Facial Surgery

Does Aesthetic Osseous Genioplasty Impact Upper Airway Volume?

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Abstract

Background: Although maxillomandibular advancement is the treatment of choice for obstructive sleep apnea syndrome (OSAS) in the presence of underlying maxillomandibular complex hypoplasia, there is still a gap in the literature regarding the impact of genioplasty upon upper airway volume (UAV).

Objectives: The aim of this study was to evaluate the impact of isolated osseous genioplasty upon UAV.

Methods: A retrospective analysis of all patients subjected to isolated osseous genioplasty between July 2015 and July 2022 was conducted. Cone-beam computed tomography was performed preoperatively and postoperatively to assess the chin and hyoid 3-dimensional (3D) spatial position and UAV changes after surgery.

Results: A total of 44 patients were included in the study. Regarding surgical movements of the chin, almost all patients received a sagittal movement ($n = 42$; 39 forward and 3 backward), while in 8 patients a vertical movement (5 upward and 3 downward) was applied, and in 6 patients the chin was centered. Statistically significant increases in total UAV ($P = .014$) and at the level of the oropharynx ($P = .004$) were observed. Specifically, chin centering, upward and forward movements enlarged the oropharynx volume ($P = .006$, .043 and .065, respectively). Chin advancement enlarged the hypopharynx volume ($P = .032$), as did upward movement of the hyoid bone ($P < .001$).

Conclusions: Results of the study suggest that aesthetic osseous genioplasty impacts the UAV: each 3D spatial chin movement differently impacts the upper airway by enlarging or narrowing it. However, further studies addressing the apnea-hypopnea index are required to assess its effectiveness in treating OSAS.

Level of Evidence: 4

4
Therapeutic

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Obstructive sleep apnea syndrome (OSAS) is the most frequent sleep-related breathing disorder. It is characterized by pauses in breathing during sleep that last at least 10 seconds, with a consequent decrease in arterial oxygen saturation of more than 3%. These pauses can be complete (apnea: >90% decrease in airflow) or partial (hypopnea: >30% decrease in airflow).[1-4] Pathophysiological causes of OSAS include upper airway (UA) anatomy, the ability of the UA dilator muscles to respond to respiratory challenge during sleep, the propensity to awaken from increased respiratory drive during sleep (arousal threshold), the stability of the respiratory control system (loop gain), and the potential for state-related changes in lung volume.[5-7]

The direct consequences of the respiratory collapse are intermittent hypoxia and hypercapnia, with increased respiratory effort leading to secondary sympathetic activation, oxidative stress, and systemic inflammation.[8] It is currently recognized by the scientific community that sleep and sleep quality are fundamental to preventing decreased quality of life.[1,9]

Benjanfield et al, following the American Academy of Sleep Medicine 2012 (AASM) diagnostic criteria and apnea-hypopnea index (AHI) threshold values, reported that approximately 12% (903-970 million) of adults (males and females) worldwide ages 30 to 69 years suffer from OSAS (mild to severe), and that approximately 5% (399-450 million) adults worldwide ages 30 to 69 years have moderate to severe OSAS.[9]

Maxillomandibular advancement (MMA) has been described as the treatment of choice for OSAS in the presence of underlying maxillomandibular complex hypoplasia.[10,11] Recent meta-analyses have evidenced that advancement and counterclockwise rotation of the maxillomandibular complex, together with genioplasty when required, significantly increase upper airway volume (UAV) and decrease the AHI.[10,12]

However, there is still a gap in the literature regarding the role of isolated genioplasty for UAV enlargement. Chin advancement involves forward movement of the genial tubercles, which leads to hyoid bone pulling. Because the hyoid bone is a mobile structure anchored to both the pharyngeal wall and to mandibular anatomical structures exerting a pulley function between them, this structure assumes a major role in widening the UAV when hyoid-mandibular muscles are straightened.[12] This consequently leads to possible increased UAV and eased airflow. In the same context, backward movement of the chin could narrow the UAV.[13]

The aim of this study was to evaluate the impact of aesthetic osseous genioplasty upon the UAV in patients undergoing isolated genioplasty. Specifically, the objectives were to correlate the magnitude and direction of the skeletal movements of the chin with the hyoid bone position and the 3-dimensional (3D) changes of the UAV (the oropharynx, nasopharynx, and hypopharynx). The authors hypothesized that each surgical movement during genioplasty would impact the UAV differently, through enlarging or narrowing it, and at different levels of the airway.

