PERIÓDICO TCHÊ QUÍMICA
ARTIGO ORIGINAL

O EFEITO DA OSTEOTOMIA SEGMENTAR ISOLADA DO QUEIXO (SCO) NO ESPAÇO DAS VIAS AÉREAS FARÍNGEAS

THE EFFECT OF ISOLATED SEGMENTAL CHIN OSTEOTOMY (SCO) ON THE PHARYNGEAL AIRWAY SPACE

DAKHNO, Larysa[1*]; LOGVYNENKO, Iryna[2];

[1] Central Laboratory Diagnosis of the Head, D. Oral & Maxillofacial Pathology and Radiology - Ukraine

[2] Bogomolets National Medical University, Department of Oral and Maxillofacial Surgery – Ukraine

** Corresponding author*
e-mail: larysadakhno1212@gmail.com

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RESUMO

O queixo afeta a estética facial e a harmonia entre as vistas frontal e lateral, sendo uma das estruturas anatômicas mais importantes do terço inferior da face. O objetivo da osteotomia do queixo é a harmonização do perfil facial, equilibrando o tamanho e a forma do terço inferior da face. Assume-se que a cirurgia isolada de genioplastia melhorará o espaço das vias aéreas faríngeas (PAS), promovendo alterações musculares, especificamente puxando o osso hióide para frente e descomprimindo a região da hipofaringe. Dois pacientes sem síndrome da apneia obstrutiva do sono (SAOS) foram submetidos à osteotomia isolada do queixo para fins estéticos. O movimento para frente do queixo pelo ponto Pg foi de 7 mm em um caso e 11 mm no outro. Eles foram avaliados por tomografia computadorizada de feixe cônico no pré e pós-operatório. O espaço das vias aéreas superiores foi subdividido em espaços retropalatais e retroglossais. Depois disso, o espaço das vias aéreas superiores foi analisado através dos seguintes critérios: 1) superfícies tridimensionais, de alta altitude e seção transversal; 2) alterações transversais e anteroposteriores do diâmetro. A genioplastia segmentar isolada foi utilizada após um planejamento virtual preciso e resultou em um aumento do espaço das vias aéreas faríngeas apenas em um caso. Houve correlação relevante entre a alteração vertical e horizontal do queixo e a hipofaringe. Houve uma média de um aumento de 1,6 vezes no volume total do espaço aéreo superior. O espaço retroglosso foi aumentado em 1,5 vezes. Em outro caso, não houve correlação relevante entre a alteração vertical e horizontal do queixo e a PAS. A osteotomia segmentar isolada do queixo fornece um resultado estético previsível na correção de diferentes deformidades anteriores da mandíbula e pode resultar em aumento do volume e alteração morfológica das vias aéreas. Mais estudos devem ser feitos para avaliar o efeito da genioplastia segmentar isolada no espaço das vias aéreas faríngeas.

Palavras-chave: Cirurgia de genioplastia, osteotomia segmentar do queixo, deformidade facial, espaço das vias aéreas faríngeas (PAS), síndrome da apneia obstrutiva do sono (SAOS) .

ABSTRACT

The chin affects facial esthetics and the harmony between frontal and lateral views and is one of the most important anatomic structures of the lower third of the face. Chin osteotomy is aimed at ensuring the harmonization of the facial profile by balancing the size and form of the lower third of the face. It is assumed that the isolated genioplasty surgery will improve the pharyngeal airway space (PAS) by promoting muscle changes, specifically by pulling forward the hyoid bone and decompressing the hypopharynx region. Two patients without obstructive sleep apnea syndrome (OSAS) underwent isolated chin osteotomy for esthetic purposes. Forward movement of the chin by the Pg point was 7 mm in one case and 11 mm in another case. They were evaluated by preoperative and postoperative cone-beam computed tomography scans. The upper airway space was subdivided into retropalatal and retroglossal spaces. After this, the upper airway space was analyzed through the following criteria: 1) three-dimensional, high-altitude, cross-sectional surfaces; 2) transverse and anteroposterior diameter changes. Isolated segmental genioplasty was used after precise virtual planning and resulted in the PAS increase only in one case. There was a relevant correlation between the vertical and horizontal chin change and the hypopharynx. There was an average of a 1.6-fold increase in the total volume of the upper airway space. The retroglossal space was increased 1.5-fold. In another case, there was no relevant correlation between the vertical and horizontal chin change and the PAS. Isolated segmental chin osteotomy provides predictable esthetic results in the correction of different mandible anterior deformities and may contribute to an increased volume and a morphologic airway change. Further studies should be conducted to

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evaluate the effect of isolated segmental genioplasty on the pharyngeal airway space.

Keywords: Genioplasty surgery, segmental chin osteotomy, facial deformity, pharyngeal airway space (PAS), obstructive sleep apnea syndrome (OSAS).

1. INTRODUCTION:

The chin is one of the most important units of facial structures responsible for common facial appearance and esthetics. Chin osteotomy is an orthognathic surgical procedure that is usually performed in addition to bilateral sagittal split osteotomy of the mandible and sometimes as an isolated surgical procedure (Haggerty and Laughlin, 2015; Santagata *et al*., 2015; Kawamata *et al.*, 2000). The aim of chin osteotomy is the harmonization of the facial profile by balancing the size and form of the lower third of the face.

