
Management of Obstructive Sleep Apnea by Maxillomandibular Advancement Surgery

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<http://dx.doi.org/10.5772/65437>

Abstract

Obstructive sleep apnea (OSA) is a common disorder characterized by recurrent episodes of partial or complete collapsibility of upper airway during sleep. The use of nocturnal positive airway pressure that pneumatically stents open the upper airway has been considered the first-line treatment of OSA. However, in the last two decades, maxillomandibular advancement (MMA) has been widely suggested as the most effective craniofacial surgical technique for the treatment of OSA in adults. It has been shown that the pharyngeal and hypopharyngeal airway could be enlarged with MMA surgery by physically expanding the facial skeletal framework. Tissue tension could be increased by forward movement of the maxillomandibular complex. Thus, collapsibility of the velopharyngeal and suprahyoid musculature could be decreased, and lateral pharyngeal wall collapse could be improved. Recent systematic reviews and meta-analyses showed that most of the subjects reported satisfaction after MMA with improvements in quality of life (QOL) measures and most of OSA symptomatology. According to the recent updates, MMA appears to be the most successful surgical option for the treatment of OSA, and it could be an excellent alternative procedure for nonresponders, or deniers of ventilation therapy.

Keywords: obstructive sleep apnea, maxillomandibular, advancement, surgery, orthognathic surgery

1. Introduction

Obstructive sleep apnea (OSA) is a common disorder characterized by recurrent episodes of partial or complete collapsibility of upper airway during sleep. Disturbed sleep pattern and less restorative sleep owing to the recurrent hypoxia events and sleep fragmentation can lead to the symptoms of excessive daytime sleepiness, fatigue, and neurocognitive deficits. The increased risk of accidents, cardiovascular and cerebrovascular morbidity and mortality such as myocardial infarction and stroke are life-threatening sequelae. Additionally, patients may have depression, physical and intellectual impairment, erectile dysfunction, and headache [1–10]. The mortality rate for severe OSA was reported as approximately 30% at 15 years, if it is left untreated [3].

Several treatment options have been recommended to OSA patients. The use of nocturnal positive airway pressure (either continuous [CPAP] or bilevel) that pneumatically stents open the upper airway has been suggested as the reference standard treatment for the management of OSA [2–5]. However, it was reported that more than 50% of patients showed poor adherence rates, within the first few months after initiation [2, 3]. Therefore, patients' compliance problem to CPAP leads them seek surgical treatment. Surgery has been shown to be another valid option for patients who are intolerant to positive pressure therapy. The posterior airspace of OSA patients, who is intolerant to CPAP, could be successfully increased by some soft tissue surgical procedures available. Despite that, the reported surgical success rate for these procedures is approximately 40–60% [3].

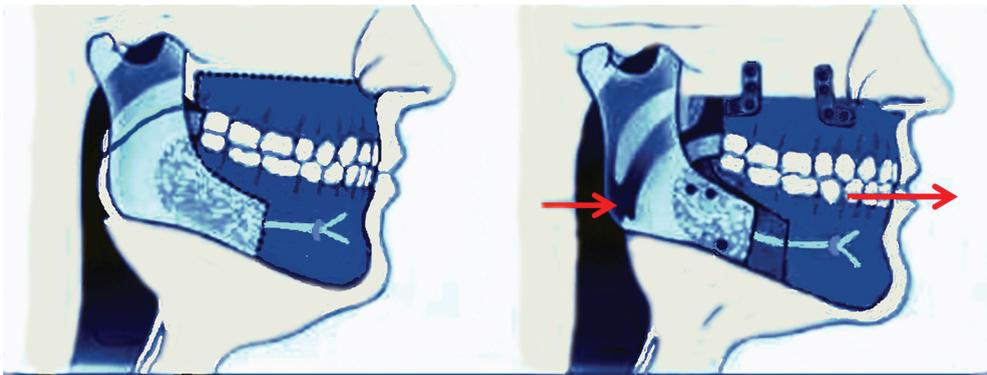


Figure 1. An illustration showing maxillomandibular advancement (MMA) surgery. Arrows show the upper and lower jaws move forward surgically and enlargement of the airway.