METHODS

Study Design and Inclusion Criteria

A retrospective analysis was conducted at our department in patients who underwent isolated aesthetic osseous genioplasty between July 2015 and July 2022, evaluating the changes in their chin and hyoid 3D spatial position and the UAV.

Inclusion criteria were age > 18 years; good systemic health (ASA score I or II); completed growth of the maxillofacial complex; attendance at all follow-up visits; and availability of preoperative and postoperative cone-beam computed tomography (CBCT) scans.

The following were regarded as exclusion criteria: patients subjected to simultaneous orthognathic surgery; surgical contraindication based on the patient medical history; any systemic disease capable of compromising bone healing; congenital anomalies; patients failing to attend all follow-up visits; and the lack of some required CBCT evaluation.

The study was approved by the Ethics Committee of Teknon Medical Centre (Barcelona, Spain; ref. 2022/77-MAX-CMT) and was conducted in accordance with the ethical standards laid down in the Declaration of Helsinki (1964 and later amendments).

The sample size was calculated to detect significant changes of mild effect ($d = 0.5$) with a statistical power of 80% and 95% confidence level for the paired samples *t*-test. Size was also tested to detect moderate correlations ($r = 0.5$) with a power of 80%.

Treatment Protocol

All patients followed the standard preoperative and postoperative imaging workflow for chin surgery of the department. This involved photographic records and CBCT registration at 2 time points: preoperatively (T0) and postoperatively at 6 to 12 months of follow-up (T1).

The CBCT scans were performed with a standardized scanning protocol (i-CATTM; Imaging Sciences International, Inc., Hatfield, PA). Patients were instructed to sit upright and position themselves in natural head position looking straight ahead. They were asked to rest the tongue in a relaxed position, breathe slightly, and avoid any other motor reaction. The original and duplicate DICOM (Digital Imaging and Communications in Medicine) data sets were exported to the Dolphin Imaging 3D version 11.8 software (Dolphin Imaging & Management Solutions, Chatsworth, CA). Files were automatically recognized by the program, and each

Figure 1. Advancement osseous genioplasty intraoperative photograph of a 28-year-old male patient.

Figure 2. Preoperative and 6-month postoperative facial photographs of a 42-year-old male patient who underwent 10-mm advancement genioplasty. The cone-beam computed tomography airway volumes were 34279 mm^3 preoperatively and 37461 mm^3 postoperatively.

pair of DICOM sequences was saved independently (as 2 different studies) for each corresponding patient.

Surgical Planning

Presurgical 3D virtual planning was performed to assess the proper dimensions of the chin. The author's reference was tracing a rectangular angle between the bony chin and the occlusal plane to guide anteroposterior positioning of the chin. In addition, a proper labiomental fold was considered, being ~4 mm in males and 6 mm in females, which also depended on the underlying dental support.[14,15] Chin asymmetries were also corrected. Regarding the transverse dimension, males looked for a square and wider chin (interpupillary length) that may have 2-point light reflection. Females, on the other hand, tended to prefer narrower chins (intercanthal length) with a single-point light reflection in the middle.[16] The vertical dimension varied depending on ethnicity, though the height of the lower-third of the face should be equal to the upper and middle thirds.

