room.

Once OSA following adenotonsillectomy has been confirmed by a PSG and the levels of collapse have been elucidated, the treatment options are surgical and nonsurgical. Much pediatric OSA could be ameliorated with CPAP, which avoids surgery. The necessary amount of positive pressure is determined during a special CPAP titration PSG, and CPAP is typically delivered using a face mask, a nasal mask, or nasal pillows. Realistically, the success of CPAP treatments is diminished by poor patient compliance. One-third of adult patients opt out of CPAP therapy when required for persistent OSA after adenotonsillectomy. Reasons for noncompliance include the obtrusiveness of the machine, a sense of claustrophobia, or physical discomfort.

For these reasons, adult and pediatric patients with OSA frequently prefer a surgical option if one is available. The objective of the present study is to describe our experience performing combined genioglossus advancement (GGA) (Repose THS; MedtronicENT, Jacksonville, Florida) and radiofrequency ablation (RFA) of the tongue base to treat OSA in children that is refractory to adenotonsillectomy and is attributable to retroglossal and base-of-tongue collapse.

**METHODS**

Among 31 patients with OSA persisting after adenotonsillectomy who were thought to have obstruction at the base of the tongue, a retrospective analysis was conducted to define postoperative success after combined GGA and RFA (n=30) or GGA alone (n=1). Patients undergoing lingual tonsillectomy, revision adenoidectomy, or uvulopalatoplasty with simultaneous GGA were included. Patients undergoing RFA or lingual tonsillectomy without sequential or simultaneous GGA were excluded from this study. Likewise, patients undergoing GGA who lacked a preoperative or postoperative full-night PSG, patients whose PSG was conducted with supplemental oxygen, and patients whose PSG was for CPAP titration were excluded. This study was approved by the institutional review board.

**SURGICAL PROCEDURES**

Genioglossus advancement was performed according to the manufacturer’s directions and included placing a titanium screw with a preattached heavy polyethylene suture into the genial tubercle through a submental incision. The heavy suture was then passed through the tongue base in a triangular fashion and was tied to the opposite suture near the genial tubercle. The tightness of the knot was titrated based on simultaneous palpation of the tongue base.

Radiofrequency ablation was performed as described by Powell et al. In brief, 1.5 mL of 1:200 000 bupivacaine hydrochloride was injected into the tongue base before RFA into sites where the probe would be inserted. A 2-pronged probe was used at a setting of 600 J. The probe was initially inserted at the vertex of the circumvallate papillae. Subsequent lesions were created 1 cm anterior to the first treatment site and, as indicated, 1 cm anterior to the second treatment site.

A plasma wand (XP Coblation; ArthroCare ENT, Austin, Texas) was used to perform lingual tonsillectomy on patients with lingual tonsillar hypertrophy who were simultaneously undergoing combined GGA and RFA. The anterior midline of the tongue was controlled with a heavy silk suture, while an appropriately sized Lindholm laryngoscope (Karl Storz, Tuttlingen, Germany) was used to expose the tongue base. The plasma wand was used to remove lingual tonsil tissue using settings 9 (ablate) and 5 (coagulate).

**RESULTS**

Thirty-one patients underwent GGA for OSA refractory to adenotonsillectomy. Only 1 patient underwent GGA as an isolated procedure, while the remaining 30 patients underwent combined GGA and RFA of the tongue base. Five patients underwent simultaneous lingual ton-
Most pediatric OSA is attributable to adenotonsillar hypertrophy, and adenotonsillectomy alone is an effective and durable treatment. In certain populations, multi-level airway obstruction is more common, and these patients demonstrate OSA that is refractory to adenotonsillectomy. The initial steps in treating children with OSA that is refractory to adenotonsillectomy include quantifying the severity of OSA with a full-night PSG and determining the levels of collapse through a detailed history and physical examination, flexible endoscopy in the office and in the operating room, and cine MR imaging. Patients with retroglossal airway obstruction after adenotonsillectomy may be candidates for CPAP, operative management, or both. Herein, we reviewed our experience with 31 consecutive patients undergoing combined GGA and RFA in whom retroglossal collapse was thought to be the primary site of obstruction. Using strict postoperative polysomnographic criteria, this surgical approach was successful in most patients.

