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Technical Note
Orthognathic Surgery

Genioglossus muscle advancement and simultaneous sliding genioplasty in the management of sleep apnoea

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Abstract. Genioglossus muscle advancement (GMA) was reported in 1993 as an option for the surgical treatment of obstructive sleep apnoea syndrome (OSAS), in the context of phase I of the Stanford University (Powell–Riley) protocol. The rationale for this technique is the placement of tension on the base of the tongue, thus preventing the tongue from falling back into the posterior airway space. However, in retrognathic patients undergoing phase I of the Stanford University protocol, an additional genioplasty will provide a better aesthetic outcome. Furthermore, genioplasty is one of the most common and versatile techniques used for the correction of dentofacial deformities. The aim of this article is to describe a technique that allows a combination of genioglossus muscle advancement (GMA) and a simultaneous sliding genioplasty. This technique can be used in patients undergoing phase I surgery, or in patients in whom a sliding genioplasty could be complemented by GMA. The advantage of this procedure is the aesthetic enhancement obtained in GMA patients. The indications, contraindications, complications, and outcomes of surgery in the first 15 patients treated with this technique are reported herein.

Key words: genioplasty; genioglossus muscle advancement; obstructive sleep apnoea; phase I.

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Genioglossus muscle advancement (GMA) was reported in 1993 as an option for the surgical treatment of obstructive sleep apnoea syndrome (OSAS), in the context of phase I of the Stanford University (Powell–Riley) protocol[1]. OSAS is a common disease with severe metabolic, cardiovascular, and cognitive sequelae if left untreated. The origin of this condition is not completely understood, although a myriad of factors are known to be involved. These factors include anatomical and functional aspects, and the ultimate cause of OSAS is collapse of the pharyngeal walls during sleep due to a failure of dilator muscle activity[2].

The pharyngeal dilator muscles are responsible for the patency of the upper airway during sleep and during wakefulness. The two main muscles responsible for pharyngeal patency are the genioglossus and the tensor veli palatini. Kobayashi et al. showed that the genioglossus muscle is a tongue protruder that prevents pharyngeal collapse when the tongue moves into a posterior position[3]. In contrast, the tensor veli palatini stiffens the soft palate and thus lowers the velopharyngeal resistance[4].

OSAS is caused by many different general and local factors, but there are two main concomitant factors: sleep-induced changes in the upper airway muscle activity and anatomical local narrowing[5].

Malhotra et al. studied postural effects on pharyngeal protective reflex mechanisms in 17 normal subjects by means of electromyography studies of the genioglossus muscle and tensor palatini[6]. They found an increased responsiveness to negative pressure pulses during sleep compared to wakefulness when subjects were in the supine position and a decrease when in the lateral decubitus position. Furthermore, they reported that genioglossus electromyographic activity was influenced by body position, with the muscle more active in the supine position during non REM sleep when compared to the lateral decubitus sleep position, and during sleep as compared to wakefulness. They speculated that this mechanism prevents pharyngeal occlusion when the upper airway is most vulnerable to collapse (during sleep in the supine position)[6].

Another factor that is altered in OSAS patients is upper airway muscle tone. Mezzanotte et al. compared the tone of the genioglossus muscle during wakefulness between OSAS patients and normal controls[7]. They found higher basal genioglossus activity in OSAS patients and thus speculated that this neuromuscular compensation present during wakefulness in apnoea patients may be lost during sleep, leading to airway collapse.

With this knowledge, stretching of the genioglossus muscle has a physiological basis and would appear to be a useful treatment for this respiratory sleep condition.

Riley et al. developed the first staged surgical treatment for OSAS (Stanford University (Powell–Riley) protocol; Fig. 1), with the first report of GMA[1]. This technique, in conjunction with an uvulopalatopharyngoplasty (UPPP) (and originally combined with hyoid myotomy and suspension), provides functional improvement of the upper airway during sleep by placing tension on the base of the tongue, thus preventing the tongue from falling back into the posterior airway space. According to Riley et al., this procedure has a success rate ranging from 42% to 75%, depending on different factors such as the severity of the disorder and body mass index (BMI)[1].

