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ORIGINAL ARTICLE CRANIOFACIAL/MAXILLOFACIAL

Effects of Hat-Shaped Mortised Genioplasty with Genioglossus Muscle Advancement on Retrogenia and Snoring: Assessment of Esthetic, Functional, and Psychosocial Results

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Abstract

Background An increasing number of patients undergo genioplasty for esthetic purposes to correct micrognathism or retrognathism. However, these conditions are considered an important risk factor for snoring. The purpose of this study was to evaluate both esthetic improvement and functional changes of snoring symptoms in patients who underwent hat-shaped mortised advancing genioplasty with genioglossus muscle advancement.

Materials and Methods This retrospective study enrolled 25 patients. We evaluated scores for subjective snoring classification (Stanford scale) and questionnaire findings for esthetic results.

Results Most people (96%) were satisfied with the esthetic improvement after surgery. The grade of subjective snoring classification (Stanford scale) improved from 8.68 (range 0–10) to 4.08 (range 0–10) after surgery. Twenty-four patients had an improved snoring grade. All patients reported a positive impact on their daily activity and self-confidence, and they were willing to recommend the same operation to someone with the same clinical problems.

Conclusion We conclude that hat-shaped mortised advancing genioplasty with genioglossus muscle advancement can relieve the symptoms of snoring for patients with hypoplastic chin or retrogenia. Patients were satisfied with the functional and esthetic results.

Level of Evidence IV This journal requires that authors assign a level of evidence to each article. For a full description of these Evidence-Based Medicine ratings, please refer to the Table of Contents or the online Instructions to Authors www.springer.com/00266.

Keywords Retrogenia · Snoring · Genioplasty · Genioglossus advancement

Introduction

In East Asia, a small and slightly backward mandible has been recognized as an esthetically pleasant facial feature. However, patients with a severe degree of mandibular retrognathism or micrognathism seem to have unsatisfactory esthetics. They lose the cervico-mental angle and can have a double-chin appearance. In these patients, advancement genioplasty can achieve esthetic improvement.

As well as esthetic problems, dento-facial deformities such as severe mandibular retrognathism and micrognathism are considered an important risk factor for progression of simple snoring to obstructive sleep apnea syndrome (OSAS). Mandibular retrognathism may be a factor responsible for the reduction in posterior airway space (PAS) and reduction in distance between the hyoid bone and mandibular plane causing hypopharynx obstruction [1, 2]. The ultimate cause of these sleep disorders is collapse of pharyngeal walls during sleep due to a failure of dilator muscle activity in terms of position and muscle tone [3]. One of the important dilator muscles for pharyngeal

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patency is the genioglossus muscle [3], which effects tongue protrusion that prevents pharyngeal collapse when the tongue moves into a posterior position [4]. Mezzanotte et al. [5] found that genioglossus activity may be lost during sleep, leading to airway collapse in patients with snoring or OSAS. Therefore, advancement of the mandible and stretching of the genioglossus muscle under proper tension, decreasing the tongue's ability to prolapse into the airway, represents a useful treatment for snoring [6, 7].

The author performed hat-shaped mortised genioglossus advancing genioplasty with genioglossus muscle advancement at the same time for patients who visited to undergo advancing genioplasty for retrogenia, especially for patients with snoring problems. The advancing genioplasty was performed to achieve an esthetic goal and at the same time genioglossus muscle advancement has a functional effect of widening the posterior space to reduce snoring.

The purpose of this study was to evaluate both esthetic and functional changes using the Stanford scale of subjective snoring [8, 9] and questionnaire [10] in 25 patients who underwent hat-shaped mortised genioglossus advancing genioplasty.

Patients and Method

After approval by the institutional ethical review board, this retrospective study was conducted as a chart review and questionnaire survey. Forty patients underwent hat-shaped mortised genioglossus advancing genioplasty by a single surgeon between 2016 and 2017.

All patients complained of perceiving their face to be unattractive due to retrogenia and snoring problems. The patients with orthognathic problems such as malocclusion were excluded, because they needed further evaluations such as the cephalometric analysis, more complicated operation like maxillo-mandibular advancement and orthognathic treatment after surgery to correct their problems. The patients with events of apnea during sleep were excluded. The author referred them to the specialist for thorough examinations. Also, exclusion criteria included patients who underwent previous genioplasty for esthetic purpose or previous surgery for treatment of snoring or OSAS. Obese patients with BMI > 25 kg/m^2 were also excluded.

In other words, among the patients with retrogenia visiting for a pure esthetic purpose, the subjects of this study were the patients who happened to notice the snoring symptoms by chance.