Surgical Procedure

Surgery was performed under local anesthesia and sedation by F.H.A. and A.V.O. The incision extended from canine-to-canine 5 mm below the keratinized mucosa. Subperiosteal dissection was limited to the osteotomy line and area of osteosynthesis placement, though localization of the mental foramen and dental roots was also carried out. The muscular insertion at the mandibular internal cortical bone was preserved to maintain vascularization of the osteotomized segment and muscular traction of the genioglossal muscle. Then, 3 vertical lines were sawed as reference lines in the transverse plane. A horizontal osteotomy was designed and performed at least 5 mm below the mental foramens and roots of canines with a reciprocating saw. Then the osteotomy was finalized with an osteotome. When required for height reduction purposes, a second parallel osteotomy was performed, and a bony slice was taken out. When modification of the transverse dimension of the chin was planned, a vertical osteotomy was performed for widening or narrowing purposes.

Once the osteotomies were completed, the free anteroinferior segment of the chin was mobilized freely while maintaining the genioglossal, geniohyoid, and digastric muscles attached to it. Finally, the mobile chin was positioned and fixed as previously planned with a pre-blended miniplate and 4 monocortical screws (OsteoMed, Dallas, TX) (Figure 1). Suprahyoid muscle repositioning was carried out by suturing the muscles over the osteosynthesis hardware, and resuspension of the mentalis muscles was mandatory before wound closure.

The postoperative visit included a clinical examination, the assessment of complications, CBCT, and photographic records (Figures 2, 3).

Study Variables

For study purposes, preoperative and postoperative CBCT scans were superimposed to evaluate 3D spatial chin and hyoid modifications, as well as UAV changes. Data were primarily saved in DICOM format with 3D software. The software orientation calibration tool was utilized along pitch (*x*), yaw (*y*) and roll (*z*). Orientation of both the base volume (original DICOM) and second volume (duplicate DICOM) was undertaken to achieve the same original positions of the CBCT scans.

The following preoperative and postoperative CBCT landmarks and angular and volumetric measurements were analyzed for study purposes: changes in 3D spatial position of B point, pogonion (Pog), and hyoid bone,

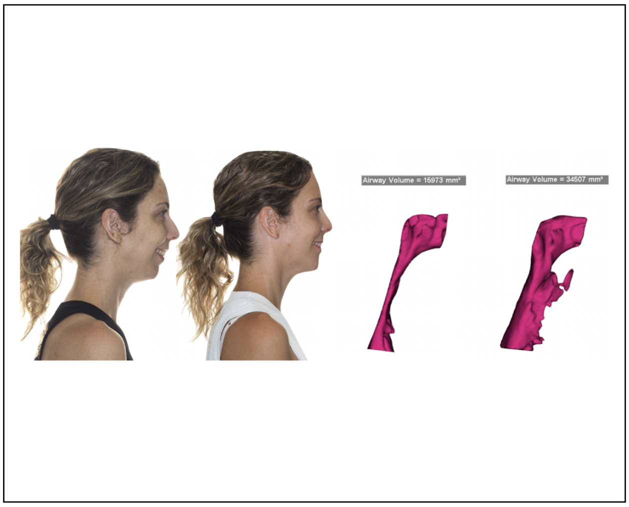

Figure 3. Preoperative and 6-month postoperative facial photographs of a 36-year-old female patient who underwent 9-mm advancement and 4-mm upward genioplasty, with the respective cone-beam computed tomography airway volumes.