An advancement genioplasty as a single procedure is not recommended for the treatment of OSAS for two main reasons:

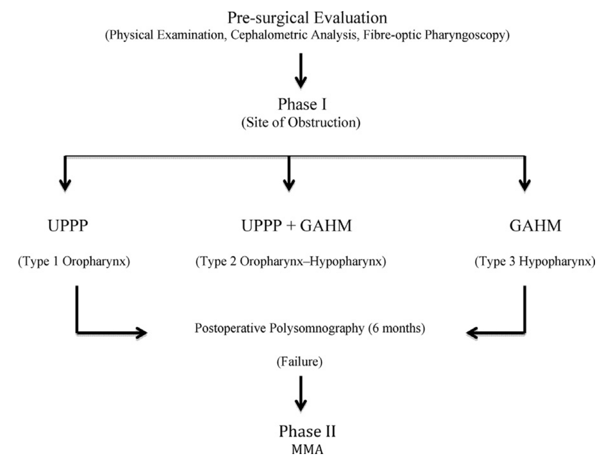

Fig. 1. Stanford University surgical protocol, as reported by Riley et al.[1] (UPPP, uvulopalatopharyngoplasty; GAHM, genioglossus advancement with hyoid myotomy and suspension; MMA, maxillomandibular advancement).

(1) the genial tubercle may not be included and therefore the pull of the genioglossus muscle will not be affected, and (2) the advancement usually needed to achieve an aesthetic outcome is limited. However, some authors have published good results in mild OSAS cases, in patients with retrognathia[8]. Nevertheless, the amount of chin advancement is usually limited to around 10 mm for aesthetic and biological reasons. In contrast, GMA allows further protrusion of the muscle than genioplasty alone. In 2014, another technique was published aiming to improve the aesthetic outcome of genioglossus muscle advancement[9]. In a series of 10 OSAS patients treated previously by the present authors' surgical team with UPPP plus GMA (traditional phase I), it was found that the minimum advancement of the osseous insertion of the muscle was 10 mm. Similar measurements were mentioned in the previous article[9].

This article describes a technique that allows a combination of GMA and a simultaneous sliding genioplasty. This technique can be used in patients undergoing Stanford University protocol phase I surgery, or in patients in whom a sliding genioplasty could be complemented by GMA. The advantage of this procedure is the aesthetic enhancement obtained in GMA patients. The indications, contraindications, complications, and outcomes of surgery in the first 15 patients treated with this technique are reported herein.

Materials and methods

A prospective study was conducted involving patients attending the Sleep Unit at Hospital del Trabajador and Clínica Santa María during a 4-year period. All patients underwent diagnostic polysomnography (PSG) and had been assessed previously by specialists in sleep medicine (ENT surgeons and neurologists). Patients with a diagnosis of OSAS were advised to undergo medical treatment with continuous positive airway pressure (CPAP) as first-line therapy. Those who refused this conservative treatment or who did not tolerate CPAP were advised to undergo surgical treatment according to the Stanford University surgical protocol only, regardless of the severity of their condition.

Inclusion criteria encompassed patients with a retrognathic profile who had elected to undergo a sliding advancement genioplasty, modified GMA, and UPPP. All patients were informed about the success rate of the original phase I technique and provided consent for treatment. Two senior ENT surgeons performed the UPPP in all patients. The patients were assessed for pain, speech difficulties, infection, haematoma, and any other complications in the immediate and late postoperative periods.

Surgical technique

The surgical approach is the same as for a genioplasty, with an incision in the mucosa of the lower lip, either blunt or sharp muscle dissection, exposure of the osseous chin, and traditional genioplasty with a reciprocating saw. Once the bone segment is released, a triangle of the lingual cortex is made in the midline with either a reciprocating saw or piezoelectric instrument (Fig. 2). This triangle of bone, including the anterior insertion of the genioglossus muscle, is released and gently pulled forward, avoiding detachment of the muscle from the bone. This is usually achieved

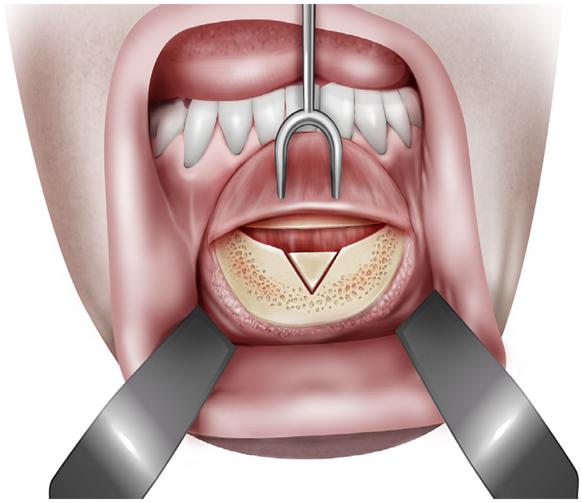

Fig. 2. Design of the bone triangle including the genial tubercle.

Table 1. Details of the patients undergoing the technique.

