Effect of Orthognathic Surgery on the Posterior Airway Space in Patients Affected by Skeletal Class III Malocclusion

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Abstract

Introduction Dentofacial deformity refers to deviations from normal facial proportions and dental relationships that are severe enough to be handicapping. These anomalies involve many aspects of patient's life and are sometimes also associated with a reduction of pharyngeal air space. Through orthognathic surgery it is possible to treat dentofacial deformities: this kind of surgery has several effects on skeletal structures and it has changes, as it is demonstrated by many studies, also on the upper airways. The orthognathic surgeries commonly used to correct this deformity are the mandibular setback and the maxillary advancement procedures. This study aims to evaluate the effects of maxillary and mandibular surgery on pharyngeal airway dimensions in skeletal class III malocclusions.

Materials and methods This study considers 76 patients, treated between 2007 and 2013 by maxillary advancement (11 patients), maxillary advancement and mandibular setback (39 patients), maxillary advancement, mandibular setback and genioplasty reduction (26 patients). Cranial latero-lateral radiography was used to compare oropharyngeal airway morphologies before and 1 year after surgery.

Conclusion The surgeon should consider bimaxillary surgery rather than mandibular setback surgery to correct a class III deformity to prevent the development of obstructive sleep apnea syndrome; in fact, bimaxillary

surgery might have less effect on reduction of the pharyngeal airway than mandibular setback surgery only.

Keywords Orthognathic surgery · Posterior airway space · Class III malocclusion · Maxillary advancement

Introduction

Orthognathic surgery for skeletal deformity alters the skeletal and soft-tissue components. Many studies on mandibular setback surgery for skeletal class III malocclusion have found that the positions of the hyoid bone and the tongue are changed [1]. The position of the hyoid bone after surgery can reflect stretching of the suprahyoid musculature, which plays an important role in maintaining the oropharyngeal airway. An increase in potential muscle tension might be related to skeletal relapse. Many studies have investigated the effect of orthognathic surgery on the pharyngeal airway space in class III skeletal deformities [2–4]. Some studies found that with time and physiologic adaptation of the soft tissues, the airway was restored to its original condition [1, 4–8].

This study aims to evaluate the effects of maxillary and mandibular surgery on pharyngeal airway dimensions in skeletal class III malocclusions and to investigate the relationship between changes in craniofacial morphology and airway dimensions.

Materials and Methods

Patients

Seventy-six (76) patients with dentoskeletal III class deformity, who needed orthognathic surgery to correct it,

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were recruited between May 2007 and September 2013, at the Multidisciplinary Department of Medical and Dental Specialties, Oral and Maxillofacial Surgery Unit, Hospital I Policlinico (AOU)–Second University of Naples (SUN), Naples, Italy. All the patients needed maxillary advancement or combined maxillary advancement and mandibular setback with or without genioplasty associated.

There were 45 women, and 31 men. Age of female patients ranged from 18 to 41 years and median age was 24; age of male patients ranged from 19 to 42 years and median age was 23.

Diagnostic records were represented by cranial latero-lateral telerradiography.

Patients were divided into the following three groups based on the surgical procedure they underwent:

- maxillary advancement (11 patients);
- maxillary advancement and mandibular setback (39 patients);
- maxillary advancement, mandibular setback and genioplasty reduction (26 patients).

Cephalometric Measurements

We used cranial latero-lateral telerradiography and cephalometric analysis to compare oropharyngeal airway morphologies, before and 1 year after surgery.

The two main parameters used to evaluate the posterior airway space modification were:

ad1: the line joining posterior nasal spine (PNS) and basion (Ba) intersecting the posterior pharyngeal wall (Figs. 1, 2).

IPS: the antero-posterior width of the pharynx, measured between the posterior pharyngeal wall till the point where the dorsum of the tongue intersects the inferior mandibular border on a parallel line to the Frankfort plane (Figs. 1, 2).

All measurements were developed by a single operator.