Cone-beam computed tomography (CBCT) with a 3-dimensional cephalometric and airway analysis is routinely used as an important and necessary tool for analyzing the skeletal and dental relationships, as well as identifying and quantifying the site of obstruction (Chen *et al.*, 2007; Hwang *et al.*, 2010; Eggensperger *et al.*, 2005).

As it is known, the upper airway volume is directly dependent on the size and relative positions of the maxillofacial skeletal structures and on the dental arches, both relative to one another and the cranial base (Tan *et al.*, 2017; Guven *et al.*, 2005; Pae *et al.*, 2008). Thus, the average rate of the minimum cross-sectional area of the upper airway is 149.3 mm^2 in normal adults. However, the upper airway size of under 52 mm^2 in adults is associated with sleep apnea (Bhattacharyya *et al.*, 2000; Schendel *et al.*, 2012; Al-Moraissi *et al.,* 2015; Choi *et al.*, 2014).

An increase in the airway size associated with maxillomandibular advancement surgery and orthognathic surgery is well studied (Zucconi *et al.*, 1999; Schendel *et al.*, 2011; Abramson *et al.*, 2011; Fairburn *et al.*, 2007; Brown *et al.*, 2013; Pirklbauer *et al.*, 2011; Boyd *et al.*, 2013; Zucconi *et al.*, 1999). However, 3-dimensional morphologic, volumetric, height, cross-sectional surface areas and diameter changes of the pharyngeal airway space (PAS) after isolated segmental chin osteotomy (SCO) are not well understood.

Therefore, this study aimed to prove the assumption that the isolated genioplasty surgery will improve the pharyngeal airway space by promoting muscle changes, specifically by pulling forward the hyoid bone and decompressing the hypopharynx region.

2. MATERIALS AND METHODS:

Two patients without obstructive sleep apnea syndrome (OSAS) underwent isolated segmental chin osteotomy to improve facial esthetics (Logvynenko and Dakhno, 2018). Informed consent in which all benefits, risks, alternatives, and limitations to the technique are considered was obtained before the operations. All methods were performed following the relevant guidelines and regulations of our hospital. The effect of this surgery on the increase of the pharyngeal airway space was studied based on these cases. The hypothesis of the present study was the statement that the advancements of the chin segment – including the mental spines and the genioglossus muscle – will cause a significant increase in the pharyngeal airway volume.

Both patients were evaluated based on preoperative and postoperative CBCT scans, which were done by using the Gendex CB-500 by iCat scanner (Imaging Sciences International, Hatfield, PA) with a low-dose protocol. The procedure was done in Natural Head Position (NHP) while the patients were seated.

The DICOM data were then 3D reconstructed and analyzed using the SIMPLANT O&O software (Materialise N.V., Belgium). The analysis of the upper airway changes was performed by comparing preoperative and postoperative images. The upper airway space was identified and measured from the level of the posterior nasal spine to the lower edge of the hyoid bone (Figure 1).

According to the demands of the study, the upper airway space was subdivided into (1) the retropalatal space (covering the area from the level of the posterior nasal spine at one point and continuing to the lower edge of the soft palate at another point), and (2) the retroglossal space (covering the area from the lower edge of the soft palate and continuing to the hyoid bone, as depicted in Figure 2).

The upper airway was analyzed for a volumetric, cross-sectional surface area, as well as transverse and anteroposterior size changes.

The next step was virtual surgical planning: interactive chin cutting and bony segment repositioning to optimize esthetic results (Figure 3, 4).

The initial 3D model and the surgical simulation 3D model of the skull were printed. An intraoperative positioning surgical guide was designed using Mimics software by Materialise NV. and printed using a 3D printer (Objet30 OrthoDesk jets, Stratasys Ltd. Nasdaq: SSYS) according to the 3D plan of segmental chin osteotomy for proper positioning of the fragments.

In the first case, the patient requested chin augmentation. She had had a bad experience with a silicone implant because of the asymmetric positioning and contouring of the implant margins, which is why it had been removed. So her expectations from chin osteotomy were high, and thorough 3D planning was required. Two pieces' segmental chin osteotomy was planned with the forward movement up to 6,66 mm and the rotation of the fragments providing more V-shape form of the chin and control of the contour of the mandible (Figure 5).

After the 3D project was approved by the patient, the 3D model of the skull was printed, and the surgical guide was designed and printed to help accurately transfer treatment plans to the operating room and to position the fragments properly. Titanium plates were curved and adapted to the fixation fragments on the 3D model.

The second case was represented by the patient with retrusive facial appearance, lip incompetence, and increased lower third of the face. As the patient rejected bimaxillary orthognathic surgery, genioplasty was proposed as an alternative plan (Figure 6).

To improve the facial profile, it was necessary to move Gn forward up to 11 mm and upward up to 5 mm. In reality, such movement is impossible if planned as sliding osteotomy for this patient, because the chin bone fragment will lose any contact with the mandible. Moreover, hanging it by plates has a lot of risks – resorption, loss of stability, steps of the contour of the mandible. That is why a decision was made in favor of segmental chin osteotomy. The combination of forward and upward movements with counterclockwise rotation in the sagittal plane, the divergence of the fragments, and the control of the contour of the mandible give us the possibility to achieve a favorable Gn position and a fine V-shape form of the chin. The patient was presented with the visualization of the complexity of achieving the desired result.

