Review Article

Effect of Orthognathic Surgery on the Posterior Airway Space (PAS)

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Abstract

Orthognathic surgery has been used regularly to treat dentofacial deformities. The surgical procedures affect both the facial appearance as well as the posterior airway space (PAS). Our current literature indicates that setback procedures produce an inferior repositioning of the hyoid bone and posterior displacement of the tongue and the soft palate. These movements cause anteroposterior and lateral narrowing of the PAS. Most authors agree that these effects are permanent. The PAS changes in turn produce an adaptive posturing, with an increased craniocervical angle to open up the PAS. Even though most patients do not display snoring and obstructive sleep apnoea (OSA) post-surgery, there is certainly an increased possibility in patients with already compromised airways. Therefore, patients who are undergoing orthognathic surgery should be screened for excessive daytime somnolence, snoring, increased body mass index (BMI) and medical conditions related to OSA and sent for an overnight polysomnography (PSG) if OSA is suspected. Then the proposed treatment plan may be modified according to the risk of potential airway compromise or even to improve it. Conversely, advancement of the maxilla and mandible causes widening of the airway in both the anteroposterior and lateral dimensions. This effect would translate to better airflow and decreased airway resistance. This is supported by the evidence showing high success rates when orthognathic surgery, especially maxillomandibular advancement (MMA), is utilised to treat OSA.

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Introduction

During the growth and development of a person, the facial structures are primarily dependent on the genetic makeup and secondarily on the environmental factors. If the facial structures grow abnormally or disproportionately, a dentofacial deformity occurs. This could be developmental or acquired; a result of trauma, infection and other external influences. This disharmony could range from mild aesthetic disturbance to severe malocclusion and crippling facial appearance that affect the masticatory, speech and social functions of the person. The treatment of these deformities is aimed at both restoring proper dental occlusion and facial harmony. This is performed by combining orthodontic treatment with orthognathic surgery.

Orthognathic surgery has gained wide popularity in maxillofacial surgery over the last 30 to 40 years. It comprises several surgical procedures that allow the repositioning of the entire mid-face, mandible and the dentoalveolar segments to their desired locations. These procedures are carried out as isolated osteotomies or in various combinations.

Orthognathic Surgery and Airway

The surgical procedures that reposition the facial skeleton alter the soft tissues that are attached to the bone in order to effect the facial changes. One aspect of this surgery, which has gained prominence over the last 2 decades, is the effect of the skeletal movements on the posterior airway space (PAS). The soft palate, tongue, hyoid bone and associated muscles are attached directly or indirectly to the maxilla and the mandible. This means that movement of the jaws will result in positional changes of the structures directly attached to the bone and changes in the tension of the attached soft tissue and muscle. This will result in an alteration in the volume of the nasal and oral cavities and

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PAS dimensions depending on the direction and magnitude of the skeletal movements.

Studies have shown craniofacial differences in patients with obstructive sleep apnoea (OSA). Some of the described features are reduced cranial base length, mandibular or bimaxillary deficiency, increased lower face height, elongated soft palate, large tongue and inferior positioning of the hyoid bone.[1-4] Research carried out in this area showed an association between the PAS and OSA. Riley et al[5] showed that a PAS of less than 11 mm and a mandibular plane-to-hyoid distance of more than 15.4 mm was indicative of OSA. Partinen et al[6] reported that patients with PAS of less than 5 mm (base of tongue level) and a mandibular plane-to-hyoid distance greater than 24 mm had the highest respiratory disturbance index (RDI). Muto et al[7] also identified a significant relationship between the PAS and the position of the maxilla, mandible and soft palate. Thus, it behoves us to believe that any alteration of the facial skeleton that replicates these features may provoke some airway disorder.

Through the research in this area, we have begun to appreciate the possible link of potential airway obstruction and the development of OSA. Certain orthognathic procedures may induce a non-adaptable and adverse change to the jaws and PAS that promotes or aggravates a breathing disorder such as OSA. Conversely, other orthognathic procedures may enhance the airway and lead to the resolution of pre-existing OSA.

Research has shown that orthognathic surgery affects the airway when there is a significant anteroposterior component. Consequently, we will be describing the surgical treatment of the Class II and Class III deformities.

Class III Deformity Surgery

The class III malocclusion affects around 22.4% of the Singapore population and it usually presents with skeletal discrepancies such as a prognathic mandible with or without a retrusive maxilla.[8] A severe class III skeletal relationship poses both aesthetic and functional problems. Its correction would involve both orthodontic and orthognathic treatment.

The orthognathic surgeries commonly used to correct this deformity are the mandibular setback and the maxillary advancement procedures.

Mandibular Setback

The most popular mandibular setback procedure in our local setting is the bilateral sagittal split osteotomy (BSSO). Its popularity is due to its versatility in correcting mandibular abnormalities. This technique was credited to Trauner and Obwegeser in 1957[9] and had undergone modifications by Dalpont in1961,[10] Hunsuck in 1968,[11] Gallo in 1976[12] and Epker in 1977.[13]

Surgeons first noticed some patients developing OSA following mandibular setback and published case reports about this potential complication.[14-16] One report mentioned a man who had developed OSA and was found to have had mandibular setback 15 years ago.[14] The cephalographs demonstrated that his posterior airway had decreased significantly both immediate postoperation and even after 15 years. He did not have other risk factors. The other 2 reports reported 2 females developing OSA after mandibular setback surgery.[15,16] As a result of this possible complication, there has been research focusing on the airway changes after mandible setback surgery alone or with advancement of the maxilla.

