Effect of Bimaxillary Orthognathic Surgery on Pharyngeal Airway Volume

Efecto de Cirugía Ortognática Bimaxilar en el Volumen de la Vía Aérea Faríngea

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SUMMARY: Subjects with maxillary skeletal classes II and III not only express alterations in the hard and soft maxillofacial tissues, but also in the morphology and dimensions of the upper airway. A small space in the upper airway has been associated with sleep disorders, such as snoring and mainly obstructive sleep apnea/hypopnea syndrome (OSAHS). Consequently, interest has increased due to the influence of orthognathic surgery in the airway space. Although there are studies in the literature that have compared upper airway spaces, most have evaluated the changes using two-dimensional images, mainly lateral skull X-rays. The present study aimed to determine the airway volume in subjects with skeletal classes II and III who underwent bimaxillary orthognathic surgery. 80 CBCT exams from 40 subjects obtained before and 6 months after surgery were used. There were 20 class II and 20 class III subjects. For the volumetric analysis, a 3D rendering of the upper airway was made in previously established segments, and then the airway volume was calculated using the 3D Slicer® software version 4.11 (Slicer, USA). The statistical analysis by t-test of related samples revealed statistically significant volumetric increases in the nasopharynx, laryngopharynx, and total volume in class II patients. However, in class III patients, there were significant increases in the nasopharynx and total volume, while the volume was maintained in the oropharynx and laryngopharynx.

KEY WORDS: Upper airway space; Orthognathic surgery; Pharyngeal airway volume.

INTRODUCTION

The maxillo-mandibular discrepancies associated with growth and bone development produce significant functional alterations. Skeletal class type II is characterized mainly by a posterior position of the mandible compared to the maxilla, due to a lack of mandibular growth, or excessive growth of the maxilla (Nath et al., 2019). In class III subjects, the opposite occurs, with the mandible in a more protruded position than the maxilla, associated with mandibular hyperplasia or maxillary hypoplasia (Chen et al., 2015). These discrepancies not only express alterations in the hard and soft maxillofacial tissues, but also in the morphology and dimensions of the upper airway, where spaces in the upper airway are frequently observed to be reduced in class II subjects. (Nath et al., 2019)

A smaller space in the upper airway and the resulting lower mobilized air volume is strongly associated with sleep disorders, such as snoring and mainly obstructive sleep apnea (OSA) (Zhang et al., 2021), which is a common disorder, with a prevalence from 9 % to 38 % in the general population (Senaratna et al., 2017). This syndrome is characterized by periods of apnea and/or hypopnea while sleeping. Apnea is the cessation of airflow by the nose or mouth, whereas hypopnea is a reduction in the airflow that enters by the nose or mouth, which causes oxygen saturation and/or ends in arousal. Epidemiological studies have repeatedly confirmed that the severity of OSA plays an important role in the development of cerebrovascular diseases, including stroke (Redline et al., 2010). Although the reduction in the

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diameter of the upper airway is not the only triggering factor of OSA, since it is a multifactor disorder, it is an anatomical factor important to consider.

For these reasons, during the past few years, interest has increased due to the influence of orthognathic surgery on the airway space. Several authors indicate that orthognathic surgery leads to an increase in upper airway space. (Chen et al., 2015; Von Bremen et al., 2021) This, of course, is very favorable, especially in class II cases where the volume of posterior air space tends to be significantly reduced (Xiang et al., 2017).

Although studies exist in the literature that have compared upper airway spaces, most have evaluated the upper airway changes using two-dimensional images, mainly lateral skull X-rays. However, cephalometric X-rays in two dimensions can limit the accuracy of the measurements of the upper respiratory tract due to the disadvantages of two-dimensionally evaluating a three-dimensional space (Abé-Nickler et al., 2017). At the moment, cone beam computed tomography (CBCT) is widely used to evaluate the shape and volume of the respiratory tract. CBCT offers the advantages of volumetric rather than linear measurements, thereby providing a three-dimensional analysis as well as measurements without distortions (Chen et al., 2015). In addition to the use of CBCT, various software packages have been developed to take volumetric measurements and can be applied to estimate upper airway volumes.

Although there is no consensus in the scientific literature regarding the three-dimensional volumetric differences of the upper airway in class II and III subjects who underwent orthognathic surgery, it is necessary to know the volume obtained after maxilla-mandibular movements to guide future conditions affecting the airway.

MATERIAL AND METHOD

An experimental, comparative, and retrospective study was conducted, approved by the Scientific Ethics Committee of the Universidad San Sebastián, Chile, file number 66-22. Twenty class II and 20 class III subjects were included as follows: 80 CBCT studies were used, 40 before and 40 after the surgery, from 40 subjects over 18 years of age who underwent orthognathic surgery. All the subjects signed an informed consent for their participation, and they were told about the scope of the study. Subjects with skeletal class I, subjects with imaging signs of facial trauma who required previous surgery, and subjects with incomplete diagnostic and imaging information were excluded.