In the operating room, under general anesthesia, osteotomies were done by piezotome. Minimal bone loss and precise cutting were admitted. In all cases, the attached lingual periosteum on all bone fragments was retained to preserve blood supply. The SCO procedure preserves the attachment of the anterior belly of the digastric muscle. SCO capturing the genial tubercle and the genioglossal muscle was precisely performed, and then the bone parts of the chin were fixed to the surgical guide by screws. After all bone parts were accurately positioned, they were fixed with rigid plates and screws to one another. The final bone gaps were filled by cortical bone particles of xenogenous origin.

Postoperative CBCT scans, 3D cephalometry, and upper airway analyses were re-performed postoperatively in 6 months and 2 years (Figure 7).

CBCT scans were done in Natural Head Position (NHP) on the same Gendex CB-500 by iCat scanner by the same operator while the patient was seated. This type of examination shows the form and size of airways only when the patient is awake and seated steadily upright. One should note that when the patient is asleep and/or lying on the back airways, the soft tissues are more relaxed and can narrow the airways and obstruct the airflow.

The next step was to analyze the DICOM data by using the SIMPLANT O&O software (Materialise N.V., Belgium). Then the upper airway changes were evaluated by comparing preoperative and postoperative scans.

3. RESULTS AND DISCUSSION:

This study involved two patients without obstructive sleep apnea syndrome who underwent isolated segmental chin osteotomy. Isolated segmental genioplasty was used after precise virtual planning and resulted in an increased pharyngeal airway space only in one case. The chin segment was moved 11.77 mm in the first case and 8.54 mm in the second (Figures 8 and 9). There were no major complications.

In the first case, the volume of the upper airway increased significantly by 59.5% as a result of chin advancement. The retroglossal volume increased more than the retropalatal volume. The area of the smallest airway (choke point) before surgery was 84.6 mm^2, and after surgery – 202,1 mm^2. Correction to the norm of the airway is confirmed by obvious changes in the PAS shape from a funnel to a tube-like one, as shown in the figures. A closer examination of the surface-area slices reveals that the anteroposterior dimension increased more than the transverse dimension in terms of millimetric changes (Figure 10).

The hyoid bone, a predictor of airway obstruction, changed and moved more superiorly and closer to the mandible. The hyoid to mandibular plane measurement decreased after surgery, indicating an elevation of the hyoid.

In the second case, the upper airway space increased only by 3.5 % in the total volume (Figure 11), which is considered not a clinically significant change. This result might be associated with a different level of osteotomy of the lingual cortical plate of the chin, and fewer muscle attachments were moved forward with the chin fragment (Figure 12). However, more clinical cases are required to be certain about this. All measures are compacted in Tables 1-3.

Obstructive sleep apnea syndrome is a condition having many factors. Its diagnostics and the way of medical treatment have to be personalized and individually differentiated. The multidisciplinary management is also essential. The specific diagnosis and the plan of treatment is usually formed after both comprehensive medical plus dental history analysis and scrupulous mediacal examination being held analysis and examination. Adjunctive diagnostic studies such as CBCT imaging for airway analysis, fiberoptic nasopharyngoscopy, polysomnography, and 3-dimensional cephalometrics are included in the workup. Obstructive sleep apnea is correlated with an upper airway anatomic obstruction. The correction of this anatomic obstruction by surgery is an effective way of treatment. Therefore, it has to be definitive medical decision due to the medical indications and has to be considered as appropriate for patients with mild, moderate, or severe OSAS (Pirklbauer *et al.*, 2011).

As it is known, maxillomandibular advancement surgery with a combination of forward and upward movements with counterclockwise rotation in the sagittal plane plays an important role in OSAS correction. Thus, in a recent study, Boyd *et al*. stated that maxillomandibular advancement should be the surgical option of choice for patients with moderate or greater OSAS (Boyd *et al.*, 2013).

Today, the widespread use of CBCT scans and the development of automated airway analysis systems allow the surgeon to have more refinement in surgical planning since the exact sites and the extent of the obstruction can be better visualized. Thus, surgery can be tailored for each patient. The upper airway can be divided into three anatomic sections for evaluation and treatment.

The first level is the nose. Each internal nose deformation immediately affects the airflow. Deformities or collapses of the alar cartilage will cause airflow reduction at the external nasal valve. Septal deviations or septal spur can obstruct the nose and cause airflow turbulence. The enlargement of turbinates may also cause nasal obstructions and reduce the airflow, so surgical reduction might be indicated. A narrow nasal floor may (anatomically) affect adversely the airflow of the nose. Since the nasal floor is the hard palate, maxillary constriction and crossbites must be considered as causative factors. For such children patients, rapid palatal expanders can be applied. For adult patients, surgically assisted rapid palatal expansion is a choice. It should also be noted that maxilla restriction will affect the tongue position and cause a decrease in the pharyngeal airway space.

The second level includes the retropalatal area and the lateral pharyngeal walls. In the adolescent age, the most widespread reason for airway obstruction is lymphoid hyperplasia with the enlargement of the adenoids and tonsils. This is reported to be the cause of airway obstruction 60% of the time and provokes mouth breathing (Zucconi *et al.*, 1999). The obstruction removal by applying appropriate surgery methods is the most effective solution. However, tonsillectomy and/or adenoidectomy alone do not resolve the obstruction for 27% of these patients. Micrognathia, retrusive maxilla, open bite and/or crossbite, and a Class III malocclusion will also result in the decreased retropalatal airway space. Airway problems can also be observed after cleft palate surgery. Adult people having a long palate may suffer from snoring and progressive thickening of the palatal tissues compounding the airway obstruction.

