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BRITISH BIOMEDICAL BULLETIN

Review

Orthognathic Procedures and its Effect on Obstructive Sleep Apnea - A Systemic Review

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ARTICLE INFO

Received 11 Dec. 2014
Received in revised form 15 Dec. 2014
Accepted 16 Dec. 2014

Keywords:
Orthognathic procedures, Posterior airway space (PAS), Obstructive sleep apnea (OSA).

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ABSTRACT

Orthognathic procedures are routinely performed for the correction of congenital and acquired deformities of the dentofacial skeleton. The surgical procedures affect both the facial appearance as well as the posterior airway space (PAS). According to several studies, mandibular setback surgery is known to reduce airway size. Patients who are undergoing orthognathic surgery should be screened for excessive daytime somnolence, snoring, increased body mass index and medical conditions related to obstructive sleep apnea. Conversely, advancement of the maxilla and mandible causes widening of the airway in both the anteroposterior and lateral dimensions. This is supported by the evidence showing high success rates when orthognathic surgery, especially maxillomandibular advancement, is utilised to treat obstructive sleep apnea (OSA). The purpose of this article is to provide information to dentists that will enable them to identify patients who may have OSA and to assist these patients in making informed decisions regarding treatment options. In patients who have identifiable anatomic abnormalities of the maxilla and mandible resulting in a narrow pharyngeal airway, orthognathic surgery appears to be an excellent treatment option.

Introduction

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. 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)[1]. Significant relationships between the pharyngeal structures and both dentofacial and craniofacial structures have been reported[2]. The complex interplay of the soft and hard tissues contributes to upper airway obstruction[3]. So the treatment plan is based on craniofacial cephalometric analysis which allows precise planning of surgical procedures with the help of the data obtained such as measures of the skull base, position of the hyoid bone, mandible configuration, posterior air space of the pharynx, tongue dimensions, along with uvula width and length among various other values.[4]

The crucial role of this anatomical region to speech and swallowing, as well as the subsequent edematous response after surgical intervention present a formidable challenge to the surgeon. Therefore, a logical and systematic approach to clinical evaluation, treatment planning, surgical execution, and perioperative management is necessary to maximize safety and improve outcomes[3]. Though orthognathic surgery has an influence on esthetics as well as masticatory function the potential change in the pharyngeal airway needs to be considered and evaluated[5].

Obstructive Sleep Apnea

Definition

Obstructive sleep apnoea/hypopnoea syndrome (OSAHS) can be defined as the coexistence of excessive daytime sleepiness with irregular breathing at night. The abbreviations OSAS (obstructive sleep apnea syndrome) and OSA (obstructive sleep apnea) are used widely and synonymously with OSAHS[6].

Prevalence

OSAS in the middle-aged population (30 to 60 years) is 4% in men and 2% in women[2]. In united states obstructive sleep apnea is one of the major health problem which in turn affects 24% of adult males and 9% of adult females[18]. However, prevalence rises dramatically with age, to an estimated 28% to 67% for elderly men and 20% to 54% for elderly women[7]. According to American Academy of Pediatrics, prevalence of OSAHS in children may range between 0.7% and 10.3%, with no gender predominance[4].

Apnea and hypopnea

Apnea in adults is considered a pause in breathing for 10 seconds or more, and hypopnea is considered a 50% reduction of the air flow for a period equal to or higher than 10 seconds, associated with over 3% decrease of oxyhemoglobin saturation.

A person is classified as apneic when he/she presents 5 or more respiratory events (apneas and/or hypopneas) per hour of sleep. However, regarding children and according to the American Thoracic Society, it is a consensus that the polysomnographic findings are normal when there is less than 1 respiratory event of apnea-hypopnea per hour, with minimal duration of less than 5 seconds, oxyhemoglobin saturation over 90% and carbon dioxide at the end of exhaling below 10% of the total sleeping time[4].

Apnea/hypopnoea index (AHI)

The frequency of apnoeas and hypopneas hourly is used to assess the severity of the OSAHS and is called the apnoea/hypopnoea index (AHI) or the respiratory disturbance index (RDI).

OSAHS may be subdivided into varying degrees of breathing abnormality, depending on the AHI:

- Mild: AHI 5-14/hr
- Moderate: AHI 15-30/hr
- Severe: AHI >30/hr[6].