Another surgical treatment option for treating the patients with OSA is maxillomandibular advancement (MMA) surgery. It was suggested that MMA is currently the most effective craniofacial surgical technique for the treatment of OSA in adults [2, 7, 11]. By expanding the skeletal framework, MMA enlarges the pharyngeal space and enhances the tension of the soft tissues, reducing the collapsibility and obstruction of the pharynx (**Figure 1**) [3, 7]. This

procedure is routinely performed to correct dysgnathia [7]. In the previous studies, the surgical technique and pre- and postoperative care in the treatment of OSA have been extensively described [12, 13].

In this chapter, we firstly present some basic information about MMA surgery, and then, we review the published data concerning the recent updates related to the evaluations of effectiveness of MMA surgery performed for the treatment of OSA syndrome.

2. Preoperative examination

2.1. General workup

An exact medical and sleep history should be taken regardless of patients' age. Epworth Sleepiness Scale can be used for adults [14], but it is not excellent and does not every time establish a connection with OSA violence. Head, neck, and nasopharynx examination are recommended with a lateral cephalometric head film and fiberoptic nasopharyngoscopy. Also, nasal airway obstruction, lateral pharyngeal walls, the palatal region, tonsils, malocclusions and skeletal abnormalities, tongue and tongue base should be examined. Especially, polysomnography (PSG) is very important for a diagnosis or treatment plan [15].

2.2. Polysomnography

Preoperative and postoperative polysomnography is very sensitive method which is to evaluate of surgery success rate. On the other hand, this method also indicates the success rate of the surgeon. Some of the parameters such as; age, body mass index (BMI), total sleep time, sleep stages, apnea index, hypopnea index, awake SaO₂, lowest SaO₂, heart rate fluctuations, and periodic leg movements should be evaluated [15, 16]. These results are expressed as the respiratory disturbance index (RDI) or the apnea-hypopnea index (AHI). An AHI of 5 or less is evaluated normal for an adult [15].

2.3. Cephalometric head film

Cephalometric head films are used in orthodontics, which evaluates soft tissue and bony anatomy. Cephalometric radiographs can also be used to understand the hard tissue and soft tissue growth rate. For this purpose, specific points, planes, and angles on the head such as sella-nasion subspinale angle (SNA), sella-nasion-supramentale angle (SNB), distance from the superior nasal spine to the tip of the soft palate (PNS-P), posterior airway space (PAS), and distance from the mandibular plane to the hyoid bone (MP-H) are used [15, 17].

2.4. Fiberoptic examination

Nasopharyngolaryngoscopy is used to determine the obstruction at the nose, retropalatal, and tongue base area. It is also used to identify upper airway obstruction causes such as tumors, cysts, and laryngeal pathology [12].

2.5. Preoperative management

A detailed history should be taken from the patient and should be determined whether there is a systemic disease. Patients who undergo bimaxillary advancement have increased risks of medical, surgical, and regarding anesthesia. For that reason, these patients regardless of age should have an exact check-up. It should be explained to the patients what they will need to do on the day before surgery. In addition, arch bars should be applied to both jaws [15].

3. Surgical stage

3.1. LeFort 1 osteotomies

Firstly, a nasal intubation is requested from the anesthetist for the MMA surgery. Following a nasotracheal intubation, hypotensive tension could be wanted from anesthetist, in order to reduce bleeding of the patient. After that, local anesthesia could be also made to reduce bleeding and gain an additional anesthesia. Surgical operation is started by a maxillary gingivobuccal incision, which is made from the first molar on one side to the first molar on the opposite side. In order to expose the anterior face of the maxilla from the piriform rims anteriorly and back to the pterygoid processes, subperiosteal dissection is performed. For the avoidance of infraorbital nerve damage, mucosa retractor has to be used safely around infraorbital nerve area. After the piriform aperture is detected, the dissection is carried out medially to the nasal spine. Then, a round bur or saw is used to make horizontal osteotomies from the nasal apertures to the pterygomaxillary fissures bilaterally. Tooth apexes should be watched out during horizontal osteotomies. After that, osteotome is used to separate the nasal septum from the maxillary crest. Finally, using a curved osteotome the pterygoid plates are separated from the tuberosities of the maxilla. While doing this osteotome, one finger should be placed in the oropharynx at the level of the hamulus, in order to obtain a bimanual tactile feedback. To refrain injuring of the pterygoid plexus, osteotome must be put correct position on the pterygoid plate's areas. Then, downfracture is made and maxilla mobilized. The descending palatine arteries are checked out and preserved. If necessary, medial wall of the maxilla and other anatomical bone structures are shaved and removed according to the maxillary advancement and impaction planned. Adequate mobility must be acquired to advance the jaw passively into the requested position, which in many patients with OSA is around 10 mm. Rigid fixation of the maxilla is done with four titanium L-shaped four-holes miniplates (two per side) using 2.0 × 5 mm mono-cortical screws. An intermediate guide splint is frequently useful here to adjust the maxillary position and prevent midline disagreements and vertical faults of the jaw [17].