Patient	Sex	Age (years)	Snoring	AHI
1	M	51	Yes	35
2	M	49	Yes	43
3	M	46	Yes	60
4	M	43	Yes	16
5	M	32	Yes	24
6	M	30	Yes	19
7	M	26	Yes	4.4
8	M	38	Yes	34
9	M	31	Yes	90
10	M	31	Yes	19
11	M	53	Yes	13
12	F	30	Yes	8.6
13	M	49	Yes	22
14	M	44	Yes	18.6
15	M	40	Yes	21

AHI, apnoea–hypopnoea index; F, female; M, male.

with Kocher forceps. The genioglossus muscle remains between the released chin and the alveolar segment of the bone. The triangle of bone is stabilized to the chin and finally the genioplasty is stabilized with a plate and screws in the usual manner. Due to the presence of the genioglossus muscle, a gap will remain between the two bone surfaces (Fig. 3). Closure in layers is finally performed.

Results

A total of 15 patients underwent the technique (Table 1). Fourteen of the patients were male (93.3%). The average age of the patients in this series was 39.5 years (range 26–53 years). Fourteen of the 15 patients were diagnosed and treated for OSAS; only one patient was treated for snoring (patient 7). According to the PSG results, the mean apnoea–hypopnoea index (AHI) of the 14 OSAS patients was 30.2, with a range from 8.6 to 90.

No complications were observed in the 14 OSAS patients. One patient developed a transient speech difficulty lasting less than a week. Only three patients underwent a control PSG; an improvement in AHI was seen in two of them. Since this follow-up test was not available for all patients (due to high cost), conclusions cannot be drawn regarding the success rate of the technique; however, it would be expected to be similar to that of the original phase I protocol.

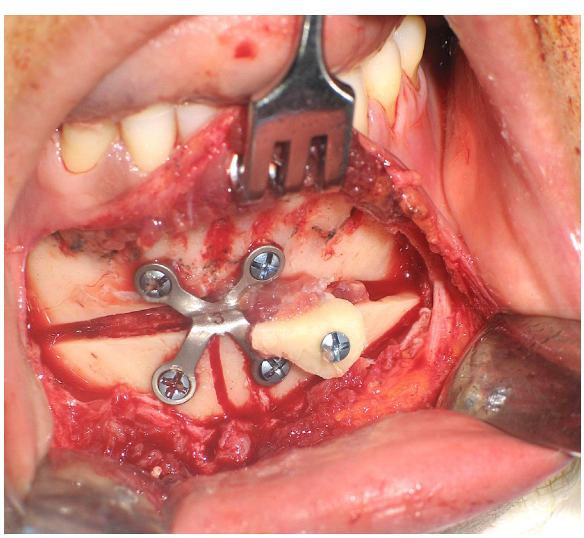

Fig. 3. Final aspect of the advancement genioplasty and stabilization of the bone triangle with a screw. Note the genioglossus muscle in the upper aspect of the triangle and subsequent ipsilateral bone gap.

Discussion

Despite the lower success rate of Stanford University protocol phase I surgery (42–75%) compared to maxillomandibular advancement (75–100%), this group of patients decided to undergo this technique. The reasons were mainly to avoid a change in their facial appearance and the need for orthodontic treatment before and after surgery.

Based on previous studies, a technique was developed that combines a traditional sliding genioplasty with GMA in an attempt to combine the functional improvement of GMA and the aesthetic gains of a sliding genioplasty.

The results from this series of 15 operated patients suggest that the two groups of patients who might benefit from this technique are (1) sleep apnoea patients or snorers requiring treatment with the phase I protocol, who have a hypoplastic chin and would therefore benefit from the aesthetic gain obtained; (2) traditional genioplasty patients, in whom further genioglossus muscle advancement is desired or needed (Fig. 4).

Regarding the contraindications to the use of this technique, the clinical outcomes of the operated patients suggest advising against proposing its use in obese patients (BMI >30 kg/m^2) and those who cannot maintain an adequate weight. Patients with a severe AHI should also not undergo this technique due to the uncertain success rate.

According to intraoperative measurements performed previously, the genioglossus muscle is advanced by at least double the amount of a traditional genioplasty in such cases.

In accordance with this protocol, ENT surgeons and neurologists (specialists in

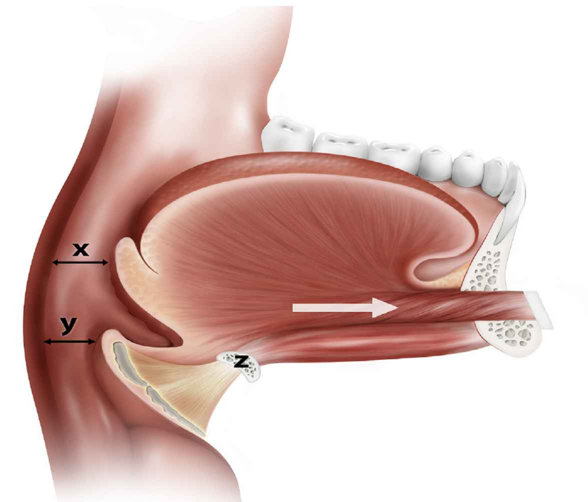

Fig. 4. Diagram showing the final lateral aspect of the technique, with further advancement of the genioglossus muscle.

sleep medicine) assessed all patients in both hospitals.