We analyzed demographic and clinical characteristics including radiographic examination consisting of standard cephalogram, panoramic radiography, and facial CT scan. We evaluated scores for subjective snoring classification (Stanford scale) [8, 9] and questionnaire [10] findings for esthetic results.

Operative Technique

All performed operations were hat-shaped mortised genioplasty as previously described by Hendler et al. [11]. An intraoral incision in the mucosa of the lower gingivolabial sulcus and subperiosteal dissection are performed as in conventional genioplasty. The upper osteotomy line is marked between canines approximately 5 mm inferior to the root apices of incisors. This osteotomy line must be designed to contain the maximum lingual surface of genioglossus muscle attachment for advancement yet avoiding potential damage to the apices of incisors. The upper osteotomy line is then carried inferiorly, slanting laterally approximately 20° and continuing to the lower osteotomy line. The lower osteotomy line is marked lateral to the canines at least 5 mm inferior to the mental foramen not to injure the inferior alveolar nerve (Fig. 1). A reciprocating bone saw is used for full thickness osteotomies. Osteotomy starts from the lateral border of the lower osteotomy line to the canine and then goes upward to the upper osteotomy line. Upper osteotomy lines from both sides are connected at the symphysis to mobilize the segment for repositioning.

The bone segment, including the anterior insertion of the genioglossus muscle, is released and gently advanced to suit the profile, avoiding detachment of the muscle from the bone. These procedures are thereby advancing the genioglossus muscle. A 2.3-mm x-shaped titanium plate is adapted, and four screws are used to stabilize the bone

Fig. 1 Osteotomy line design on the mandible. The upper osteotomy line is marked between canines approximately 5 mm inferior to the root apices of incisors. The upper osteotomy line is then carried inferiorly, slanting laterally approximately 20° and continuing to the lower osteotomy line. The lower osteotomy line is marked lateral to the canines at least 5 mm inferior to the mental foramen to avoid inferior alveolar nerve injury

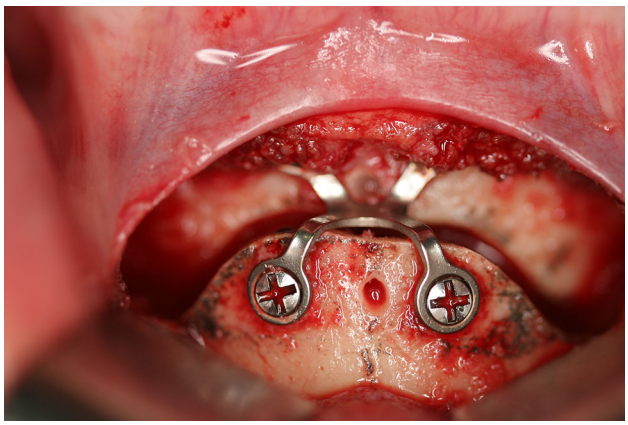

Fig. 2 Fixation of the bone segment. A 2.3-mm x-shaped titanium plate is adapted, and four screws are used to stabilize the bone segment

segment (Fig. 2). Complimentary wiring can be applied for stability. The mentalis muscles are reattached with 3–0 resorbable sutures, and the mucosa is closed with 3–0 resorbable sutures.

Questionnaire

The questionnaire [10] contained 13 questions. Two questions were related to snoring. We used the Stanford subjective snoring scale [8, 9] to evaluate subjective improvement in snoring (Table 1). Four questions were related to esthetic outcome, and three questions were related to possible complications.

PATIENT QUESTIONNAIRE

Esthetic and Surgical Outcome

1. Are you satisfied with protrusion of your chin after surgery?
   5. very much 4. very 3. rather 2. a little 1. not at all
2. Can you feel an objectionable palpable jaw line or bony step caused by the operation?
   5. not at all 4. a little 3. rather 2. very 1. very much
3. Do you feel any visible deformity caused by the operation?
   5. not at all 4. a little 3. rather 2. very 1. very much
4. Do you feel an improvement in the final shape of your face after surgery?
   5. very much 4. very 3. rather 2. a little 1. not at all

Complication: *Numbness*

1. Did you experience numbness in the lower lip after the operation?(Yes/No)
2. If yes, how long did it last? (_____)
3. Did the postoperative numbness cause any inconvenience or influence your daily activities?
   5. not at all 4. a little 3. rather 2. very 1. very much

Complication: *Tooth pain*

1. Did you experience the tooth pain after surgery?(Yes/No)
2. If yes, how long did it last? (_____)
3. Did tooth pain cause any inconvenience or influence your daily activities?
   5. not at all 4. a little 3. rather 2. very 1. very much

Complication: *Mouth closing*

1. Did you notice a decrease in mouth closing ability?(Yes/No)
2. If yes, how long did it last? (_____)
3. Did the decreased chewing ability cause any inconvenience or influence your daily activities?

