INTRODUCTION
Autism spectrum disorders (ASDs) are a group of behaviors characterized by impaired social interaction, communication, and restricted and stereotyped patterns of interests. ASD have significant impact on the child and their family members. Tic disorders including Tourette syndrome (TS) are estimated to have a prevalence of 8–20% in children with ASD. Tics are defined as sudden, brief, involuntary motor (motor tics) or sound (phonic tics) production. The natural progression of tics is variable but can remain chronic and debilitating into adulthood. Behavioral, pharmacologic, and surgical interventions have all met with mixed success. Here, we present the successful use of laryngeal framework surgery to reduce the frequency and severity of phonic tics in a pediatric patient with ASD and debilitating phonic tics.

Case report
A 14-year-old boy with ASD and TS diagnosed with severe vocal tics since he was 5 years old was evaluated for the management of phonic tics. Despite behavioral and antipsychotic medical intervention, he still had nearly 2000 vocalizations per day of approximately 90 dB per vocalization. Vocalis muscle injection with botulinum toxin-A (BTX-A) was performed on five different occasions, with two injections providing mild symptomatic relief lasting 10 weeks. However, on the fifth injection, there was concern for aspiration of thin liquids. He was then referred to the senior author (S.H.D.) for further evaluation. Office laryngeal examination demonstrated normal supraglottic and glottic structures with symmetric and normal arytenoid mobility in adduction and abduction.

Parameters for a successful outcome for this patient included an intervention that would retain maximum laryngeal function while minimizing morbidity and allowing for the possibility of revision and not eliminating any options. Normal growth of the larynx was also a desired outcome. Options discussed were unilateral recurrent laryngeal nerve (RLN) section, anterior vocal fold web creation, and type IIB thyroplasty. A midline lateralization (type IIB) thyroplasty was presented as a possible intervention to his parents, and with appropriate consent we performed a type IIB thyroplasty.

He was brought to the operating room, anesthetized, intubated, and the area overlying the larynx was prepared in the standard sterile fashion. Through a 4-cm horizontal incision, subplatysmal flaps were raised. Strap muscles were lateralized and the thyrohyoid muscle was divided bilaterally to more completely expose the thyroid cartilage measuring 15 mm from the thyroid notch to the inferior portion of thyroid cartilage. The larynx was visualized from the superior thyroid notch to the inferior portion of the cricoid cartilage. A cartilage graft
measuring 5 mm in width by 15 mm in length was excised from the right superior ala of the thyroid cartilage with a no. 15 blade scalpel preserving the outer thyroid ala perichondrial layer. Perichondrium was left intact on the interior of the cartilage graft. Next, with a no. 15 blade scalpel, a midline laryngofissure was performed, being careful to preserve the endolaryngeal mucosa. Direct microlaryngoscopy was performed to confirm adequate vocal fold separation. After a bioresorbable temperature sensitive plate was placed in 55°C water, it was fashioned to match the contour of the thyroid alae, taking into account the graft to be placed in between. The harvested cartilage graft was centered on the plate and sutured to the plate with 4-0 prolene sutures. With the graft in place, the plate was fitted over the thyroid cartilage extramucosally and four points for suture placement on the left and right thyroid cartilage alae were marked. Using 4-0 prolene sutures, the mesh was secured through these four points in the thyroid cartilage (Figure 1). The wound was closed in layers over a passive drain, and the patient was extubated with no tracheotomy performed. The patient was admitted to the pediatric otolaryngology service for 2 days. His hospital course was uncomplicated with minimal pain and no oxygen desaturation episodes noted. A speech-language pathologist evaluated him on postoperative day 2 for aspiration risk. Mild pharyngeal swallow delay with some wincing on swallowing was noted on swallow evaluation 24 hours after surgery. Barium swallow evaluation 48 hours after surgery demonstrated no aspiration of liquids. He was then discharged.

Standard phonatory measures were very difficult to obtain given the patient’s ASD status. However, at his 2-week follow-up visit, his parents reported a 50% reduction of phonic tic frequency postoperatively and we measured a 50% (90–45 dB) decibel reduction of the loud phonic tics. His parents also noted that he was speaking and smiling more and was able to return to school activities, previously severely curtailed because of his phonic tics. Importantly, he was eating without aspiration and had gained 8 lbs.

At his 6-month follow-up visit, we performed a stroboscopic examination of the glottic larynx that demonstrated a healthy endolarynx without webbing of the vocal folds. His vocal folds displayed no difficulty in moving. There was no airway stenosis and no foreign body reaction to the extramucosal bioresorbable mesh. Phonic tics had decreased to 10% of preoperative tic frequency, by parental report. Of note, his loudest vocalizations remained at 50% (45 dB) of preoperative intensity.

His parents reported that he had sustained social interactions and was able to enjoy public places with his family, such as restaurants. People had no difficulty understanding his speech, and his vocabulary had been increasing. To date, he has not had any signs or symptoms of dysphagia or aspiration.