Several operations have been developed to improve retroglossal collapse. Radiofrequency ablation provides a minimally invasive means to deliver limited thermal damage to the tongue base, creating lesions that diminish the bulk and flaccidity of the tongue base through fibrosis. The GGA technique attempts to stabilize the tongue base to prevent its retrodisplacement during supine sleep. Differing from musculoskeletal advancement procedures, GGA relies on a heavy suture that is triangulated through the tongue base submucosally to apply tension directly at the site of obstruction. Over time, a fibrotic bridge forms around the implanted suture and provides additional strength.

Other surgical procedures that address base-of-tongue obstruction described in adult populations include hyoid myotomy and suspension, as well as midline mandibular osteotomy with GGA. The hyoid myotomy and suspension procedure advances the hyoid complex to improve the retroglossal airspace by placing traction on the hyoid directly. The midline mandibular osteotomy procedure pulls the genioglossus muscle forward from its insertion onto the genial tubercle. Both of these procedures have shown variable success in adults and are of limited use in children because of the chang-
The present study defines success and failure based on PSG variables, including AHI, SpO₂, and ETCO₂. The adult literature considers an AHI of 20 events per hour to be a reasonable threshold to treat; however, the pediatric literature uses more restrictive AHI values. Although an AHI exceeding 1 event per hour is considered abnormal by many pediatric sleep medicine practitioners, it would be unreasonable to recommend a tongue base operation to such a patient without a nadir SpO₂ below 90% or without significant sleep time spent in hypercapnia. The present review considers 5 events per hour to signify patients who might benefit from surgery. However, 3 patients herein with AHIs between 5 and 6 after undergoing GGA were deemed surgical successes because they had no concomitant hypercapnia or desaturation and their sleep architecture had subjectively and objectively improved. The preoperative AHIs for these 3 patients were 11.3, 26.5, and 26.9 events per hour. Likewise, patients who were CPAP intolerant before surgery who became CPAP tolerant after surgery (regardless of PSG results) represent some degree of improvement, although we did not use CPAP tolerance as a criterion for success in the present study.

As with any retrospective analysis, a major limitation of our study was the inability to control the data. In our series of 31 consecutive patients undergoing combined GGA and RFA, few patients underwent simultaneous lingual tonsillectomy. However, the reported success rates with GGA are not altered statistically by lingual tonsillectomy, nor were the success rates altered statistically by the addition of revision adenoidectomy or uvulopalatoplasty in 5 additional patients. Likewise, although children with Down syndrome represented a physiologically unique group in our study, no statistically significant difference was seen in overall success rates between patients with vs without Down syndrome undergoing combined GGA and RFA. Finally, PSGs were performed no less than 2 months (range, 2–24 months) after surgery. However, it is unclear what the optimal period should be for a postoperative PSG. In 2 patients, we observed improvement over time (based on a second postoperative PSG) without any additional operations. In both of these patients, parental reports of improvement led to a second postoperative PSG. For children who failed to improve sufficiently following combined GGA and RFA, most are being treated with CPAP or with bilevel positive airway pressure.

In conclusion, patients with retroglossal and base-of-tongue obstruction after adenotonsillectomy may be candidates for CPAP or for operative management that includes combined GGA and RFA. Our results indicate the combination of GGA and RFA is successful in alleviating pediatric OSA in most appropriately selected patients. However, because we theorize that it is a combination of glossoptosis and macroglossia that contributes to retroglossal collapse, procedures that more aggressively reduce the bulk of the tongue base may be indicated. Accordingly, we are enrolling patients into a prospective study of refractory pediatric OSA that sequentially applies midline posterior glossectomy with plasma wand ablation, followed by combined GGA and RFA (if necessary).
Submitted for Publication: February 17, 2009; final revision received February 5, 2010; accepted May 13, 2010. 

Correspondence: Christopher T. Wootten, MD, Department of Otolaryngology–Head and Neck Surgery, Vanderbilt University, Medical Center E, South Tower 1215, 21st Ave S, Seventh Floor, Ste 7202, Nashville, TN 37232 (christopher.t.wootten@vanderbilt.edu).

Author Contributions: Drs Wootten and Shott had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Wootten and Shott. Acquisition of data: Wootten and Shott. Analysis and interpretation of data: Wootten and Shott. Drafting of the manuscript: Wootten and Shott. Critical revision of the manuscript for important intellectual content: Wootten and Shott. Statistical analysis: Wootten. Study supervision: Shott.

Financial Disclosure: None reported.

Previous Presentation: This study was presented at the Annual American Society of Pediatric Otolaryngology Meeting, May 24, 2009, Seattle, Washington.

REFERENCES