The third level includes the retroglossal area and the tongue. The retroglossal area is mostly influenced by the position of the mandible and the tongue. Mandibular retrognathia may lead to the base of the tongue to the position posteriorly during sleep and obstruct the airflow. Mandibular retrusion can also cause obstructions at the palatal level. These deformities can be evaluated with CBCT scans and 3-dimensional cephalometric and 3-dimensional airway analyses.

The tongue, mandible, and hyoid system are functionally composed of two bony components, the hyoid and mandible, and one muscle component, the tongue. The tongue, mandible, and hyoid system are functionally arranged as follows: the genioglossus originates from the apophysis geni superior, and the geniohyoid muscle – from the inferior point (the intrinsic tongue muscle the first and the latter that inserts distally on the hyoid bone). There are also some insertions of the mylohyoid and pharyngeal constrictor muscles supplied additionally by the pterygomandibular ligament (located in the mandible’s inner part).

There are insertions of several muscles on the body of the hyoid, originated either from the tongue or the mandible likely to the geniohyoid and mylohyoid muscles, as well as the sternohyoid, sternothyroid, thyrohyoid, and omohyoid ones. There is the insertion of the hyoglossus on the hyoid horns, the pharyngeal constrictor muscles, the stylohyoid, as well as the tendinous pulley of the digastric muscle. There is also the longitudinal superior muscle insertion took place, the longitudinal inferior muscle, and the stylohyoid ligament on the distal part of the horns. Two longitudinal muscles are the internal tongue muscles.

In this regard, seven pairs of these muscles hold the hyoid bone in place and cause it to move when needed. Two of them pull the hyoid bone upward and forward. One pulls it upward and backward. One pulls it upward, and three – downward. Therefore, it was suggested that the forward movement of the chin would cause changes in the hyoid bone position and, as a result, lead to an increase in the PAS volume.

The normal morphology, volume, choke point, and growth pattern of the upper airway were described by Schendel *et al.* (2011). The authors studied 1,300 normal subjects from 6 to 65 years of age and found out that the usual choke point was in the retroglossal space.

Other researchers showed a significant increase in both lateral and anteroposterior airway dimensions with maxillomandibular advancement (Abramson *et al.*, 2011; Fairburn *et al.*, 2007). They concluded that the changes were secondary to the enlargement of the entire velopharynx by elevating the tissues and increasing the tension on the suprahyoid and velopharyngeal muscles. Based on Pouseille's law, as the radius increases and the height decreases, the resistance decreases. Therefore, an increase in the surface area due to an increase in the anteroposterior and transverse dimensions combined with a decrease in the total airway height results in a total decrease in airway resistance. Airway resistance was most likely also decreased because of the increased airway volume and the decreased airway height, but this required further investigation.

In the first case of segmental chin osteotomy, the most outstanding discovery is probably the increase in the anteroposterior airway dimension that is always less than the transverse airway dimension in cases with maxillomandibular advancement surgery (Schendel *et al*., 2012; Brown *et al*., 2013).

Knowledge about the preoperative smallest cross-sectional area (choke-point size) and its position allows surgery to be more precisely planned. For example, a small retroglossal cross-sectional area can be entirely corrected by chin advancement, if it is sufficiently large and the plane of osteotomy is performed high enough.

The CBCT study accounts for the airway shape and size only when the patient is awake, static, and in the upright, seated position. When the patient is in the supine position and asleep, the tissues relax further and can obstruct the airflow. Thus, it is understandable that any measurements of the airway will be worse during normal sleeping in the supine position when the muscles are relaxed.

Furthermore, the study was limited by two cases, presenting two different (controversial) results. This is why more work needs to be done in this area to allow precise planning based on the expected airway changes when chin surgery is used.

5. CONCLUSIONS:

Isolated segmental chin osteotomy provides predictable esthetic results in the correction of different mandible anterior deformities. The present study evaluated two patients without OSAS by a 3-dimensional analysis; therefore, clinical correlations in the increase between the PAS and OSAS parameters (apnea-hypopnea index, body mass index, oxygen saturation, etc.) are not possible.

Currently, the protocol of orthodontic examination includes CBCT data used to diagnose skeletal and dental deformations, which are also ideal for detecting the anatomic obstruction of the upper airway space. CBCT images are an important and required instrument for revealing the area of the decreased airway space and for quantitative evaluation of its volume on different levels, as well as for diagnosing skeletal and dental deformations using a 3D-cephalometric analysis.

Bimaxillary surgery with forward movement and counterclockwise rotation in the sagittal plane is performed on patients with obstructive sleep apnea syndrome to increase the upper airway space. However, this surgery is technically complicated and requires a long rehabilitation time for the patient. Moreover, it significantly changes the appearance of the patient with big (more than 5 mm) forward movements.

In this regard, the use of less traumatic surgery, which can affect the retroglossal area and the tongue position to increase the upper airways, seems more promising in the context of achieving positive dynamics in addressing such medical issues. The study proved that segmental chin osteotomy could increase the pharyngeal airway space, which is associated with the forward movement of the mental area of the mandible and hyoid bone and the tongue muscles following. Such surgery can be an effective way of treatment with a high success rate for patients with an anatomic obstruction of the upper airway, who cannot withstand bimaxillary orthognathic surgery but still want improvements.