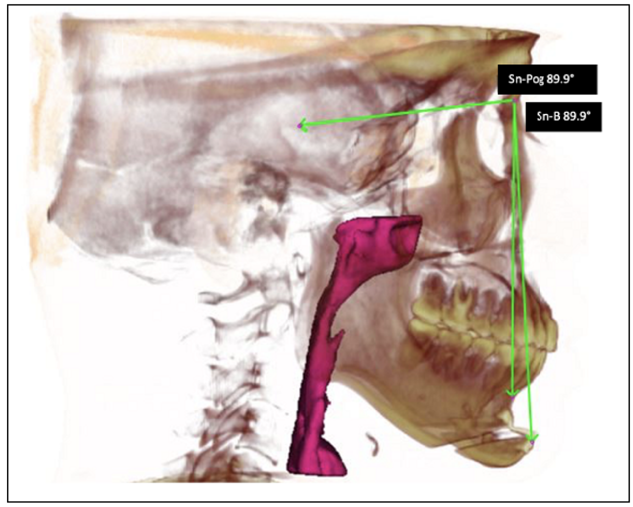

Figure 4. Cone-beam computed tomography that shows study measurements: airway volumetry, sella-nasion B point (Sn-B), sella-nasion-pogonion (Sn-Pog) and mandibular occlusal plane angles, and hyoid bone, B point and pogonion 3-dimensional spatial position.

sella-nasion-pogonion (SNPog), mandibular occlusal plane (MOP: line through upper first molar cuspid and upper incisor and true vertical line through nasion), and UAV (total, hypopharynx, oropharynx, and nasopharynx) (Figure 4).

Data referring to demographics (gender and age) and postoperative complications (wound dehiscence with bone exposure, bleeding, infection, and need for removal of the osteosynthesis fixation) were also acquired.

Statistical Analysis

The data were analyzed with the SPSS version 22.0.0 (IBM Corp., Armonk, NY) statistical package. A normality test in the form of the Kolmogorov-Smirnov test confirmed normal distribution of the data. Therefore, for comparisons of skeletal and volumetric values, a paired *t* test was applied. Correlations between volumetric and skeletal changes were assessed with the Pearson correlation coefficient. Finally, an unpaired *t* test and the nonparametric Mann-Whitney *U*-test and Kruskal-Wallis test were performed to evaluate volumetric changes according to facial profile and genioplasty movement. Statistical significance was considered for $P < .05$.

RESULTS

A total of 44 patients who underwent isolated osseous genioplasty were included in the study. There were 31 females (70.5%) and 13 males (29.5%), with a mean age of 33.4 ± 8.4 years (range 18-48). Preoperatively, 47.7% of the patients were diagnosed with dentofacial deformity class I, 38.6% with orthodontically compensated class II, and 13.6% with orthodontically compensated class III. The mean follow-up time was 9 months (range: 6-12 months).

Regarding surgical movements of the distal segment of the chin, almost all the patients received a sagittal movement ($n = 42$; 39 forward and 3 backward); in 8 patients a vertical movement (5 upward and 3 downward) was applied; and in 6 patients the chin was centered (Figure 5). Specific 3D mean surgical movements are summarized in the Table 1. Although significant 3D positional changes in skeletal landmarks (B point, Pog and hyoid bone) were observed, there were no significant changes in MOP. The most clinically relevant lineal changes were: a mean sagittal Pog advancement of 4.24 ± 19.6 mm, a mean Pog vertical descent of 4.69 ± 12.3 mm ($P = .015$), and a mean hyoid bone vertical ascent of 1.78 ± 17.9 mm.

The results showed that the total airway size increased significantly from T0 to T1 (+9.89%) (mean: 2817 ± 7256 mm^3, $P = .014$), as did the oropharynx (+16.8%) (2778.8 ± 6026 mm^3, $P = .004$). A nonsignificant trend to increase the nasopharynx volume was recorded (+6.81%) (443.6 ± 1734.3 mm^3, $P = .097$), whereas volumetric permanence was admitted for the hypopharynx (−7.56%) (−404.9 ± 2122.7 mm^3, $P = .210$). It is important to highlight that in the 5 cases in which chin advancement was not performed (3 backward and 2 nonsagittal movement), the volume was always reduced (Figure 6).

On considering specific skeletal movements, chin centering significantly increased the oropharyngeal and total airway volumes (median = 8420 mm^3, $P = .006$; and median = 8651 mm^3, $P = .007$, respectively); upward movement

Table 1. Summary of Skeletal Dimensions and T1 – T0 Changes.