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. [14,17-27] Tselnik et al[18] reported a reduction of the retrolingual airway by 28% in distance and 12.8% in volume. Studies also showed posteroinferior displacement of the hyoid bone postoperation, which moved the tongue in the similar vector.[21,24-26] The posteriorly displaced tongue in turn narrows the retrolingual dimension and decreases the PAS.[14,18,21,22,24] In addition, Turnbull et al[28] found that there was a decrease in the intermaxillary space (volume of the oral and oropharyngeal region) and an increase in the tongue proportion. This equates to a lesser volume for the tongue and thus posterior displacement and a narrower PAS. Liukkonen et al[14] also noted that the degree of posterocaudal (clockwise) rotation of the mandible during the setback, correlating to the degree of airway narrowing.

All the above studies were cephalometric studies that only assessed the 2-dimensional anteroposterior changes of the airway. Despite this, the results are still relevant as Riley and Powell[29] showed a significant correlation between the PAS measured on the cephalographs and the volume of the airway calculated from computed tomography. Kawamata et al[24] used actual three-dimensional computed tomography (3DCT) to look at the airway changes after mandibular setback found that the lateral width decreased by 23.6%, the frontal width decreased by 11.4% and the hyoid bone was displaced downward and posteriorly. The changes were found to be stable after 1 year and were positively correlated to the amount of setback.

Another observation of several studies was the adaptive increased craniocervical inclination (counter clockwise rotation of the face or chin up movement) of the patients after mandibular setback procedures.[22,30,31] Muto et al[32] assessed the relationship between this change and the pharyngeal airway space (PAS) dimension and determined that the PAS correlated with the inclination at the cervical vertebrae. They concluded that an increase of 10° in the inclination or 10 mm in the distance from the C3 vertebrae to the menton, increases the PAS by approximately 4 mm. This was supported by Winnberg et al[33] who found that the changes in head posture influenced the position of the hyoid bone. Thus, the relapse of the hyoid bone position mentioned by some authors could be due to this phenomenon. This means that the maintenance of the PAS and prevention of OSA after mandibular setback is influenced by the adaptive change in the craniocervical inclination. Furthermore, we could potentially have a method of estimating the impact of our setback magnitude if research can show that a setback of 10 mm (C3-menton decrease by 10 mm) equates to a reduction of the PAS dimension by 4 mm.

There are conflicting views on the degree and duration of the postoperative changes in the hyoid bone position and PAS decrease. The findings of Kawakami et al[34] showed initial downward hyoid bone displacement which went back to normal after 1 year with simultaneous narrowing of the retrolingual dimension. Some studies suggested that the changes are temporary as the tissues re-adapt, resulting in partial or total resolution.[20,21,23,25,26,35] However, most of the other studies showed that the airway changes are stable over the long term.[17,18,22,24,25,27] 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.[36]

Bimaxillary Surgery

Contrary to logic deduction, the addition of the maxillary advancement may not result in an increase in the retropalatal dimension. In 2 studies, bimaxillary 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.[23,28] Another study showed that the bimaxillary 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.[20]

This was postulated to be due to 2 key issues. Firstly, maxillary advancement results in adaptive changes of the soft palate in order to maintain velopharyngeal seal and palatal function.[37] 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 2 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. However, that being said, it is still better to decrease the magnitude of the mandibular setback by performing simultaneous maxillary advancement.

Class II Deformity Surgery

Our local population has been shown to have about 29.5% of Class II malocclusion with only a fraction having severe problems.[8] This is less than the Caucasian population where 10% of the population has severe overjet and anteroposterior discrepancies.[38] The main component of this deformity is usually the mandibular deficiency[39] with infrequent maxillary protrusion. The milder cases can be treated with growth modification and orthodontic camouflage, while the severe ones need orthognathic surgery. A large proportion of such surgery is directed at the advancement of the mandible and a much lesser extent at maxillary setback. In this group of patients, we are worried that they may already have snoring or OSA, as this deformity has already been shown to be a possible clinical feature of an OSA patient.

Kuo et al in 1979[40] and Bear and Priest in 1980[41] were the first to document that surgical advancement of the mandible improved OSA. Turnbull et al[28] found that the advancement improved the retropalatal and retrolingual dimensions of the airway significantly. Furthermore, there was increased intermaxillary space and decreased tongue proportion.This was also confirmed by several authors who noted an increase in the PAS after mandibular advancement.[42,43] Powell et al[44] was amongst the first to report the use of mandibular advancement for the treatment of OSA. Mehra et al[45] assessed the PAS changes with counterclockwise rotation of the maxillomandibular complex and found it a useful tool to complement maxillomandibular advancement in high occlusal angle patients.

