

Changing of Facial Skeleton for Treatment of Obstructive Sleep Apnoea Syndrome

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Abstract: Obstructive sleep apnoea syndrome (OSAS) is a potentially life-threatening disorder. It is characterized by at least five episodes of apnoea or hypopnoea during sleep lasting for more than 10 seconds. Apnoea or hypopnoea are accompanied by respiratory efforts. Changes of the facial skeleton by mandibular or maxillo-mandibular advancement belong to surgical techniques which might affect moderate and severe OSAS. In the surgical procedure mandible alone or the upper and lower jaws are moved forward by at least 10 mm. Thus also muscles fixed to the facial skeleton and upper airway dilators are moved forward. The discussion also mentions possible complications and limitations of this surgical technique.

Key words: Facial skeleton – Obstructive sleep apnoea syndrome – Maxillo-mandibular advancement – Upper airway dilatation – Stability

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Introduction

Obstructive sleep apnoea syndrome (OSAS) is a potentially life-threatening disorder [1] affecting in the USA, for example, up to 18 million people [2]. It is characterized by at least five episodes of apnoea or hypopnoea lasting for more than 10 seconds per hour of sleep. Apnoea and hypopnoea are accompanied by respiratory efforts. If the effort is missing it is central apnoea.

Obstruction in the upper airway may occur at the level of velopharyngeal area (Fujita type I) or at the level behind the tongue base (Fujita type III) and/or concurrently at both levels (Fujita type II) [3].

Craniofacial abnormalities could be among the causes of airway obstructions; however, usually it is impossible to find an unambiguous pathology leading to this disorder.

According to the number of apnoea and hypopnoea episodes per hour of sleep (respiratory disturbance index – RDI) OSAS can be classified as mild OSAS (RDI 5–15), moderate OSAS (RDI 15–30) and severe OSAS (RDI > 30).

Both surgical and non-surgical techniques are used to treat the disorder. Non-surgical treatment for mild and moderate OSAS consists of changes in the sleep habits (sleep hygiene) or using lower jaw positioners. Severe OSAS requires the use of a device delivering air with elevated pressure to upper airway during sleep (continuous positive airway pressure – CPAP or bi-phasic, which pressure fluctuates depending on the respiration). The device could also have an autotitration feature when the pressure is regulated based on the current resistance in the upper airway. Pressure effect is fully curative for OSAS [4].

All the above devices require fixed mounting of a nasal breathing mask throughout the whole duration of the sleep. This is unacceptable for some patients for various reasons. Also, patients with a hypoplastic lower jaw show low compliance. For them, pressure in the upper airway is heavily uncomfortable [5].

Surgical techniques extend the upper airway by various mechanisms. Table 1 [6] gives success rates of individual surgical techniques.

In mild and moderate OSAS we modify the airway depending on the location of obstruction by uvulopalatopharyngoplasty – UPPP (obstruction of Fujita type I) or genioglossus advancement and hyoid myotomy – GAHM (obstruction of Fujita type III) [7].

Surgical treatment which might affect severe OSAS includes only permanent tracheotomy, maxillo-mandibular advancement and in case of mandibular hypoplasia just mandibular advancement. There are strict indication criteria available for use of tracheotomy and this technique is used only rarely in practice (see Table 2) [8]. Mandibular and maxillo-mandibular advancements represent a socially well accepted solution. Our indication for use of maxillo-mandibular advancement and mandibular advancement see Tables 3 and 4.

Table 1 – Overview of surgical treatment success rate for OSAS (in %) [6]

Surgery	Obstruction Localisation	Success Rate*
UPPP	type I	74.6%
GAHM	type II	67.0%
UPPP + GAHM	type II	83.3%
GAHM	type III	85.7%
MMA	type I–III	94.7–100%
Tracheotomy	type I–III	100.0%

*Success rate of the treatment is defined as RDI decrease to at least a half, however at most to 20, and increase of the average oxyhemoglobine desaturation by a half, however at least to 90%. List of acronyms: UPPP – uvulopalatopharyngoplasty, GAHM – genioglossus advancement and hyoid myotomy.