	T0	T1	T1 – T0	CI 95%	*P* value
	(mm)	(mm)	(mm)	(mm)	
Point B *x*	−4.89 ± 4.95	−5.26 ± 5.75	−0.38 ± 5.20	−1.96 to 1.20	.633
Point B *y*	−24.0 ± 43.1	−23.0 ± 44.9	0.95 ± 17.8	−4.46 to 6.36	.725
Point B *z*	70.8 ± 9.37	69.9 ± 8.34	−0.85 ± 11.2	−4.25 to 2.54	.615
Point B	—	—	15.6 ± 14.9	11.1 to 20.1	*P* < .001***
Pog *x*	−4.60 ± 5.18	−5.31 ± 5.93	−0.70 ± 4.97	−2.21 to 0.81	.354
Pog *y*	−32.0 ± 58.1	−36.2 ± 54.9	−4.24 ± 19.6	−10.2 to 1.73	.159
Pog *z*	71.1 ± 10.4	75.7 ± 8.97	4.69 ± 12.3	0.97 to 8.41	.015*
Pog	—	—	17.9 ± 16.5	12.9 to 22.9	*P* < .001***
Hyoid *x*	−4.46 ± 4.82	−5.10 ± 5.56	−0.64 ± 5.17	−2.21 to 0.93	.417
Hyoid *y*	−36.5 ± 61.3	−35.7 ± 61.7	0.72 ± 32.6	−9.19 to 10.6	.885
Hyoid *z*	27.7 ± 13.3	25.9 ± 10.7	−1.78 ± 17.9	−7.22 to 3.65	.512
Hyoid	—	—	23.2 ± 29.4	14.3 to 32.1	*P* < .001***
SNPog	75.5 ± 6.09	79.7 ± 4.87	4.20 ± 4.52	2.83 to 5.58	*P* < .001***
MOP	83.1 ± 4.99	83.8 ± 4.81	0.68 ± 3.93	−0.52 to 1.87	.261

Mean ± SD. Note that the *x* component represents the sagittal vector, the *y* component represents the vertical vector, and the *z* component represents the transverse (centering) vector. T1 – T0: arithmetic mean, repeated measures *t* test and 1-sample *t* test. **P* < .05; ****P* < .001. CI, confidence interval; MOP, mandibular occlusal plane; Pog, pogonion; SNPog, sella-nasion-pogonion; T1, postoperative; T0, preoperative.

increased the oropharynx ($r = 0.31$, $P = .043$); sagittal advancement showed a marginally significant correlation (trend) with oropharynx enlargement ($r = 0.28$; $P = .065$); and hyoid bone advancement was related to total airway volume enlargement ($r = 0.46$; $P = .002$) (Figure 7A). Furthermore, elevation of the hyoid bone promoted enlargement of the hypopharynx volume ($r = 0.54$; $P < .001$) (Figure 7B), whereas a negative correlation was observed between hypopharyngeal airway volume and downward Pog movement ($r = -0.32$; $P = .036$, respectively).

To quantify the number of millimeters of chin advancement, ascent, or centering that we had to carry out to obtain a significant increase in UAV, it was estimated that an increase of +8% in total UAV already reached statistical significance ($P < .05$). An increase of 8% corresponded to the additional 2280 mm^3 from an average baseline value such as that of the current sample. The results indicated that the following range of isolated 3D spatial movements would be required to obtain a significant increase of the UAV: 1 mm forward, 4.5 mm upward, and 2 mm centering.

In sum, the most relevant skeletal movements upon each airway area were: hypopharynx final volume depended on whether sagittal advancement was performed or not ($P = .032$) (Figure 7A); upward movement increased the oropharynx ($r = 0.31$, $P = .043$); forward movement tended to increase the oropharynx ($r = 0.28$; $P = .065$); and centering genioplasty impacted the oropharynx ($P = .006$) and total airway volume ($P = .007$) (Figure 8A, B).