5. not at all 4. a little 3. rather 2. very 1. very much

Functional Outcome

1. How is your snoring grade before surgery according to the subjective snoring classification?
   0 (no snoring) 1 2 3 4 5 6 7 8 9 10 (partner leaves the room)
2. How is your snoring grade after surgery according to the subjective snoring classification?
   0 (no snoring) 1 2 3 4 5 6 7 8 9 10 (partner leaves the room)

Psychosocial Benefits

1. Has the operation had a positive influence on your daily activity?
   5. very much 4. very 3. rather 2. a little 1. not at all
2. Has the operation had a positive influence on your self-confidence?
   5. very much 4. very 3. rather 2. a little 1. not at all

General Outcome

1. Would you undergo the same operation again?
   5. very much 4. very 3. rather 2. a little 1. not at all
2. Would you recommend this operation to friends with the same clinical problem?
   5. very much 4. very 3. rather 2. a little 1. not at all

Results

Forty patients were administered the questionnaire (Table 2). Among 40 patients, 25 patients completed the questionnaire for a response rate of 62.5%. Of the 25 patients, 12 were male and 13 were female and mean patient age was 25.28 years old (range 18–39 years). The

Table 1 Scale of subjective snoring (Stanford)

Grade	0	1–3	4–6	7–9	10
Classification	No snoring	Mild	High	Very high	Intense

0 = no snoring; 1–3 = mild (does not disturb the partner during sleep); 4–6 = high (enough to disturb the partner); 7–9 = very high (disturbs people in other rooms); 10 = intense (the partner leaves the room)

Table 2 Baseline characteristics

No.	Sex	Age (years)	Height (cm)	Weight (kg)	Body mass index (kg/m^2)	Smoking	Comorbidity
1	M	26	182	81	24.45	N	N
2	M	35	164	60	22.31	N	Rhinitis and sinusitis
3	F	20	158	50	20.03	N	N
4	M	22	172	56	18.93	N	N
5	M	25	178	72	22.72	N	N
6	M	18	164	51	18.96	N	N
7	F	21	158	48	19.23	N	N
8	F	22	157	50	20.28	N	Sinusitis
9	M	21	184	66	19.49	N	N
10	M	31	173	68	22.72	Y	N
11	F	21	156	50	20.55	N	Sinusitis
12	F	20	162	54	20.58	N	N
13	M	24	176	76	24.54	N	N
14	F	26	156	52	21.37	N	N
15	M	25	170	58	20.07	N	N
16	M	26	177	76	24.26	N	N
17	F	28	152	52	22.51	N	N
18	F	28	153	50	21.36	N	N
19	F	23	153	53	22.64	N	N
20	F	22	174	58	19.16	N	N
21	M	32	172	68	22.99	Y	N
22	F	36	171	58	19.84	N	N
23	M	22	180	76	23.46	N	N
24	F	19	165	58	21.30	N	N
25	F	39	172	54	18.25	Y	N

mean body mass index (BMI) was 21.28 kg/m^2 (range 18.25–24.54 kg/m^2).

The mean time of surgery was 29.4 min. Mean mandibular advancement was 8.8 mm (range 6–10 mm) after genioplasty. Preoperative and postoperative CT images and gross photographs are presented in Figs. 3 and 4.

The mean score for satisfaction with esthetic improvement was 4.64 (range 2–5). Eleven patients (84%) gave a higher rating for satisfaction with their facial appearance postoperatively, three patients (12%) were rather satisfied, and one patient (4%) was a little satisfied with the result. Five patients (20%) felt a palpable jaw line, and four patients (16%) felt the visible deformity of the mandible. Complications such as numbness, tooth pain, and mouth movement disorder were not reported.

The subjective snoring (Stanford scale) grade was 8.68 (range 0–10) before surgery and 4.08 (range 0–10) after surgery. Twenty-four patients exhibited improved snoring grade. All patients had a positive influence on their daily activity and self-confidence, and they were willing to recommend the same operation to someone with the same clinical problems (Table 3).