**DISCUSSION**

Here, we report the successful use of midline lateralization thyroplasty (type IIB) in a 14-year-old male with ASD and TS with severe phonic tics. This is the first report to our knowledge of using type IIB thyroplasty to provide symptomatic relief for phonic tics. This patient was an ideal candidate for some type of alternate intervention, given the failure of behavioral and medical management over several years. The loud and frequent vocalizations had a profound impact on his ability to participate in any type of standard activities such as school. Also the vocalizations were very hard on family members trying to care for the patient whose twin brother is also severely autistic.

The pathophysiology of phonic tics in TS is complex and believed to involve disinhibition of the cortico-striatal-thalamo-cortical circuit. Tics are associated with preceding sensory discomfort or premonitory urges. Porta et al reported after vocalis muscle injection of BTX-A improvement of phonic tic frequency and 50% of patients experiencing elimination of phonic tics. In addition to phonic tic frequency improvement, the frequency of premonitory urges was also reduced. BTX-A temporarily disrupts alpha motoneuron transmission and muscle spindle afferent conduction. Emerging functional magnetic resonance imaging data demonstrated pre-tic activation sensory association areas (ie, parietal operculum) may be the neurologic substrate for premonitory urges. Premonitory urges have been postulated to arise from subclinical isometric contractions. It remains to be determined if BTX-A effect on tic production and urges is through reduced sensory cortex input by spindle inhibition.

The additional factor of the patient’s autism diagnosis also played into decision making. Individuals on the ASD spectrum often engage in self-stimulatory behaviors, some involving painful or damaging stimuli. Examples include head banging and scratching to the point of bleeding. The patient treated in this report had engaged in multiple self-injurious behaviors thought to satisfy an internal mismanagement of

**FIGURE 1.** Intraoperative photograph with bioresorbable mesh being sutured to thyroid cartilage with dyed 4-0 prolene sutures. Black arrow signifies cephalad position. Upper and lower black lines demarcate cephalad and caudal border of mesh. Left and right green lines demarcate anterior cartilage graft sutured to mesh. Circle represents 4-0 prolene sutures securing mesh to thyroid cartilage. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article).
sensory processing. The patient’s loud vocalizations were thought to be another manifestation of this sensory processing disorder.

Our treatment hypothesis was based on the consideration of the phonic tics in the setting of self-stimulatory autistic behavior traits. Type IIB thyroplasty clearly alters the geometry of the vocal fold and theoretically would permanently alter vocalis muscle spindle afferent output. Our patient had exceeded the time frame that BTX-A injections provided relief, which suggests that rigid length changes of spinal nerve afferents might induce long-lasting neuroplastic changes involved in neurocircuitry for tic generation. Also we hypothesized that if the loudness could be reduced by limiting vocal fold adduction with a type IIB thyroplasty, then the patient would be less likely to perform the vocalization activity, given that the desired stimulus of loud voice would be attenuated. This hypothesis may be more likely in this case and was supported by the patient’s favorable postoperative outcome.

Alternate surgical strategies were considered such as RLN section and intentional creation of a glottic web, both with a primary notion of trying to short-circuit the self-stimulatory behavior of loud voice creation. The former was not selected due to the risk of dysphagia and the possibility of reinnervation of RLN with a possibility of a midline vocal fold, which would permit loud voicing. Both were not selected because of the difficulty with revision of the anatomy to a normal state should the phonic tics cease. With a type IIB thyroplasty with autologous cartilage and bioresorbable mesh, we sought to preserve normal swallowing function, allow for the possibility of revision once fully grown, allow normal laryngeal growth, prevent thermal sensitivity and palpability of the plate under the skin (as can be seen with titanium), and permit adequate but quieter voice quality. Care was taken in the consideration of how best to separate and secure each hemilarynx.

Successful use of resorbable polymer plates has been reported in laryngeal reconstruction in adult laryngeal fracture reduction and pediatric laryngeal reconstruction for tracheomalacia and subglottic stenosis. Titanium mesh and plates have traditionally been used for laryngeal reconstruction but may cause growth restriction, thermal sensitivity, inference with diagnostic imaging, extrusion, and palpability. Resorbable lactic acid polymer plates are 100% biocompatible and completely convert to carbon dioxide and water in over 18–36 months. Moreover, New Zealand rabbit laryngeal structural integrity after laryngeal reconstruction with resorbable plates was not compromised at 12 months postoperatively.

Absence of endolarynx inflammation was likely the result of extraluminal placement of the cartilage graft and nonresorbable suture placement. Monocryl suture used for securing resorbable meshes placed through-and-through have not demonstrated gross inflammation. Given recent success with monocryl suture, we may consider using it in future operations.

CONCLUSION

This case demonstrates that laryngeal framework surgery may improve the quality of life in patients with severe and intractable phonic tics, with or without the comorbidity of autistic self-stimulatory behaviors. Additional investigation into the mechanism of action, such as functional neuroimaging studies, may help determine the true role of laryngeal framework surgery for this debilitating disorder. Long-term follow-up of this patient’s voice and behavioral development as well as his laryngeal growth is warranted. Maximization of lateralization effects on phonation for this indication may also benefit from intraoperative voice evaluation.

REFERENCES