Factors predisposing to apnoeas and hypopnoeas include

- Increasing age
- Obesity
- Sedative drugs
- Smoking and alcohol consumption[6].
- Increased neck circumference >17 inches in male, >16inches in female
- Body mass index BMI >30kg/m^2
- Retrognathia
- Macroglossia
- Lateral peri tonsillar narrowing
- Elongated/enlarged uvula
- Nasal abnormalities[8] etc.

Clinical features of obstructive sleep apnoea

- Excessive daytime sleepiness
- Impaired concentration
- Snoring
- Un refreshing sleep
- Choking episodes during sleep
- Witnessed apnoeas
- Restless sleep
- Irritability/personality change
- Nocturia
- Gasping
- Morning headaches
- Fatigue
- Symptoms of depression
- Decreased libido.[6]

The respiratory consequences of OSAS

- Hypoxemia and hypercapnia
- Pulmonary hypertension
- Cor pulmonale
- Chronic carbon dioxide retention
- Polycythemia

The cardiovascular consequences of OSAS

- Systemic hypertension,
- Cardiac arrhythmias,
- Myocardial infarction,
- Cerebral vascular accidents

Clearly, OSAS can be a debilitating and potentially life threatening condition. Thus, both proper diagnosis and appropriate treatment are important[7].

Diagnosis

- History
- Physical examination
- Polysomnography
- Cephalometric radiography assessment
- Computed tomography (3D CT)
- Magnetic resonance imaging
- Endoscopy

Cephalometric assessment of Posterior airway space

Cephalometry provides a two dimensional image of the pharyngeal air way and is used extensively in the assessment of craniofacial form and pharyngeal morphology before and after surgery. Advantage of cephalometry includes its wide availability, simplicity, low expense, & ease of comparison[8]. Cephalo-metric analysis of posterior airway space (PAS) differs in several aspects. According to some authors posterior airway space was defined as the distance between the posterior pharyngeal wall and the base of the tongue along the mandibular plane.[9] While some authors defined PAS as the line drawn from point B through gonion, this line intersects the base of the tongue on posterior pharyngeal wall. However the original position of point B and gonion may be changed after orthognathic surgery[5]. Posterior airway space can also be measured from the distance between TB-PHW which represents the narrowest portion between tongue base and posterior pharyngeal wall parallel to Frankfort horizontal plane and UP-PHW represents the narrowest portion between soft palate protrusion and posterior pharyngeal wall parallel to Frankfort horizontal plane[10]. (See figure 1.)

Head posture has been suggested to influence the dimensions of the oropharyngeal airway. Change in the angle of odontoid process to the head posture is one of the important variables and showed that 10 degree of head extension can improve the oropharyngeal airway by 4mm[11]. The variable head posture and differences in breathing and deglutition when cephalometric radiographs were made, affect this relationship, since the posture of tongue base changes during deglutition and breathing[5]. To avoid these changes lateral cephalogram should be taken with bilateral ear rods which is gently inserted in to the external auditory canal to stabilize the head posture and teeth in occlusion during exposure. To standardize the hyoid position radiographs should be exposed at the end of expiration.

Treatment

- Non surgical
- Surgical

Non-surgical

- Continuous positive airway pressure
- Oral appliances
- Medications such as Protriptyline and Medroxyprogesterone
- Behavioural treatment (weight loss)[7]

Surgical

1. Upper airway bypass procedure: Tracheostomy.
2. Nasal procedures:
   - Septoplasty
   - Functional rhinoplasty
   - Turbinate reduction
   - Nasal polypectomy
3. Oral, oropharyngeal & naso pharyngeal procedures:
   - Uvulopalatopharyngoplasty
   - Palatal advancement pharyngoplasty
   - Tonsillectomy/adenoidectomy
4. Hypopharyngeal procedures:
   - Tongue reduction
   - Tongue advancement/stabilization
   - Genioglossus advancement
   - Mandibular advancement
   - Hyoid suspension
5. Laryngeal procedures:
   - Epiglottoplasty
   - Hyoid suspension
6. Global airway procedures:
   - Maxillomandibular advancement
   - Bariatric surgeries[12].