Discussion

In East Asia, a slender and oval-shaped lower face is considered beautiful and harmonious. The chin has various manifestations, including receding, short, and broad forms. Given its prominence, the chin has an important role in facial esthetics [12]. As the importance of lower chin contour has been emphasized, genioplasty is commonly performed to alter the masculine appearance of a face into a more feminine one for esthetic reasons [13]. Many variations of osteotomy of the mandible may be adopted to meet the individual's esthetics needs [14]. For esthetic improvement, there are a wide range of approaches to genioplasty, such as sliding genioplasty, lengthening genioplasty, narrowing genioplasty, and advancing genioplasty [12]. Hofer [15] first described a sliding osseous genioplasty using submental incision in 1942. Trauner and

Fig. 3 Preoperative and postoperative gross photographs. **a**, **b** Preoperative photographs, **c**, **d** postoperative photographs

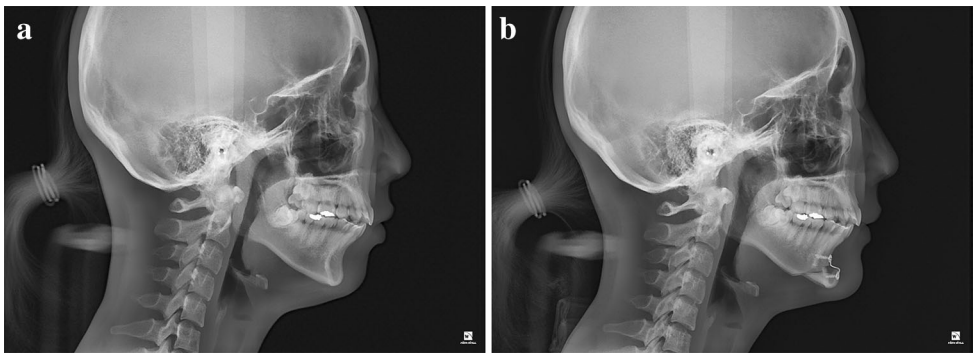

Fig. 4 Preoperative and postoperative X-ray lateral profile images. **a** Preoperative image, **b** postoperative image

Obwegeser [16] used an intraoral incision in their description of horizontal osteotomy for genioplasty. The mortised genioplasty, described by Hendler et al. [11], allows for advancement of the genioglossus muscle as well as the digastric, mylohyoid, and geniohyoid muscles. This technique uses a rectangular box that contains the genioglossus muscle attachment with the inferior aspect of the box extended laterally to well beyond the mental foramen [11].

There are an increasing number of patients who seek surgery for purely esthetic purposes. However, these procedures can also lead to functional improvements such as the correction of sleep apnea related to receding chin structure [17]. Retrognathism is the most important risk factor in patients with non-obese obstructive sleep apnea syndrome. A receding mandible leads to narrowing of the retroglossal area (velopharynx), the critical area of airway obstruction. Snoring during sleep is mainly caused by narrowing of the retroglossal area. Snoring is observed in most patients (90–95%) with OSAS, and increased frequency or intensity of snoring can indicate worsening OSAS [18].

The genioglossus muscle has an important anatomical role in snoring and OSAS. The genioglossus muscle originates from the genial tubercle of the mandible, and inserts at the tip of the tongue, dorsum of the tongue, and into the body of the hyoid bone. The genioglossus acts as a pharyngeal dilator by stiffening during inspiration. However, its muscle tone decreases during sleep, potentially leading to obstruction [19, 20]. Advancement of the mandible places the genioglossus under tension, thereby decreasing the tongue's ability to prolapse into the airway [7]. The end result is increased diameter of the oro- and hypopharyngeal airway, which allows for more efficient airflow during sleep [21]. Many surgeons have performed orthognathic surgery such as maxillo-mandibular advancement for patients suffering sleep disturbance who are diagnosed as OSAS [6, 22–24].

In this study, the author performed hat-shaped mortised advancing genioplasty with genioglossus muscle