3.2. Bilateral sagittal split osteotomies

After local anesthesia, an incision is made throughout the external oblique ridge from midramus height to the mandibular first molar. Subperiosteal flap is raised to expose the lateral border of the mandible and anterior aspect of the ramus. Muscle on the medial part of the ramus

is stripped high enough on the coronoid process to access to the mandibular foramen and lingual process. The Hunsack modification of the Obwegeser and DalPont bilateral split sagittal osteotomy technique is applied [17]. Using lingula retractor, 4–5 mm horizontal osteotomy is made with a saw or burr until to just behind and above of the lingula. Osteotomy is made half way through the thickness of the bone, and parallel to the occlusal plane. Continuing osteotomy is made inferiorly with a sagittal saw blade along the anterior border of the ascending ramus till to the level of the first molar (remaining 5 mm lateral to the teeth). Then, the vertical osteotomy is performed on the buccal cortex, in a vertical direction near to the first molar, and is extended down to the inferior border. At the inferior border, the osteotomy must be completed to include both inner and outer cortices. The osteotomy should be extended superiorly at least 5 mm or more at the inner cortice of the mandible; otherwise, the bad split might be occurred. Osteotomes are used to track the osteotomy site throughout the entire length of the cuts, after that spreader is used to complete the splits on both sides of the mandible. Then, the inferior alveolar nerve must be detected, and if it is in the lateral segment, inferior alveolar nerve must be entrenched into the medial segment of the mandible. Surgical sites are abundantly irrigated and the throat pack is removed. The same surgical protocols applied for the opposite side. The correct position of the jaw is achieved by using the final splint. Maxillo-mandibular fixation is made by intermaxillary wires. Medial and lateral fragments of the mandible are fixed with three bi-cortical screws through intraoral and percutaneous approaches. Titanium plate/plates could be also placed and secured with mono-cortical screws. After that, intermaxillary fixation is solved by cutting the wires and the final splint is removed from the mouth. The mandibular movements and occlusion is checked. Bleeding is controlled, and then, soft tissues are sutured with 3-0 silk or chromic sutures. Finally, to avoid relapse, six or eight ounce elastic bands are placed and a head dressing is applied [17].

4. Postoperative evaluations

Patients with OSA who underwent MMA surgery stay mostly overnight in the intensive care unit (ICU). The use of CPAP could be useful, particularly when the patients are sleeping, to maintain the opening of airway, control of edema, and lessen the use of narcotics [15, 17]. Antibiotics, analgesics, steroids, and mouth rinse are prescribed. Higher lying position (around 30–45°) is set, and intravenous fluids are given. Application of ice is recommended in the first 48 h. Rigid fixation is not recommended because of the possibility of vomiting and airway obstruction. Advancement of the patients' diet consist of intravenous fluids for the first 24 h, then a full liquid diet is launched for a week, and followed by a no chew diet for 5–6 weeks. Discharge of the patient from the hospital is evaluated according to the absence of some parameters such as; fewer, pain, oral intake, surgeon, and patient's opinions. Generally, hospitalization time is 2–3 days for an adult OSA patient, who is underwent a bimaxillary procedure. Using of CPAP could be advised to the patients while sleeping until the follow-up polysomnography. The follow-up polysomnography is generally performed between the 4th and 6th months postoperatively [17]. If everything goes well, periodic controls are made at every 6 months for the first year, and then yearly.

5. Recent updates in management of obstructive sleep apnea by maxillomandibular advancement surgery

To date, MMA has been suggested as the most effective surgical treatment option available for OSA by sufficient number of published data [1–8]. Also, it was reported that MMA could possibly be the definitive primary single-stage option for the treatment of OSA in selected patients [2].