The gold standard treatment for adults is positive airway pressure (PAP). Although extremely effective, tolerance and compliance remain considerable hurdles. Certain interventions may promote compliance to PAP, such as correction of nasal obstruction, attention to mask fit, desensitization for claustrophobia, heated humidification, patient education, regular follow-ups, compliance software, and support groups[19]. Despite these measures, PAP therapy remains a considerable challenge for many individuals, and surgical intervention is often an effective therapeutic alternative[20]. Surgery aims to alleviate anatomic site of obstruction in the naso-oro and hypopharynx. In adults, surgical options include phase I surgeries (nasal, palate reduction, and tongue advancement or reduction surgeries), and phaseII surgery

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(maxillomandibular advancement). Other surgical therapies for OSA include distraction osteogenesis of the maxilla and mandible, and finally tracheotomy. Phase I and II surgeries are generally performed sequentially, although some surgeons will perform phase II surgery initially or, less commonly, combine phase I and II surgeries. In children, tonsillectomy and adenoidectomy represent the major surgical intervention and, if needed, radiofrequency treatment of the nasal turbinates combined with aggressive treatment of allergies. Adjunctive treatment in children includes maxillary and mandibular distraction via orthodontics[21]. However no currently available treatment modality completely eliminates OSA. Positive airway pressure is considered the gold standard therapy for OSA, yet even PAP users achieve only approximately 50% of ideal use[36]. Surgical success for OSA is often unpredictable and is less effective than PAP(with the exception of tracheotomy). Surgical success depends on appropriate patient selection, the type of procedure performed, and the experience of the surgeon. In general, phase I surgeries have a reported success rate of 50% - 60% in significantly improving OSA by greater than 50% in selected patients, whereas phase II surgeries have a success rate of greater than 90%[37,38]. Surgery is considered appropriate on a case by case basis in patients with usually moderate to severe OSA with associated symptoms of excessive daytime sleepiness or with significant medical morbidities.

Orthognathic surgery and airway

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 posterior airway space (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. Research carried out in this area showed an association between the PAS and OSA. Riley *et al* 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* 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). Thus, any alteration of the facial skeleton that replicates these features may provoke some airway disorder. 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. Consequently, we will be describing the surgical treatment of the Class II and Class III deformities[1].

Class III deformity surgery

It is common to combine surgery and orthodontics to treat skeletal Class III. Usually presents with skeletal discrepancies such as a prognathic mandible with or without a retrusive maxilla. The orthognathic surgeries commonly used to correct this deformity are the mandibular setback and the maxillary advancement procedures[1]. Mandibular setback surgery can improve the occlusion, masticatory function, and esthetics by markedly changing the position of the mandible[1]. However, mandibular setback surgery causes changes in the position of the hyoid bone and the tongue, and consequent narrowing of the pharyngeal airway space(PAS),which might be a reason for obstructive sleep apnea (OSA) [13]. OSA is considered a risk factor for systemic and pulmonary hypertension and cardiac arrhythmias and may increase morbidity and mortality[14].

Mandibular setback

The most popular mandibular setback procedure 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 and had undergone modifications by Dalpont in1961, Hunsuck in 1968, Gallo in 1976 and Epker in 1977[1]. Surgeons first noticed some patients developing OSA following mandibular setback due a change in the position of the hyoid bone and reduction in the dimensions of the retrolingual and hypopharyngeal airway after mandibular setback surgery. Tselnik *et al* 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 post operatively, which moved the tongue in the similar vector. The posteriorly displaced tongue in turn narrows the retrolingual dimension and decreases the PAS. In addition, Turnbull *et al* 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* also noted that the degree of posterocaudal (clockwise) rotation of the mandible during the setback, correlating to the degree of airway narrowing[1].

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*[22] showed initial downward hyoid bone displacement which went back to normal after 1year with simultaneous narrowing of the retrolingual dimension. Some studies suggested that the changes are temporary as the tissue re-adapt, resulting in partial or total resolution[23-28]. However, most of the other studies showed that the airway changes are stable over the long term[22,26,29-32]. The study with the longest follow-up of 12years 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[33]. 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. Muto *et al* 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[15].

Bimaxillary surgery

Contrary to logic deduction, the addition of the maxillary advancement may not result in an increase in the retropalatal dimension.

This was postulated to be due to 2 key issues:

(1). Firstly, maxillary advancement results in adaptive changes of the soft palate in order to maintain velopharyngeal seal and palatal function.

(2). 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[1].

Class II deformity

The main component of this deformity is usually the mandibular deficiency 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 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 and Bear and Priest in 1980 were the first to document that surgical advancement of the mandible improved OSA. Turnbull *et al* 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. Powell *et al* was amongst the first to report the use of mandibular advancement for the treatment of OSA[1].