The study is limited by two cases with different effects. That is why further examination is needed to test the hypothesis that an increase in the hypopharyngeal region, associated with genioplasty, is clinically effective for OSAS.

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Table 1. *RPV (cc3) data*

Patient	Chinadvancement (mm)	Change in UAV (%)	RPV (cc3)	
			Pre-surgery	Post-surgery
1	11.77	59,5	9.42	13.53
2	8.54	3.5	9.38	10.03

Table 2. *RGV (%) data*

Patient	Change in RPV (%)	RGV (cc3)		Change in RGV (%)
		Pre-surgery	Post-surgery	
1	44	5,53	10.27	86
2	7	8.89	8.85	-0.5

Table 3. *Postoperative smallest RG area data*

Patient	Preoperative smallest RG area (mm²)	Postoperative smallest RG area (mm²)
1	84.6	202.1
2	144.72	146.15

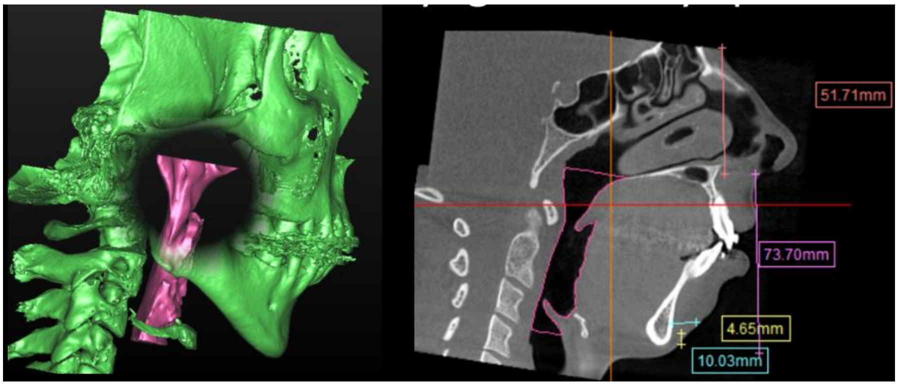

Figure 1. *Upper airway analysis from the level of the posterior nasal spine to the lower edge of the hyoid bone in the lateral view before SCO surgery*

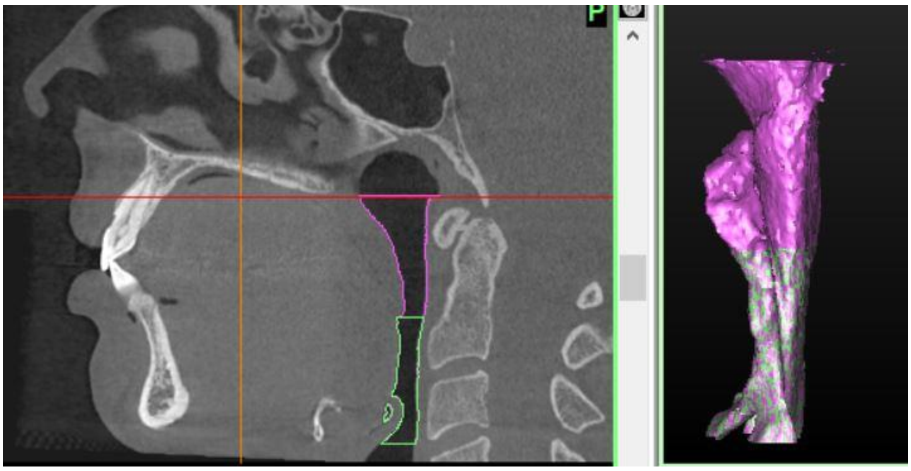

Figure 2. *Preoperative lateral view of the retropalatal space*

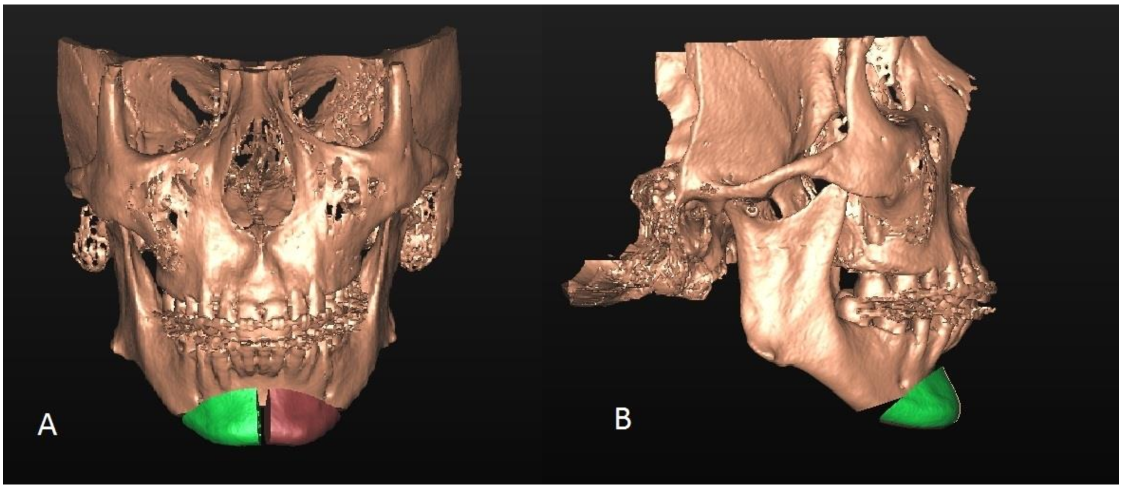

Figure 3. *SCO 3D planning prepared for augmentation genioplasty: (A) frontal view, (B) lateral view*