In 2010, Holty and Guilleminault at the end of their meta-analysis including 22 studies of 627 adult OSA subjects treated by MMA reported four key findings [3]. Firstly, they suggested that MMA is highly effective at treating OSA. They found that the mean AHI decreased from 63.9/h to 9.5/h with a pooled surgical success rate of 86.0%. Moreover, they specified that long-term surgical success was maintained at a mean follow-up of 44 months. Secondly, it was stated that the surgical success with univariate or multivariate analysis would not be predicted by the degree of mandibular advancement. Thirdly, it was concluded that MMA was generally safe procedure for treating OSA with a reported major surgical complication rate of 1.0% and minor complication rate of 3.1% and no reported deaths. Malocclusion (up to 44%) and persistent facial paresthesias (14.2% at one year) were also reported. Fourthly, satisfaction with the surgical outcome with few noting aesthetic complaints were reported by the most of subjects. After MMA, improvements in quality of life measures, OSA symptomatology (i.e., excessive daytime sleepiness), and blood pressure control were statistically significant [3].

Li [2] reported more than 600 MMAs for the treatment of OSA, with a success rate of 89% till 2011. This report was consistent with the published data and the results from the meta-analysis by Holty and Guilleminault [3]. Li [2] asserted that younger age and a lower BMI would be predictors for greater surgical success, as long as sufficient advancement could be performed. On the other hand, negative predictors were reported as older age (upper than 60 years), greater BMI (upper than 33 kg/m²), and limited advancement. Probable poor candidates for surgery were specified as obese patients with white fat accumulation and abnormal adipocyte activity, or those with a long disease duration with a greater risk of permanent neurologic deficits in the pharyngeal airway. However, it was also reported that patients with negative predictors could experience significant improvement. Thus, a dramatic resolution on the symptoms could be obtained in the most of patients with some residual OSA on polysomnography. In spite of that, a few patients with minimal improvement despite a very successful operation with 15-mm advancement were reported [2].

Thus, though good outcomes could be obtained, successful outcomes might not be achieved in all patients. Therefore, the complexity of OSA should be accepted. As a result, it must be recognized that a 100% success rate should not be claimed by any surgeon. Moreover, the major concern of MMA surgery should be the associated risks, as with any surgical intervention. Conclusively, followings are essential to achieve an ideal and successful outcome; performing of proper surgical methods with adequate advancement and fixation techniques, management of the soft tissue changes without compromising the esthetic results, and precautionary in airway management [2].

In order to achieve greater advancement with minimal adverse esthetic effects, certain reserachers have also tried to modify surgical techniques. For example, Bruno-Carlo et al. [18] described monocortical genioplasty, and segmentectomy after premolar extraction in both jaws was performed by Goh et al. [19].

In another systematic review of 39 studies conducted by Pirklbauer et al. [7], maxillomandibular advancement was reported as the most successful surgical therapy. Also, the postoperative polysomnography results were comparable to those under ventilation therapy. According to their results, recently MMA was preferred as a primary intervention by more investigators than had been done in the past. Thus, they concluded that OSAS patients with skeletal deficiency could benefit from MMA as a primary surgical intervention and do not need be subjected to less successful surgical procedures [7].

Because sleep endoscopy during spontaneous sleep does not seem applicable in routine clinical practice, airway endoscopy with pharmacologic sedation, or druginduced sleep endoscopy (DISE) was described [20]. Dynamic evaluation of the airway during drug-induced sleep using endoscopy has increased in popularity and also proved to be an important tool in predicting the outcome of upper airway surgery for patients with OSA [21, 22]. It is still inconclusive whether drug-induced sleep could be generalized to natural sleep. On the other hand, it is obvious that DISE can allow to observe the dynamic airway activity in real time.

It was reported that MMA expands the skeletal frame attached with the pharyngeal structures and tongue. Thus, it results in an increased upper airway space by reducing airway collapsibility during negative-pressure inspiration [3, 23, 24].

Before, the intrapharyngeal changes after MMA had only been studied using static imaging and endoscopy of subjects who were awake. In 2015, Liu et al. [23] aimed to characterize the patterns of dynamic airway collapse during sleep endoscopy for subjects before and after MMA. At the end of their study, their results showed that the tension in the lateral pharyngeal wall increased significantly after MMA and the change correlated highly with surgical success. They reported that the tension in the lateral pharyngeal wall would contribute more to success than did the changes at the palate or tongue base. As a result, they concluded that the subjects without a history of intrapharyngeal soft tissue surgery (palatal or tongue) had greater improvement in the AHI [23].