Surgical Procedure

Maxillary Advancement

A maxillary advancement was obtained by making a vestibular incision from the first molar to the contralateral one, then, the superficial tissues are reflected subperiosteally and the nasal mucoperiosteum was elevated to complete the exposure of the osseous surgical site.

After recording the reference measurements, a Le Fort I maxillary osteotomy was performed.

The next step is represented by the mobilization of maxilla from the cranial base: at this moment it is important to remove all the interferences back to the second molar before thinking of re-attaching the removed bone.

Fig. 1 *ad1* and *IPS* measurement on cephalometric RX, pre-surgery

Fig. 2 *ad1* and *IPS* measurement on cephalometric RX, post-surgery

When the maxilla was free, it was wedged into the mandible by the interposition of an occlusal splint. Finally when the desired movement was achieved, the maxilla was fixed in position with internal rigid fixation.

Mandibular Withdrawal

To prepare the mandibular setback, a bilateral incision was performed in vestibular region. Mucoperiosteal flap at the retromolar trigone was prepared.

Once uncovering was completed, the Obwegeser–Dal-Pont osteotomy was performed bilaterally.

Mobilization of the mandibular segment was now possible, the reposition of the mandible in the correct way was made with the assistance of an occlusal splint.

When the desired movement was achieved, mandible was fixed in position with internal rigid fixation.

Every surgical procedure was developed by a single operator.

Results

In all cases, a good, aesthetical and functional result was reached; no complications occurred.

About maxillary advancement, the average of advancement was 3.2 mm (SD 0.9 mm). About mandibular setback the average of the setback was 1.9 mm, (SD 0.4 mm). These results were developed including the three groups in the same group.

Every group had a normal distribution and the significance (p value), the average and the standard deviation for cephalometric measurements was developed for each group. In Table 1, the significance (p value), the average and the standard deviation for cephalometric measurements, in all the three groups of patients separately, are shown before and 1 year after surgery.

The results showed an increase in cephalometric measurement of PAS after surgery for each group.

The p value was >99 % for *adl* and *IPS* in patients treated by maxillary advancement or maxillary advancement and mandibular setback; the p value was >95 % for *adl* and *IPS* in patients treated by maxillary advancement, mandibular setback and genioplasty (Table 1).

Discussion

Surgical alteration in the position of the bony facial skeleton will inevitably affect the soft tissue relationships. However, an aspect of orthognathic surgery that is rarely evaluated is the effect of the skeletal movements on the pharyngeal airway. Changes in airway dimensions have been demonstrated after surgical repositioning of the mandible or maxilla [2–15].

We evaluated airway size by analysing cephalograms. Tongue, pharyngeal airway and hyoid bone are three-dimensional structures evaluated by a two-dimensional lateral cephalogram, and a question concerning validity could be raised. Computerized tomography (CT) might be a better method. However, Riley and Powell [16] evaluating the reliability of CT scans and cephalograms in determining the posterior airway space reported a very high, statistically significant correlation between posterior airway space and the volume of the pharyngeal airway. Besides, the advantages of cephalometry include its wide availability, simplicity, low cost, and simplicity of comparison with extensive normative data and other studies.

The orthognathic surgeries commonly used to correct skeletal class III malocclusions are the maxillary advancement, mandibular setback procedures and genioplasty [2].

The maxillary advancement, through LeFort I osteotomy, leads to the anterior movement of the soft palate resulting in an increase in volume of the PAS, especially of the nasopharynx [2, 7, 10, 15, 17].

The most popular mandibular setback procedure is the bilateral sagittal split osteotomy (BSSO). The isolated mandibular setback has been the target of several studies. These studies reported a change in the position of the hyoid bone and reduction in the dimensions of the retrolingual and hypopharyngeal airway after mandibular setback surgery [3–14].

