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Genioglossus advancement for obstructive sleep apnea

Nicholas Wirtz, MD, David Hamlar, MD, DDS

From the Departement of Otolaryngology, University of Minnesota, Minneapolis, Minnesota

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Surgical interventions for the upper airway have long been a part of treatment algorithms for sleep-disordered breathing. Genioglossus advancement is one such procedure designed to specifically treat obstructed breathing related to hypopharyngeal collapse. The procedure involves surgical manipulation of the genioglossus muscle's attachment to the mandible. The result is reducing obstruction at the hypopharynx and tongue base by displacing this musculature anteriorly. The last 30 years have introduced variations of the procedures and further explored the relevant anatomy. Although there is a paucity of high-level evidence, studies have shown promising outcomes when the procedure is tailored to those with appropriate anatomy and pathophysiology.

Introduction

Surgical treatment of obstructive sleep apnea (OSA) is a complex topic involving a myriad of procedures targeting specific areas of the upper airway. The spectrum of physiological and anatomical causes of this disorder necessitates tailoring of treatments to offer the patient the best possible outcome. Fujita classification breaks down this spectrum into 3 types.[1] Type I describes abnormalities of the upper oropharyngeal airway, including the palate, uvula, and tonsils. Type II consist of upper oropharyngeal and hypopharyngeal airway pathology, and type III involves only the hypopharyngeal airway (lingual tonsils, tongue base, supraglottis, and hypopharynx). For the purpose of this article, we will discuss a specific procedure designed to treat those with type II and type III OSA.

Genioglossus advancement (GA) was first described by Riley in 1984.[2] The procedure involved the advancement of the genial tubercle or genioglossus muscle for the treatment of hypopharyngeal obstruction in OSA. The rationale of this technique was to stabilize the hypopharyngeal airway by moving forward the genioglossus complex providing tension on the base of the tongue and thereby expanding the airway during sleep. Over the last 30 years, there have been variations proposed to the original technique to both improve outcomes and limit complications.[3-6] Despite these variations, the principle of the procedure remains the same and results have shown significant subjective and polysomnographic improvement in those exhibiting type II (when combined with oropharyngeal procedures) and type III obstruction.

Surgical technique

To fully understand the GA, one must become familiar with the relevant anatomy. The genioglossus muscle is an extrinsic muscle of the tongue, originating from a remote structure and inserting within the tongue itself; it serves as a dilator of the pharynx. The genioglossus originates from the superior mental spine or genial tubercles, and then fans posterior to insert at the tip of the tongue, dorsum of the tongue, and into the body of the hyoid bone. The muscle is

Address reprint requests and correspondence: Nicholas Wirtz, MD, 2893 Knox Ave S, Apt 512, Minneapolis, MN 55408.
E-mail address: wirtz039@umn.edu

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innervated by cranial nerve XII and receives its major vascular supply from the lingual arteries.

The anatomical dimensions of the musculature and its relationship to the anterior mandible are clinically significant to the GA. In a study of 41 human skulls, Mintz et al[7] observed the width of the genial tubercle attachment to fall between 3 and 8 mm, whereas a later study by Silverstein et al[8] reported the attachment to be as wide as 15 mm. In the context of GA, understanding the proximity of the tubercle attachment to the tooth roots is also crucial. The superior border of the genial tubercle has been described, on average, just 6.45 mm inferior to the apex of the central incisor with 35% of specimens having less than 5 mm clearance from the incisor roots.[7] Understanding the anatomical relationship of these muscles to the anterior mandible helps the surgeon design an osteotomy for advancement of the tongue musculature. To advance the greatest amount of musculature, the dimensions of the osteotomy must be large enough in all dimensions to allow for the greatest muscle mass advanced.[8]

The inferior border advancement genioplasty, was the initial GA procedure described by Riley et al.[2,3,6] The inferior border of the mandible is sectioned and advanced anteriorly with the dentoalveolar process left intact (Figure 1).[9] The osteotomized segment must extend superiorly enough to incorporate the genioglossus attachment but not involve the tooth roots of the lower incisors or canines. Concerns regarding mandibular fracture led to minor innovations in the procedure by leaving an intact inferior mandible and advancing the genial tubercles anteriorly through a rectangular window osteotomy (Figure 2).[10] Li et al describes this procedure as follows.