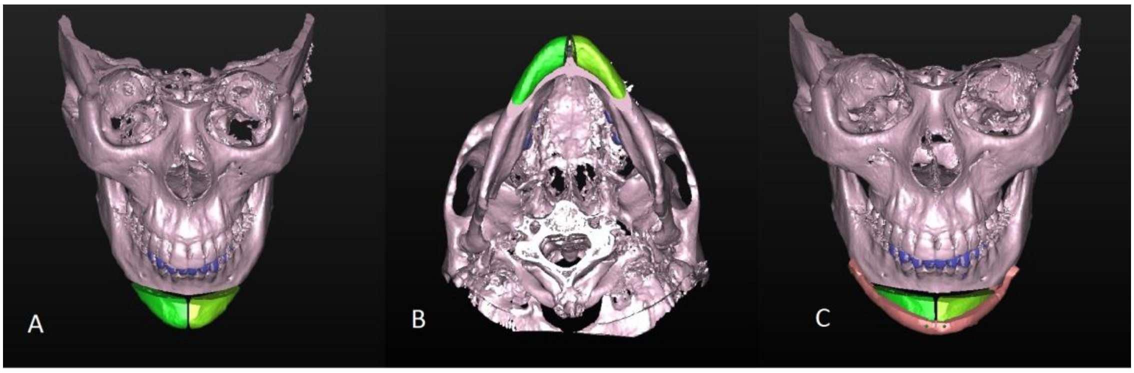

Figure 4. *SCO 3D planning: (A) frontal view, (B) bottom view, and (C) surgical positioning guide designed for augmentation genioplasty (frontal view)*

Figure 5. *First case – (A) preoperative lateral view showing the irregular contour of the mandible, sagging of soft tissues of the cheek and neck; (B) 3 months postoperative lateral view showing the balance of soft and hard tissues, the clear contour of the mandible, and the submandibular-neck angle*

Figure 6. *Second case – (A) preoperative lateral view showing the poor contour of the mandible and chin, horizontal chin deficiency, short mandible body, increased lower third height of the face, and incompetency of lip closure; (B) 3 months postoperative lateral view showing significant improvement of the balance of soft and hard tissues, the clear contour of the mandible, the submandibular-neck angle, and the passive adequate lip closure*

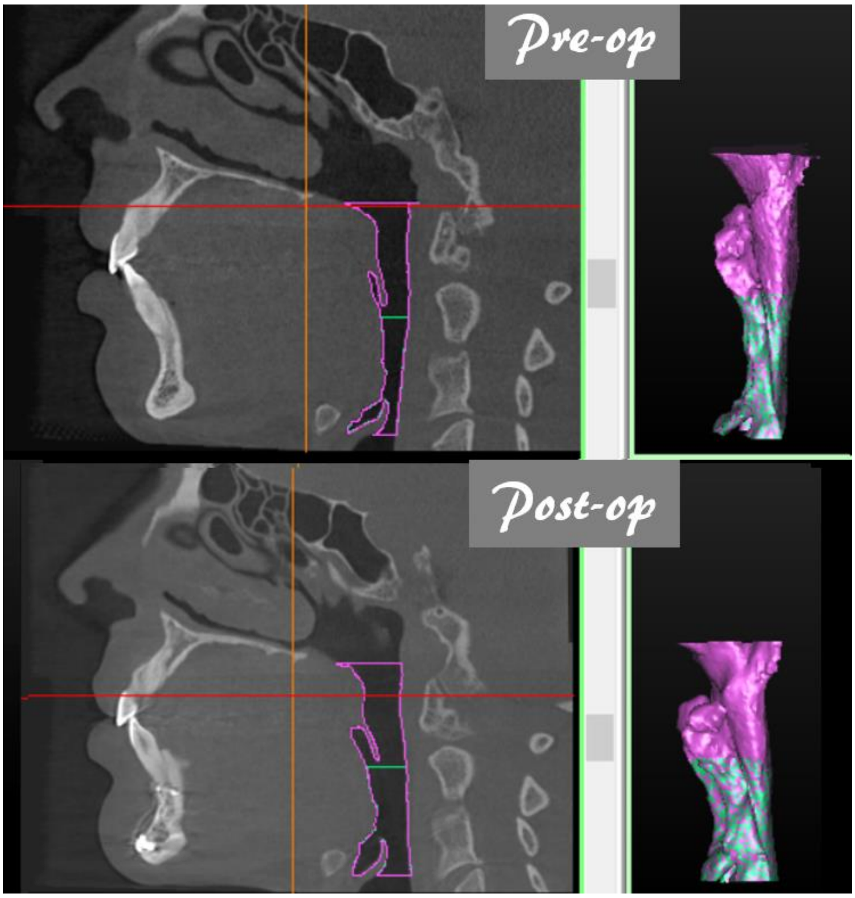

Figure 7. *Airway comparison analysis in the lateral view before surgery operation (pre-op) and after SCO (post-op), showing a considerable airway increase*