DISCUSSION

As the initial working hypothesis of the authors, each surgical movement during genioplasty was considered to act differently upon each level of the upper airway. The results obtained in the present study evidence a statistically significant increase in total UAV ($P = .014$), and more specifically at the level of the oropharynx, after isolated osseous genioplasty ($P = .004$), which is in line with the published literature. Volumetric changes in the hypopharynx were also observed, though they were less predictable. Cabral et al found statistically significant differences in the size of the oropharynx and the positioning of the hyoid bone after advancement genioplasty; they concluded that the oropharynx increased in size, indicating improvement of the position of the tongue, and the hyoid bone moved forward on average, suggesting a change in the position of the larynx.[17] Chin advancement in the presented sample also

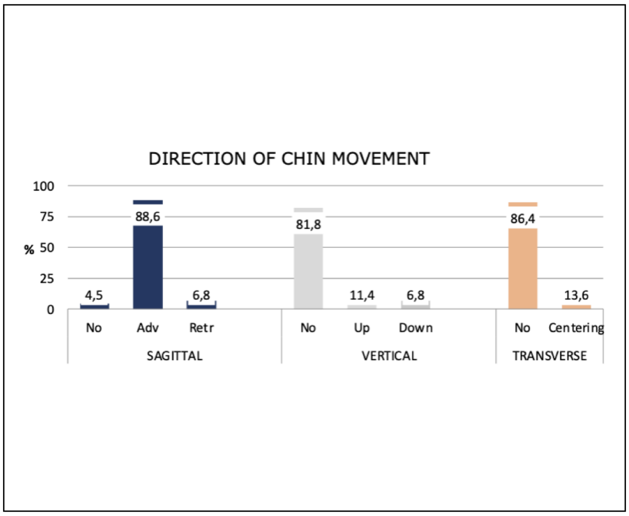

Figure 5. Description of the type of chin movements carried out during the genioplasty procedure. Adv, advance; Retr, retract.

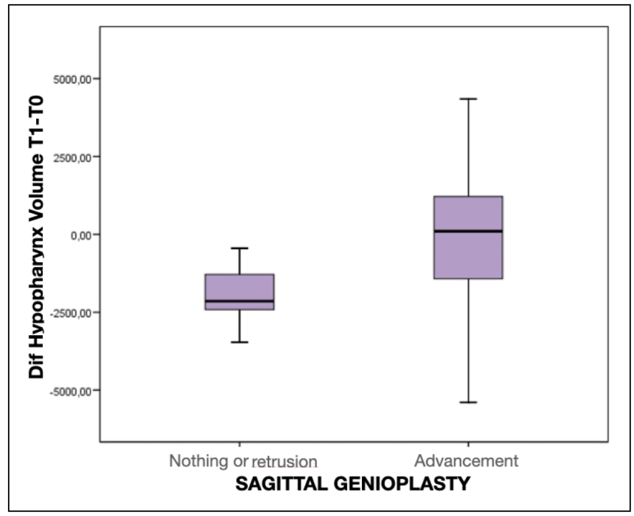

Figure 6. Box and whisker plot, in which the *y* axis represents changes in airway volume at the level of the hypopharynx, and the *x* axis represents the type of sagittal movement during genioplasty: advancement vs no sagittal movement or setback. This plot suggests that changes in the hypopharynx depend on whether advancement was performed or not ($P = .032$). Note that in all 5 cases in which no advancement was performed, the hypopharynx decreased. Dif, difference in; T1postoperative; T0 preoperative.

resulted in enlargement of the hypopharynx volume ($P = .032$), as Santos et al concluded in their study evaluating hypopharynx size after genioplasty alone.[18] It is important to highlight that our data evidence statistically significant advancement of B point, which a priori should not experience changes after genioplasty. The authors grant the changes due to the added osteosynthesis material volume. Additionally, in our study, the MOP did not change significantly ($P = .261$), because isolated genioplasty cannot modify the occlusal plane.