In 2016, Faria et al. [25] also compared the dynamic differences occurring in the pharynx during sleep after MMA surgery for the treatment of patients with OSA. This was a prospective, cross-sectional study. Twenty patients (fifteen men and five women) were submitted to magnetic resonance (MR) during propofol-induced sleep before and six months after surgery. Then, their variability before and after MMA were compared. During induced sleep after MMA, 66% mean linear anteroposterior increase of the pharynx was reported in the retrolingual region. It was specified that the coefficient of variation of the linear measurements was reduced from 117.5 to 51 % after surgery. At the end of the study, it was concluded that MMA promoted an important increase in the pharynx during induced sleep. Also, the diameter of the organ was with a lower variation during the respiratory movements. Thus, there was greater airway

stability and a consequent maintenance of the pharyngeal lumen that reduces or even prevents pharyngeal collapse [25].

In another meta-analysis conducted in 2015, comparison of the patients with OSA who undergo MMA with counterclockwise (CCW) rotation and those who undergo MMA without CCW rotation was investigated by Knudsen et al. [26]. Consequently, they reported that CCW-MMA or MMA in patients with OSA resulted in a statistically meaningful decrease in postoperative AHI and a statistically meaningful increase in postoperative lowest oxygen saturation (LSAT) [26].

Another important issue is that the comprehensive examination of the long-term effectiveness and safety of MMA as an alternative therapy to CPAP. In 2015, Boyd et al. [5] conducted a study to determine if MMA is a clinically effective and safe long-term treatment for OSA patients by measuring the changes in the AHI, blood pressure, sleepiness, and QOL. Their results showed that MMA produces substantial and sustained reductions in the diastolic blood pressure, and subjective sleepiness, AHI with accompanying improvements in QOL. It was important that MMA had a good risk-benefit ratio, as these successful outcomes had been achieved in the context of minimal long-term treatment-related adverse outcomes. They concluded that the results of their study provided compelling evidence to suggest that MMA should be the alternative treatment of choice for patients with severe OSA who cannot fully adhere to CPAP [5].

Beside many studies regarding long-term effectiveness and safety of MMA surgery for the management of obstructive sleep apnea (OSA), the subjective effect of this treatment modality was also investigated by Butterfield et al. [4] in 2016. In this study, quantification of the subjective change in QOL in patients who had undergone MMA for the management of OSA; assessment of the effect of the treatment-related side effects of MMA on patient QOL; and evaluation the relationship between objective changes in OSA severity with the subjective changes in QOL were studied. Their study showed that although some patients might experience few MMA-related postoperative side effects during recovery, MMA for OSA significantly improved patient's subjective overall QOL [4].

In addition to many studies in the literature showing MMA as a safe treatment modality, there is another study dealing with detailed comparison of outcomes in OSA and dentofacial deformity (DFD) patients undergoing the same procedures. Passeri et al. [11] compared morbidity and mortality rates in OSA versus DFD patients undergoing equivalent maxillofacial surgical procedures. Their study indicated that even though the patients in the OSA group were older, had more comorbidities, and ultimately had a greater number of early, late, minor, and major complications than those in the DFD group, MMA seemed to be a safe procedure [11].

As well as many adult OSA patients, Ahn et al. [27] reported that a 11.1 years old female patient with refractory OSA (AHI score of 8.2, and RDI score of 11.6) and serious medical history (pneumonia, asthma attacks, hyperventilation-related dyspnea or tachypnea, psychosocial problems, etc.) could be treated by modified MMA surgery, accompanied by upper and lower anterior segmental osteotomies (ASOs). As a conclusion, they proposed that modified MMA

surgery, combined with ASOs, could be a successful treatment alternative for a preadolescent patient with refractory OSA. They specified that postoperative improvement occurred in the affected functions and esthetics, and the improvements were stable throughout the growth period of their patient [27].

6. Conclusions

In our opinion, the recent evidences in the published data support the recommendation of MMA to treat patients with severe OSA who cannot fully adhere to CPAP.

According to the recent updates, MMA appears to be the most successful surgical option for the treatment of OSA, and it could be an excellent alternative procedure for non-responders, or deniers of ventilation therapy. However, more randomized controlled trials on larger sample sizes, and long-term investigations are needed to attain this recommendation.

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