Besides mandibular advancement, there are also other orthognathic procedures that could benefit OSA patients, like genioglossus advancement (GGA), Geniotomy advancement and maxillomandibular advancement (MMA). GGA was initially described as a rectangular osteotomy at the chin, which contains the genial tubercles.[46] GGA has been a frequently performed procedure but not as an isolated procedure to treat OSA. GGA is often performed together with uvulopalatopharyngoplasty (UPPP) with an acceptable success rate of more than 80% for moderate OSA (RDI 21 to 40), 64% for moderately severe OSA (RDI 41 to 60) and only 15% for severe OSA (RDI > 61).[47] Other techniques following the same principle are the inferior horizontal advancement geniotomy and the mortised geniotomy, which also advance the genial tubercles but with the entire chin. However, the most successful orthognathic procedure that has been documented to date is the maxillomandibular advancement.

Maxillomandibular Advancement (MMA)

Maxillomandibular advancement (MMA) was first described as a treatment regime for OSA by Waite et al and Riley et al.[48,49] MMA is the advancement of the maxilla and mandible via the LeFort I and Bilateral Sagittal Split Osteotomies. The rationale of these procedures is the advancement of the skeletal attachment of the suprahyoid and velopharyngeal muscles and tendons. This leads to the anterior movement of the soft palate, tongue and anterior pharyngeal tissues, resulting in an increase in volume of the nasopharynx, oropharynx and hypopharynx and therefore increasing the PAS. As the treatment is for OSA, surgical success is obtained when there is significant improvement of the sleep events. The most commonly accepted definition for surgical cure is a postoperation RDI or Apnoea Hypopnoea Index (AHI) of less than 20 and a reduction of more than 50% from the preoperation value, a few desaturations of less than 90% (oxygen saturation) and improvement of subjective symptoms.

Since its inception, there have been several publications that demonstrated a more than 96% success rate for curing severe OSA.[48,50-52] There is also strong evidence of its long term efficacy as Li et al[53] showed a 90% success rate for a group of 40 patients with a mean follow-up period exceeding 50 months.

There are however 2 philosophies with regards to the utilisation of MMA. Some groups believe in a 2-stage protocol where MMA is the stage 2 procedure if stage 1, which consists of UPPP, GGA and hyoid suspension, fails.[51,54] This protocol was developed in order to reduce the use and complications of the more invasive MMA procedure for patients who would have responded to the first stage procedure. The landmark study for this protocol found that the success rate was 60% for stage 1 surgery and 97% for stage 2 surgery.[51] However, only 25% of the stage 1 non-responders went on to stage 2. This was probably due to the perceived trauma from the first surgery and the discouragement from the first failure. Therefore, other groups believe in using the most efficacious technique from the start and proceed directly with MMA.[48,50] Waite et al[48] evaluated 23 patients in a key study who had MMA surgery together with septoplasty and inferior turbinectomies. The success rate achieved was 96%, based on the success criteria of 50% reduction in the RDI and a final RDI less than 20. Hochban et al[50] and Prinsell[52] also used MMA as the primary procedure for 38 and 50 OSA patients, achieving 97% and 100% success respectively.

As for the PAS, Fairburn et al[55] studied 20 patients who had CT scans pre-operation and after MMA. They demonstrated significant increases in both the anteroposterior and lateral PAS dimensions at all levels. The maximal increase was at the tongue base level, with an increase of 179% in the anteroposterior dimension and 37% in the lateral dimension.

Maxillomandibular Expansion

Other than procedures that affect the anteroposterior position of the facial skeleton, Conley et al[56] suggested the use of maxillomandibular expansion in the treatment of OSA. This is transverse widening of dental arches and jaws via orthognathic surgery or distraction osteogenesis. Hypothetically, if the patient has narrow jaws and arches, the lingual tissue and tongue cannot be contained within the normal confines of the constricted oral cavity. Hence, transverse expansion will create increased space for the tongue and oral tissue which prevent their displacement posteriorly. In addition, the expansion of the maxilla may widen the nasal floor, enlarge the nasal cavities and decrease the nasal resistance. However, the recent research done in this area did not agree with this. Studies have shown that the increased nasal patency and decreased nasal resistance did not last over the long term and the maxillary and mandibular expansion did not result in significant anteroposterior and lateral widening of the airway.[57-61]

Conclusion

The literature has not yielded a unanimous stand on the effect of mandibular setback surgery on the posterior airway. The evidence points to a detrimental effect on the airway but most studies have not taken all the factors into consideration. This means that more research needs to be done with better technology to look at the airway volume and its implications in terms of airway resistance, obstruction, collapsibility and the resultant effect on OSA. Meanwhile, treatment recommendations based on current evidence should be as follows: Patients who are undergoing orthognathic surgery should be screened for excessive daytime somnolence, snoring, increased BMI and medical conditions related to OSA and sent for an overnight PSG if OSA is suspected. Then the proposed treatment plan may be modified according to the risk of potential airway compromise or even to improve it. In contrast, advancement procedures of the facial skeleton, especially MMA, have been shown to effectively open up the PAS and cure existing OSA.

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