Table 3 Subjective data for patients who completed the questionnaires

No.	Esthetic and surgical outcome				Complication			Functional outcome		Psychosocial benefits		General outcome	
	1	2	3	4	Numbness	Tooth pain	Mouth closing	1	2	1	2	1	2
1	5	5	5	5	N	N	N	5	0	5	5	2	2
2	5	5	5	5	N	N	N	10	2	5	5	5	5
3	5	5	5	5	N	N	N	8	3	3	3	3	3
4	5	5	5	5	N	N	N	10	3	5	5	3	3
5	5	5	5	5	N	N	N	7	7	3	3	3	3
6	5	5	5	5	N	N	N	10	2	5	5	5	5
7	2	2	3	2	N	N	N	0	0	2	2	2	2
8	5	5	5	5	N	N	N	10	6	5	5	5	5
9	5	4	5	5	N	N	N	10	1	5	5	5	5
10	5	5	5	5	N	N	N	7	5	4	4	4	4
11	5	5	5	5	N	N	N	10	5	5	5	5	5
12	5	5	5	5	N	N	N	10	3	5	5	5	5
13	5	5	5	5	N	N	N	10	8	2	2	3	3
14	5	5	5	5	N	N	N	8	1	4	5	5	5
15	5	5	5	5	N	N	N	10	2	5	5	3	3
16	5	5	5	5	N	N	N	10	7	2	2	3	3
17	5	5	5	5	N	N	N	8	2	4	5	5	5
18	5	5	5	5	N	N	N	8	5	3	3	3	3
19	5	5	5	5	N	N	N	10	2	5	5	5	5
20	3	3	3	3	N	N	N	8	7	3	3	3	3
21	5	5	5	5	N	N	N	10	8	5	5	5	5
22	3	3	3	3	N	N	N	8	6	3	3	3	3
23	5	5	5	5	N	N	N	10	10	3	3	3	3
24	5	5	5	5	N	N	N	10	2	5	5	5	5
25	3	3	3	3	N	N	N	10	5	3	3	3	3

advancement to advance not only the chin to correct microgenia or retrogenia but also the genioglossus muscle to improve snoring. The authors have performed hat-shaped mortised advancing genioplasty with genioglossus muscle advancement for patients to correct the microgenia or retrogenia for esthetic purposes. Among these patients, functional and esthetic outcomes before and after surgery were compared in patients with normal BMI and who snored during sleep but were not diagnosed with OSAS. To rule out other factors that may affect snoring other than microgenia or retrogenia, patients with a BMI of 25 or higher, patients with hypertension or diabetes, and those who had previously been diagnosed and treated surgically to correct snoring or OSAS were excluded from this study.

During hat-shaped mortised advancing genioplasty with genioglossus muscle advancement, the amount of chin advancement is directly related to the amount of genioglossus muscle advancement, which is related to improvement of snoring symptoms [19–21]. In determining the amount of advancement, the author focused more on the esthetic point of view to achieve the ideal profile than the functional aspect to improve snoring. As a result, all patients were satisfied with esthetic improvement.

No complications were observed. Deformities, visible or palpable bony step, were observed in the 36% of the patients. However, the degree of deformity was mild, and no patients wanted to correct the deformity through reoperation. In addition, 88% of patients who underwent hat-shaped mortised advancing genioplasty with genioglossus muscle advancement had improved snoring symptoms. The overall improvement of snoring symptoms was an average of 4.6 on the Stanford scale. In cases with 6-mm advancement of mandible, improvement was only 1.4. In other words, the less genioglossus muscle advancement, the less improvement in snoring symptoms.

Hat-shaped mortised advancing genioplasty with genioglossus muscle has benefits including short operative time and can improve the esthetic profile and snoring

symptoms at the same time. Patients can be discharged from the hospital on the day of surgery and resume normal activities immediately. With caution, serious complications requiring reoperation can be avoided through preoperative planning and counseling. It also may be combined with other procedures for rejuvenation such as submental liposuction or face lift, which improves rejuvenation in the submental area.

This study had several limitations. First, cephalometric analysis is a useful diagnostic tool available for precise quantitation in the planning of variable surgeries for craniofacial bone. Virtual surgical planning, based on current computed tomography and advanced software, enables to measure precisely and plan the surgical movement in three dimensions. However, this study lacks the quantitative analysis, including cephalometric analysis, for surgical movement of the mandible before and after surgery. Second, the evaluation tools of snoring symptoms depend on a questionnaire based on the patient's subjective feelings. Because patients sought surgery for esthetic purposes and they did not complain of sleep disturbance, we identified snoring symptoms only from questionnaires. Objective evaluation methods, such as polysomnography were not implemented and compared.

Conclusion

We conclude that hat-shaped mortised advancing genioplasty can relieve the symptoms of snoring for patients with hypoplastic chin or retrogenia. Patients were satisfied with the functional and esthetic outcomes. Further study on the quantitative analysis on correlation between hat-shaped mortised advancing genioplasty and relief of the snoring symptom of obstructive sleep apnea disorder is useful.

Compliance with Ethical Standards

Conflict of interest The authors have no potential conflicts of interest with respect to the research, authorship, and publication of this article to declare.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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