Several techniques for the surgical treatment of OSAS have been published to date, the most accepted of which is the Stanford University protocol, which consists of two stages: phase I (UPPP ± GMA) and phase II (maxillomandibular advancement). Phase II, i.e. maxillomandibular advancement, has proved to be the most effective surgical method. Nevertheless, the change in facial appearance and the need, in most cases, for orthodontic treatment, prevented many patients in the present OSAS population from accepting this procedure.

CPAP remains the gold standard for the treatment of OSAS. However adherence with CPAP remains low in the long term[10], particularly in young patients, who do not wish to depend on a machine for life. In this population of patients, phase I surgery techniques represent a viable treatment option, in spite of the lower success rates compared to maxillomandibular advancement.

A combination surgery consisting of GMA and simultaneous sliding chin advancement has been developed in order to provide an aesthetic gain with the phase I protocol. This technique was used uneventfully in this series of patients. A trained surgeon can perform the technique easily and the only difficulty, in some patients, may be the pulling of the bone triangle, due to the stretching of the muscle. With regard to the aesthetic outcome of the technique, care must be taken to avoid asymmetry of the genioplasty, since the genioglossus muscle emerges either right or left of the midline, which will lead to a gap on one side. To overcome this difficulty, the same gap must be maintained on both sides of the genioplasty. Occasionally the genioglossus muscle can be located in the midline; however this will depend on the type of plate used to fix the genioplasty.

With this modification to the technique, better functional outcomes than with traditional phase I protocol surgery would be expected, due to further pulling of the genioglossus muscle. However postoperative PSG is needed to compare patients undergoing this technique with those undergoing the traditional phase I protocol. Further studies with larger numbers of patients are necessary to clarify whether only aesthetic or also functional improvements are achieved with this technique compared to classic phase I surgery.

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Competing interests

None.

Ethical approval

Exempt.

Patient consent

Not required.

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References

1. Riley R, Powell N, Guilleminault C. Obstructive sleep apnoea syndrome. A review of 306 consecutively treated surgical patients. *Otolaryngol Head Neck Surg* 1993;**108**:117–25.
2. Mezzanotte WS, Tangel DJ, White DP. Waking and sleeping upper airway muscle activity in apnoea patients versus normal controls. *Am J Respir Crit Care Med* 1996;**153**:1880–7.
3. Kobayashi I, Perry A, Rhymer J, Wuyam B, Hughes P, Murphy K, Innes JA, McIvor J, Cheesman AD, Guz A. Inspiratory coactivation of the genioglossus enlarges retroglossal space in laryngectomized humans. *J Appl Physiol (1985)* 1996;**80**:1595–604.
4. Tangel DT, Mezzanotte WS, White DP. Influence of sleep on tensor palatini EMG and upper airway resistance in normal men. *J Appl Physiol (1985)* 1991;**70**:2574–781.
5. White DP. Pathogenesis of obstructive and central sleep apnoea. *Am J Respir Crit Care Med* 2005;**172**:1363–70.
6. Malhotra A, Trinder J, Fogel R, Stanchina M, Patel SR, Schory K, Kleverlaan D, White DP. Postural effects on pharyngeal protective reflex mechanisms. *Sleep* 2004;**27**:1105–12.
7. Mezzanotte WS, Tangel DJ, White DP. Waking genioglossal electromyogram in sleep apnoea patients versus normal controls (a neuromuscular compensatory mechanism). *J Clin Invest* 1992;**89**:1571–9.
8. Santos Junior JF, Abrahão M, Gregório LC, Zonato AI, Gumieiro EH. Genioplasty for genioglossus muscle advancement in patients with obstructive sleep apnea–hypopnea syndrome and mandibular retrognathia. *Braz J Otorhinolaryngol* 2007;**73**:480–6.
9. García Vega JR, de la Plata MM, Galindo N, Navarro M, Díez D, Láncara F. Genioglossus muscle advancement: a modification of the conventional technique. *J Craniomaxillofac Surg* 2014;**42**:239–44.
10. Donovan L, Boeder S, Malhotra A, Patel S. New developments in the use of positive airway pressure for obstructive sleep apnea. *J Thorac Dis* 2015;**7**:1323–42.

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