CBCT examinations: The CBCT examinations were obtained by specialized technicians with 5 years of experience with a NewTom VGi EVO 3D scanner (Verona, Italy) with a 24 ¥ 19 cm window, taken with an exposure time of 15 s at 110 kV and 8 mA. To obtain the volume, the patient was seated in a vertical position, with the lips at rest and without forced muscle contraction. The examinations were input with an ordinal number, indicating only the patient’s age, sex, and skeletal class, determined previously using cephalometric analysis by the surgical team who performed the orthognathic surgery, and thus the subjects’ identity was kept confidential. The presurgical imaging occurred between two and four weeks before the intervention.

Volumetric Analysis. For the volumetric analysis, the 3D-Slicer® software version 4.11 (Slicer, USA) was used. To this end, the examinations were opened in DICOM format and segmented, rendering the upper airway three-dimensional, using the following reference points (Fig 1): (1) Anterior: posterior nasal spine in the sagittal plane and choanae in the axial plane. (2) Posterior: posterior wall of the pharynx. (3) Superior: highest point of the nasopharynx. (4) Inferior: below the hyoid bone at the level of the lower margin of the C4 vertebral body.

Fig. 1. Reference points for the three-dimensional rendering of the total airway.

An independent analysis of the airway segments was then performed. The previously segmented airway was divided into nasopharynx, oropharynx, and laryngopharynx,
outlined in Figure 2. After segmentation, the volumetric calculations were made of each individualized segment and the total volume before and after orthognathic surgery with the corresponding modules from the previously individualized software.

Statistical analysis. First, a test of normality was done with the Shapiro-Wilk test. Then, the differences between the groups were analyzed using a t-test for related samples. p<0.05 was considered statistically significant. For the analysis, the SPSS version 21 statistics software was used (IBM Corp., Armonk, NY, USA).

RESULTS

The statistical analysis by t-test of related samples revealed (Fig. 3) statistically significant volumetric increases in class II patients in the nasopharynx (p=0.017), laryngopharynx (p=0.045), and total volume (p=0.015). By contrast, in the oropharynx, although the values after orthognathic surgery were higher than the presurgical condition, they were not statistically significant (p=0.062).

In class III patients (Fig. 4), statistically significant increases were noted in the nasopharynx (p=0.007) and total volume (p=0.045), whereas in the oropharynx, although the values after orthognathic surgery were higher than the presurgical condition, they were not statistically significant (p=0.060). By contrast, in the laryngopharynx, mean volumetric values were slightly lower after orthognathic surgery; however, they were not statistically significant (p=0.521).

DISCUSSION

In this study of the airway, only CBCT after orthognathic surgery with a post-operative minimum of 6 months were included. Before this time, according to reports in the literature, edema could produce a reduction in initial volume, which would mask the real volumetric increases (Brunetto et al., 2014).

It is important to note that there is no standardization in the literature to determine the anatomical limits of the upper airway, which could make a comparison of the results difficult. However, the projection of the hard palate and posterior nasal spine has been described frequently in the literature (Pereira et al., 2021, Yoshino et al., 2021).
The clinical importance of the relation between the surgical movement of the maxilla and/or mandible and the size of the upper airway is based on the effects of its positional change. In this respect, planning orthognathic surgery is a complex procedure that involves different components and variables. Apparently, class II patients generally benefit in terms of an increase in the upper airway space; class III patients tend to remain relatively constant (Von Bremen et al., 2021).

In class II patients, most studies on the airway show volume increases due to the advancement of the mandible, which produces an early increase in air volume, especially in the oropharynx and nasopharynx. In this respect, in a study with 11 class II patients with follow-up for up to four years, Pereira et al., (2021) found a significant and sustained increase in the upper airway volume. In the present study, significant volume increases were reported in the nasopharynx, laryngopharynx, and total volume, which may be related to what is described in the literature.

In the case of class III patients, maxillary advancement leads to an increase in the upper airway (Souza et al., 2019), whereas a mandibular setback usually results in a reduction of the upper airway (An et al., 2019). In a study with 30 patients who underwent orthognathic surgery, Li et al. (2022) reported a significant increase in air volume of the nasopharynx, which agrees with the results of the present study. However, they reported a significant decrease in volume in the oropharynx, which differs from our results, where there were no differences in the pre- and postoperative conditions.

The results of the present study are clear concerning the early condition of the airway volumes before and after orthognathic surgery. However, new studies with other diagnoses, surgical techniques, and therapeutic strategies are needed, correlating the volumetric differences in the airway with related factors.

Even considering the limitations of the present study, the findings make it possible to conclude that there is a significant increase in air volume in the nasopharynx, laryngopharynx, and total volume in class II patients, and a significant increase in the nasopharynx, and maintaining of the pharyngeal air volume in the other segments in class III patients who underwent bimaxillary orthognathic surgery.

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PALABRAS CLAVE: Vía aérea superior; Cirugía Ortognática; Volumen aéreo faríngeo.


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