Tselnik and Pogrel [5] reported a reduction of the retrolingual airway by 28 % in distance and 12.8 % in

Table 1 PAS measurements

Surgery	Cephalometric measurement	No. of patients	Average pre (mm)	Average post (mm)	SD pre	SD post	p value	p (%)
Maxillary advancement	adl	11	22.54	24.09	0.6876	1.13	0.00010	>99
Maxillary advancement	IPS	11	10.27	10.90	0.4671	0.5394	0.0078	>99
Bimaxillary	adl	39	20.44	21.27	0.7361	1.1306	0.0017	>99
Bimaxillary	IPS	39	10.44	11.31	1.1522	1.2565	0.086	>99
Bimaxillary + genioplasty	adl	26	20.26	20.96	1.0023	1.1482	0.0247	>95
Bimaxillary + genioplasty	IPS	26	12.00	12.65	0.9796	1.1642	0.0331	>95

volume. Studies also showed posteroinferior displacement of the hyoid bone post-operation, which moved the tongue in the similar vector [8, 11, 13]. The posteriorly displaced tongue in turn narrows the retrolingual dimension and decreases the PAS [3, 5, 8, 9, 11]. Liukkonen et al. [3] also noted that the degree of postero-caudal (clockwise) rotation of the mandible during the setback, correlated to the degree of airway narrowing [3]. Some studies suggest that the changes are temporary as the tissues re-adapt, resulting in partial or total resolution [3, 7, 8, 10, 12]. However, most of the other studies showed that the airway changes are stable over the long term [4, 5, 9, 11, 12, 14].

The study with the longest follow-up of 12 years showed that the decrease in the lower pharyngeal airway was stable but the upper and middle pharyngeal airway continued to decrease over the 12 years [18].

Contrary to logic deduction, the addition of the maxillary advancement may not result in an increase in the retropalatal dimension. In two studies, maxillary advancement and mandibular setback surgery was performed to treat the class III skeletal deformities and the authors found that there was still a significant reduction in the retropalatal dimension [10, 15]. Another study showed that the maxillary advancement and mandibular setback surgery group resulted in the reduction of the retropalatal dimension but it was not significant after 2 years and was to a much lesser degree than the group which only had mandibular setback [7]. This was postulated to be due to two key issues. Firstly, maxillary advancement results in adaptive changes of the soft palate in order to maintain velopharyngeal seal and palatal function [19]. The second matter concerns the posterior and superior movement of the tongue from the mandibular setback which comes into contact and displaces the soft palate backwards and upwards. Combining the two factors, the soft palate becomes longer and thinner and the palatal angle increases. Therefore, the maxillary advancement may not gain a significant enlargement of the retropalatal dimension and coupled with the mandibular setback, there may even be a narrowing of the retropalatal airway.

In the present study we can provide PAS augmentation (significance value >99 %) after maxillary advancement or maxillary advancement and mandibular setback but we can not find a direct connection between the millimetres of maxillary advancement and PAS augmentation because too many bias can falsify the results.

In the same way we can provide PAS augmentation after maxillary advancement, mandibular setback and genioplasty reduction (significance value >95 %).

By our study, it is possible to observe that orthognathic surgery has great effects on the pharyngeal posterior airway space. These changes of positions determinates an increase in nasopharynx and hypopharynx volume in each

group, as it is shown by the evaluation of *adl* and *IPS*, before and 1 year after surgery.

In maxillary advancement or maxillary advancement and mandibular setback surgery, the increase of nasopharynx and hypopharynx volume and the differences between the averages observed before and after surgery, is significant for $p < 0,01$ (significance value >99 %).

In maxillary advancement and mandibular setback with genioplasty reduction there is an increase of nasopharynx and hypopharynx air space but the difference between the average before and after surgery is significant for $p < 0,05$.

The outcome of this research has important consequences because it affirms that orthognathic surgery in skeletal class III malocclusions, have been effectively shown to open up the posterior airway space. This is true for maxillary advancements and combined maxillary advancement and mandibular setback, but not for isolated mandibular split.

Conclusion

The surgeon should consider bimaxillary surgery rather than mandibular setback surgery to correct a class III deformity to prevent the development of obstructive sleep apnea syndrome; in fact, bimaxillary surgery might have less effect on reduction of the pharyngeal airway than mandibular setback surgery only.

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