Regarding chin vertical movement, some patients underwent sole chin vertical reduction by means of a bony slice removal, which entailed upward repositioning of the genial tubercles, and therefore pulled the hyoid bone upward. However, downward movement of the chin jeopardized UAV ($P = .036$). Therefore, descending movement should be accompanied by concomitant chin advancement to compensate its impact upon the UAV when genioplasty alone is carried out. To our knowledge, this is the first study to evaluate the impact of transverse chin changes upon UAV, which became significant in the region of the oropharynx ($P = .006$).

The presented results have demonstrated that the upward and forward movements of the hyoid bone impact positively on the upper airway: while forward movement of the hyoid bone increased the hypopharynx volume ($P < .001$) and total UAV ($P = .002$) and was related to total airway volume enlargement ($r = 0.46$; $P = .002$) (Figure 7A), elevation of the hyoid bone promoted enlargement of the hypopharynx volume ($r = 0.54$; $P < .001$) (Figure 7B). Similarly, Goh et al reported that anterior displacement of the body of the hyoid bone and lateral displacement of the greater wing of the hyoid bone could expand both the oropharynx and the hypopharynx.[19] In this context, Chen et al proposed a modified cosmetic genioplasty in which the position of the hyoid bone moved up and forward and obtained enlargement of the total UAV and hypopharynx volume ($P = .001$).[20]

Song et al, in a meta-analysis, concluded that genioplasty alone can increase the pharyngeal airway space by an average of 3.2 mm.[21] However, because genioplasty is a 3D procedure in which the chin can be moved in the vertical, transverse, and sagittal planes, impacting the UAV 3-dimensionally and at all 3 levels, it is more appropriate to evaluate it also with a 3D imaging tool such as CBCT—which is a low-dose technique that allows adequate assessment of the skeletal points as well as of the UAV.[22,23]

The genioglossus muscle plays a major role in pharyngeal dilation both during sleep and wakefulness, and is implicated in the pathophysiology of OSAS.[24,25] Therefore, genioglossus advancement with hyoid bone upward positioning has been reported since 1993 as an option for the treatment of OSAS.[26] In this context, the cornerstone of the genioplasty procedure for UAV enlargement purposes is to maintain the integrity of the genial processes in the inner region of the chin to pull the hyoid bone forward and decompress the pharynx.[27]

Other chin surgeries have been described to enlarge UAV, such as sagittal osteotomy of the anterior mandible with advancement and counterclockwise rotation to pull

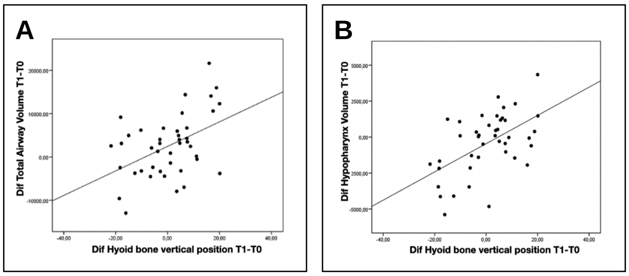

Figure 7. (A) Scatter plot, in which the *y* axis represents the change in total airway volume and the *x* axis represents the change in vertical position of the hyoid bone. Note that when the hyoid bone is elevated, there is a greater gain in total airway volume ($r = 0.46$; $P = .002$). (B) Scatter plot, where the *y* axis represents the change in airway volume at the level of the hypopharynx, and the *x* axis represents the change in vertical position of the hyoid bone. This plot shows that elevation of the hyoid bone promotes enlargement of the hypopharynx ($r = 0.54$; $P < .001$). Dif, difference in; T1, postoperative; T0 preoperative.

the genioglossal muscle forward, produce hyoid bone pulling, and reduce upper airway obstruction during sleep.[28] Furthermore, other authors have described modified genioplasty techniques to enlarge the hypopharynx even more as a treatment option for OSAS patients.[20,25] Box osteotomy of the genial tubercle has been described as an effective technique for increasing the UAV, though its amount of advancement is quite limited.