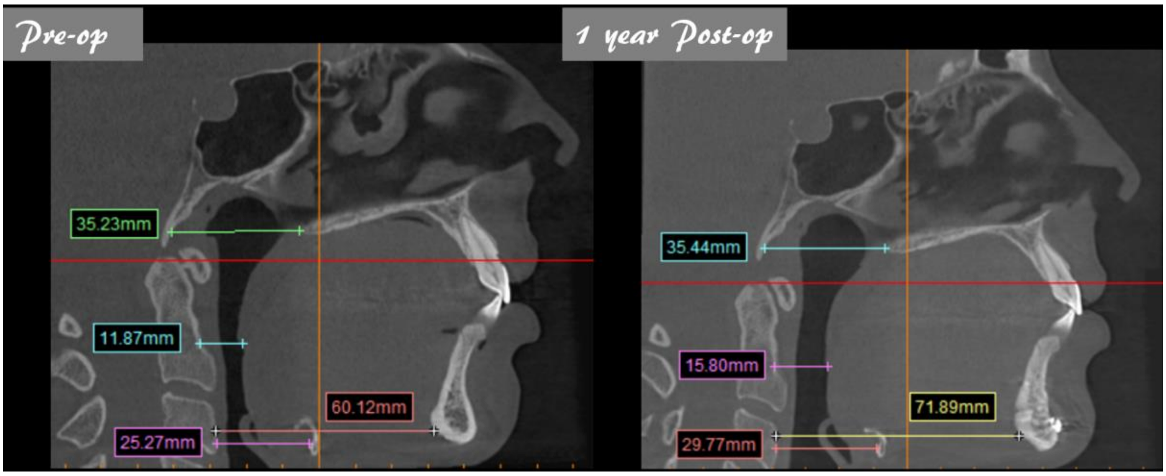

Figure 8. *Preoperative and postoperative lateral views and measures of the first case-patient showing the advancement after genioplasty*

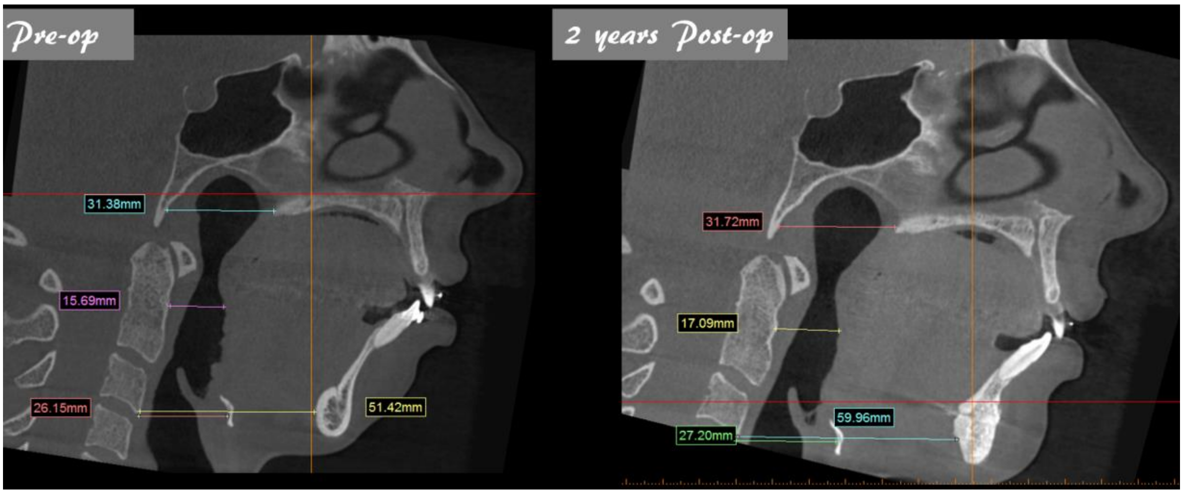

Figure 9. *Preoperative and postoperative lateral views and measures of the second case-patient showing SCO results*

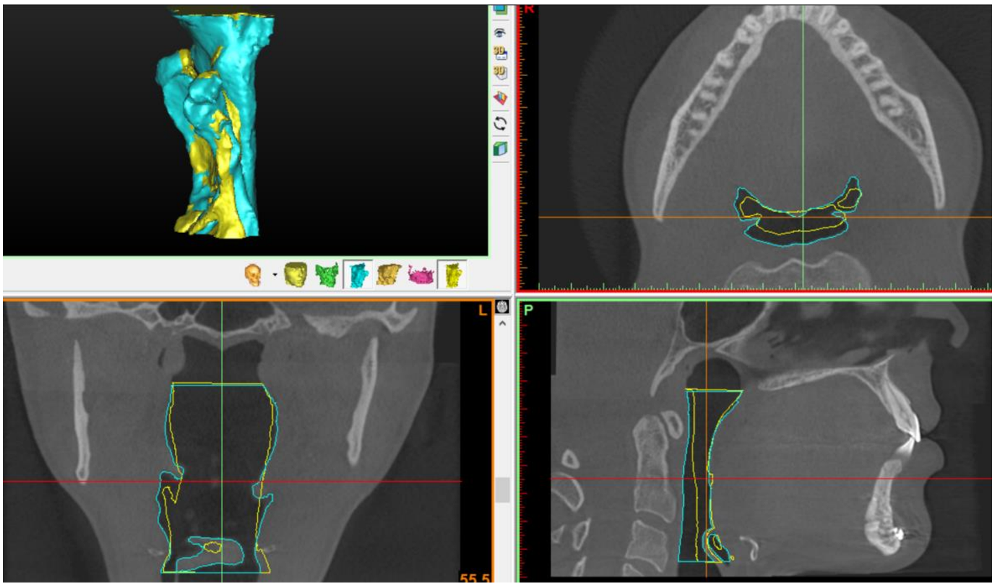

Figure 10. *Preoperative and postoperative superimposition and changes in the anteroposterior and transverse dimensions of the upper airway in the first clinical case. Yellow outline – preoperative; blue – 1 year postoperative*