Mandibular advancement also leads to the advancement of the suprahyoid and tongue muscle as the hyoid bone is attached to the mandible via the geniohyoid, anterior digastric and mylohyoid muscle. Consequently the position of the base of the tongue is dictated by the position of the mandible. Isono *et al* (1990) in his study demonstrated that forward displacement of the mandible widens velopharyngeal and oropharyngeal airway and reduces collapsibility of the oropharynx[16]. Besides mandibular advancement, there are also other orthognathic procedures that could benefit OSA patients, like genioglossus advancement (GGA), Geniotomy advancement and maxillomandibular advancement (MMA) [1].

Maxillomandibular advancement (MMA)

Maxillomandibular advancement (MMA) was first described as a treatment regime for OSA by Waite *et al* and Riley *et al*.[34,35] 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, anterior pharyngeal tissues and the chin which contains the genial tubercles resulting in an increase in volume of the nasopharynx, oropharynx and hypopharynx and therefore increasing the PAS[17]. Mehra *et al* 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[39]. Most surgeries are done in combination and in multistep manner, with maxillomandibular advancement typically being reserved for refractory or severe OSA, or for those with obvious and significantly maxillomandibular deficiency.

Conclusion

Obstructive sleep apnea (OSA) is a common condition associated with significant morbidity and mortality. It is therefore important that dental professionals be aware of the signs and symptoms of OSA, so that the diagnosis can be confirmed and treatment initiated as soon as possible. As knowledge about the pathophysiology of OSA improves, treatments may be designed to address the specific causes of the condition. Treatment recommendations based on current evidences 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 polysomnography 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 Maxillomandibular advancement, have been shown to effectively open up the PAS and cure existing OSA.

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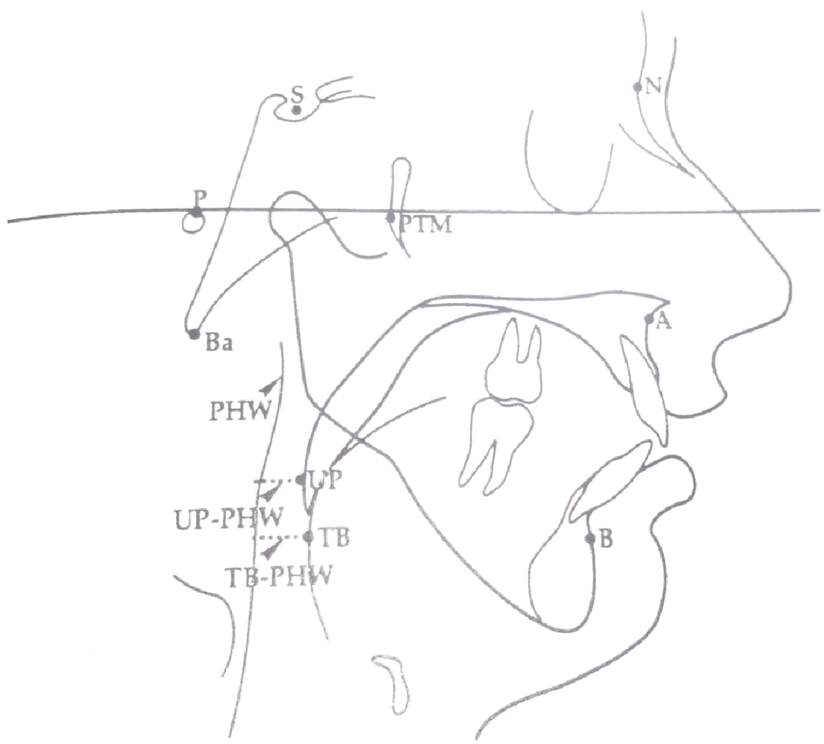

Figure 1. N – Nasion, S-Sella, P-Porion, Ba-Basion, PTM-Pterygomaxillary fissure, PHW-Posterior Pharyngeal wall, TB-Tongue base, UP-Soft palate protrusion, FH-Frankfort Horizontal plane, UP-PHW: Distance between soft palate protrusion and posterior pharyngeal wall parallel to Frankfort horizontal plane, TB-PHW: Distance between tongue base and posterior pharyngeal wall parallel to Frankfort horizontal plane

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