Last, other surgical techniques have been described to pull the hyoid bone upward and forward, because it is relevant in sleep apnea and related surgeries due to its connection with the tongue base and hypopharynx. It is a floating bone with muscle attachments, providing an anchor for the tongue base. Muscles attached to the hyoid bone include those of the tongue, suprahyoid muscles, and strap muscles. The greater cornua also attaches to the middle constrictor muscle. For this reason, in the early 1980s hyoid suspension to the lower border of the mandible with fascia lata was the preferred technique in multilevel expansion surgery for OSAS.[19] In the early 1990s, it was modified to hyothyroidopexy, which involves suturing of the hyoid bone to the thyroid cartilage.[19] The effect of the likely preferred hyothyroidopexy in a multilevel procedure requires further evaluation.

Therefore, although further studies are required to draw firm conclusions regarding the role of sole genioplasty for UAV enlargement, preliminary results indicate that genioplasty can be more effective than the previously mentioned techniques, because greater advancement or upward pulling can be carried out. Moreover, additional aesthetic benefits should be highlighted in patients with an underlying dentofacial deformity, because an appropriate chin position and proportion warrants an adequate lip-chin

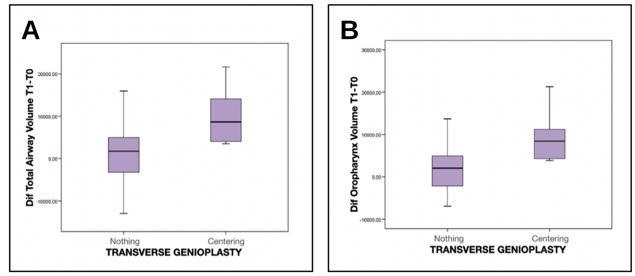

Figure 8. (A) Box and whisker plot, in which the *y* axis represents airway volume changes at oropharynx level, and the *x* axis represents whether a centering genioplasty was performed or not. This plot shows that centering the chin directly impacted the oropharynx, because the oropharynx increased by an average of 8420 mm^3 when centering was performed, but merely 2047 mm^3 when it was not carried out. (B) Box and whisker plot, in which the *y* axis represents total airway volume changes, and the *x* axis represents whether a centering genioplasty was performed or not. This plot suggests that centering the chin directly impacted the oropharynx, because the total airway volume increased by an average of 8651 mm^3 when centering was performed, but merely 1737 mm^3 when it was not carried out. Dif, difference in; T1, postoperative; T0 preoperative.

relationship, contributes to normal vertical facial proportions, and gives support to the submandibular soft tissues.

Unfortunately, the AHI was not evaluated in the present study, so the authors cannot conclude that aesthetic osseous genioplasty is effective in treating OSAS. However, from the obtained results, the authors will design a following study to specifically assess the impact of advancement, upward, and/or centering genioplasties on UAV and AHI, and the potential benefits for treatment of OSAS. Further studies assessing the impact of genioplasty upon the AHI are required for this purpose, as well as assessment of its combination with other procedures such as rhinoseptoplasty or orthognathic maxillary and/or mandibular surgery.

Other limitations of this study were its single-center and retrospective design, with the inherent biases this implies. Additionally, 2 surgeons were involved in the present study (though they followed the same technique) and some bias could arise from this fact.

CONCLUSIONS

In conclusion, the present study suggests that aesthetic osseous genioplasty impacts the UAV and, specifically, each chin movement differently impacts the upper airway by enlarging or narrowing it, and at different airway levels. Although most clinically relevant genioplasty movements to magnify the UAV are upward and forward chin translation, further studies involving the apnea-hypopnea index are required to assess its effectiveness in treating OSAS.

Disclosures

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