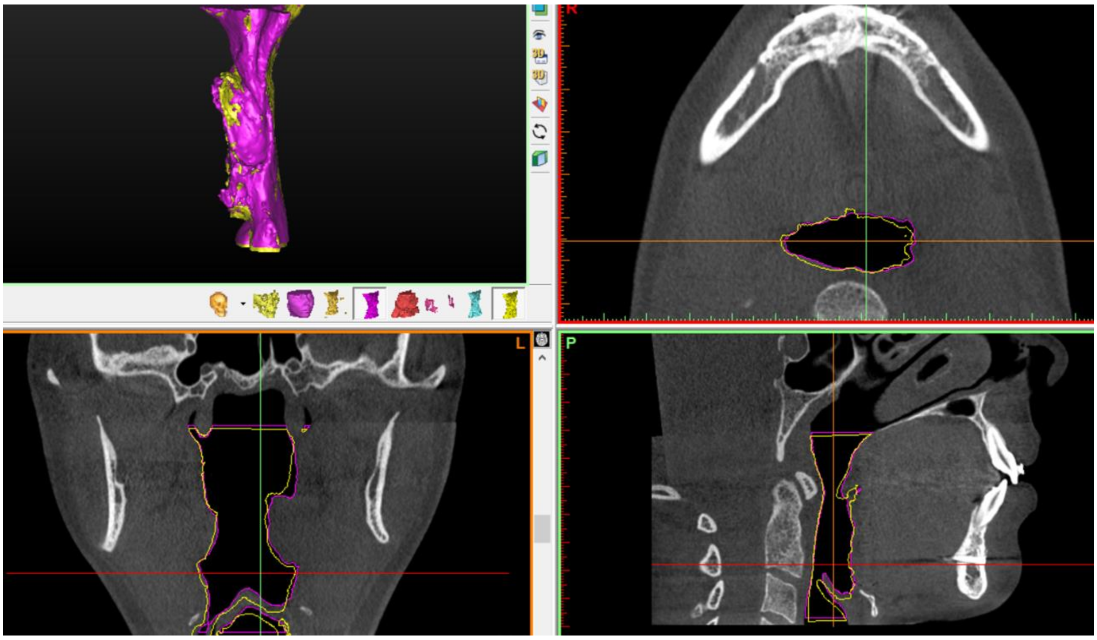

Figure 11. *Preoperative and postoperative superimposition and changes in the anteroposterior and transverse dimensions of the upper airway in the second clinical case. Yellow outline – preoperative; pink – 1 year postoperative*

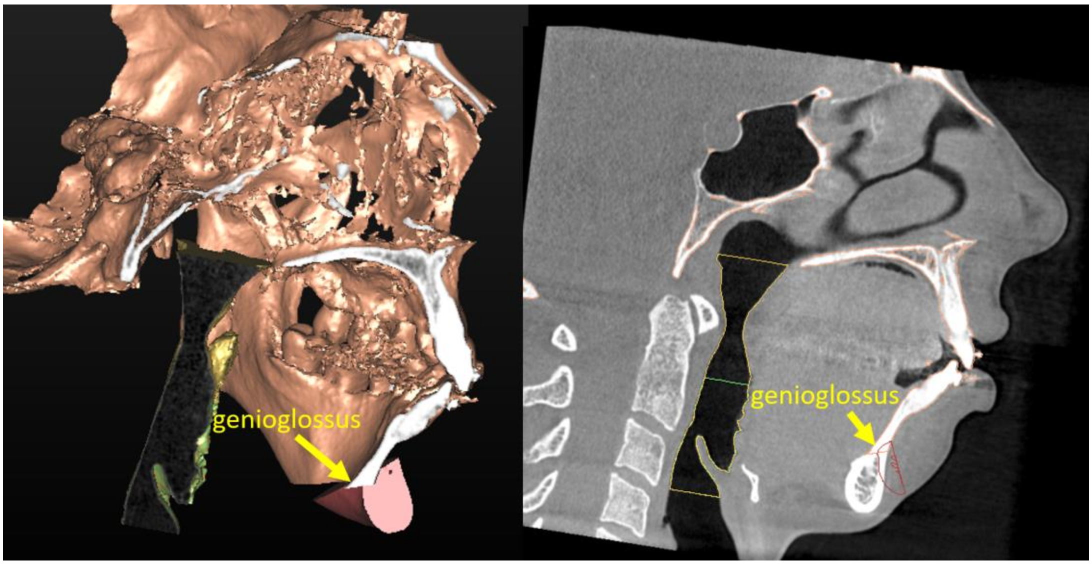

Figure 12. *Lateral view of the osteotomy level of the chin lower than the apophysis geni superior. The yellow arrow is the origin of the genioglossus muscle in the second case*