A mucosal incision is made approximately 10-15 mm below the mucogingival junction and a subperiosteal flap is developed to expose the symphysis. A rectangular osteotomy encompassing the estimated location of the genioglossus attachment is performed with the superior horizontal bone cut approximately 5 mm below the root apices. The inferior horizontal bone cut is approximately 10 mm above the inferior border of the mandible. The vertical osteotomies are made just medial to the canine tooth to avoid root injury. Before completing the osteotomy, a titanium screw is placed in the outer cortex to control and manipulate the bone flap. The bone flap is advanced anteriorly over the labial surface of the mandible and rotated about 30°-45°, just sufficient to create bone overlap for a fixation screw. The outer cortex and marrow are removed and the inner cortex is rigidly fixed with a 2.0-mm lag screw. The mentalis muscles are approximated or suspended and mucosal closure is performed.[5] A pressure dressing around the submentum is recommended for 48 hours.[11]

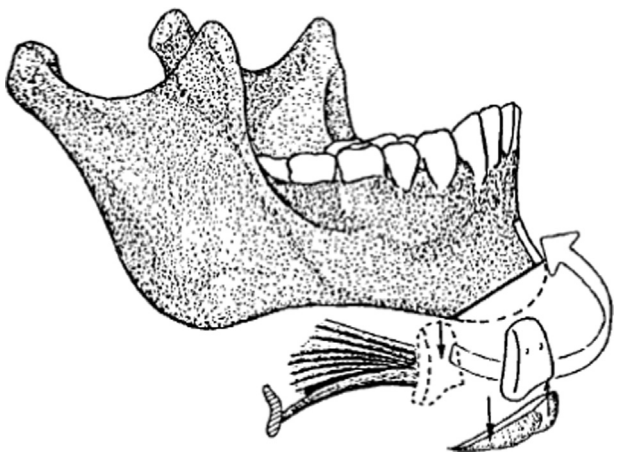

Figure 1 Mandibular osteotomy with genioglossus advancement as described by Riley et al.[9]

Li also notes that exceptions can be made when making the superior osteotomy, because occasionally the genial tubercle is located only 1-2 mm from the incisor root apex.[7] This would call for less clearance from the tooth root but is necessary to assure adequate genioglossus capture.

Variations of this procedure include different types of osteotomies and slight alteration in transposition of the bone segment. The rotation involved in the above-stated procedure drew criticism for its risk of stripping the genial tubercle form the lingual cortex. An alternative technique involves a similarly placed osteotomy with laterally slanting vertical cuts. A 2-mm locking plate is molded to the anterior mandible before the bone segment is freed. An 18-mm screw is secured into the segment for manipulation. The freed block is then split in the coronal plane, removing the labial cortex and medullary bone. The lingual cortical plate is then brought anteriorly and secured with the prebent plate (2 holes in segment and 3 on either side in mandible). The bone that is removed should be morselized and used to fill gaps around block.[4,11]

Garcia et al[9] proposes a slight alternative to the rectangular window by introducing a longitudinal groove on the floor of the window after the bony block is freed. The segment is then brought anterior and displaced inferiorly to overlap intact mandible for the genial tubercle to rest in the created groove. Labial cortex and medullary bone is divided from the segment. The bony defect created superiorly is plugged with the free cortical and medullary bone piece. The advantages with this technique are greater anterior advancement of genioglossus with inferior displacement, more bone overlap than the rotation method for securing and lack of segment rotation (avoid possible stripping).[4,11]

A circular trephination approach is also described, designed to reduce risk of lateral incisor tooth root injury while maintaining optimal genial tubercle capture.[7] The approach is the same as the previously described techniques. Once the anterior mandible is exposed, a bicortical drill is used and thickness measurements are obtained. An appropriately sized trephine drill with stop placed at the measured thickness is used to create a circular bone flap. This segment is transpositioned anteriorly and the medullary bone and lateral cortex are osteotomized. A customized fixation plate is used to secure the lingual cortical plate of the bone flap.[6]

In the patient with micrognathic OSA, further chin augmentation with mandibular advancement may be desired. In these instances a genioplasty combined with