Table 2 – Tracheotomy indication by Fujita [8]

Apnoea accompanied by bradycardia (pulse <40)
Apnoea accompanied by frequent asystolia
Frequent decrease of O ₂ saturation below 50%
Ventricular tachycardia
Severe hypercapnia (PCO ₂ >50 ml)
OSAS with cor pulmonale

Table 3 – Indication criteria for maxillo-mandibular advancement

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|---|
| 1. Manifested moderate or severe OSAS (RDI>15, decrease in the lowest saturation below 90%, manifested excessive daytime sleepiness). |
| 2. Treatment by pressure in the upper airway is not successful or not tolerated by the patient. |
| 3. Patient does not suffer from a severe internal disease (ASA<3). |
| 4. Patient is not psychologically altered and wishes to undergo a surgical treatment. |
| 5. PAS (Posterior Airway Space) at the lateral cephalogram does not exceed 9 mm. |
| 6. Pre-existing defect of the facial skeleton. |

Table 4 – Indication criteria for mandibular advancement

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| 1. Manifested moderate or severe OSAS (RDI>15, decrease in the lowest saturation below 90%, manifested excessive daytime sleepiness). |
| 2. Treatment by pressure in the upper airway is not successful or not tolerated by the patient. |
| 3. Patient does not suffer from a severe internal disease (ASA<3). |
| 4. Patient is not psychologically altered and wishes to undergo a surgical treatment. |
| 5. PAS (Posterior Airway Space) at the lateral cephalograms does not exceed 9 mm. |
| 6. Pre-existing hypoplastic mandible – congenital or post-traumatic |
| 7. Angle class II. division A or B malocclusion |

Surgical Technique of Maxillo-mandibular Advancement

The principle of this surgical treatment for an OSAS patient was described for the first time in 1979 [9]. It is shown in Figure 1.

Preoperative orthodontic preparation help to adjust the patient's dental arches in order the maximal intercuspitation is achieved. The fixed orthodontic device together with a surgical arch is applied to improve further the oral architecture. The surgical arch is then used during and after the surgery for stabilization and immobilization through elastic intermaxillary fixation.

Standard preparation is performed similarly to any orthognathic surgery. The surgery is first simulated on a lateral cephalogram. The movement of the upper jaw is at least 10 mm anteriorly and we also plan possible reclining of the occlusal level in accordance with the size of the gonion angle and the smile line. Reclining angle is always around 3 to 5 degrees in the clock wise motion. Then, we make impressions of the patient's upper and lower teeth and register intermaxillary relations and the gradient of the articular path by a facial arch. This registration is then transferred to the articulator adjusted individually. We simulate the surgery in a lab using a plaster model with relevant movements in the articulator. Thus we make two splints.

A peroperative splint will help us to locate exactly the upper dental arch relaxed in the line of Le Fort I against the rigid lower dental arch. The postoperative splint is then made in accordance with the planned habitual occlusion.

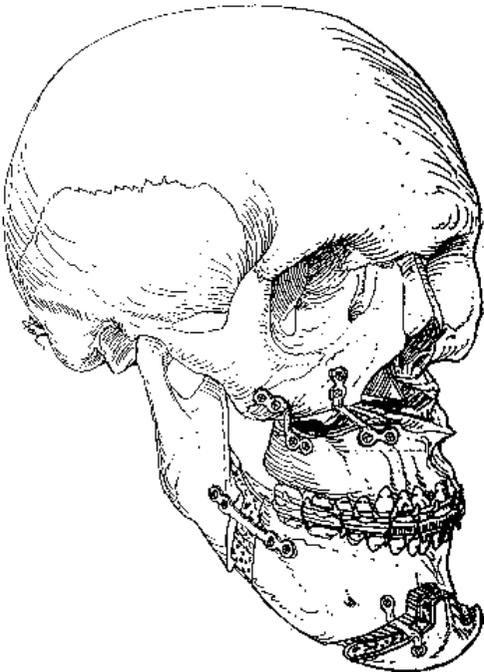


Figure 1 – Principle of the maxillo-mandibular advancement.

The surgery is performed under general anaesthesia with a naso-tracheal intubation.

The surgery starts with osteotomy of the upper jaw in the Le Fort I line extended also to the caudal part of the processus pterygoideus. Having cut off the nasal septum, down fracture and mobilised the lower fragment of the upper jaw together with the upper dental arch we move this released fragment together with the muscular insertions of the soft palate forward by 10 mm with a 3-mm caudal inclination in the anterior part. Thus we also expand the capacity of the nasal cavity and velopharyngeal isthmus. Osteotomy is performed as low as possible to avoid excessive postoperative change of the paranasal area, however at least 5 mm above the apexes of upper teeth. A peroperative splint into which we temporarily fix dental arches using wire intermaxillary fixation will determine the size and direction of the movement. We fix the moved fragment of the upper jaw with the dental arch in the new position with four titanium mini splints and a total of 16 titanium screws in the area of paranasal and infrazygomatic pillars.

Following fixation of the upper segment we remove the temporary wire intermaxillary fixation and perform bilateral sagittal osteotomy of the lower jaw ramus (sec. Obwegeser or sec. Epker). The anterior section is placed on corpus mandibulae as anteriorly as possible, approximately in the area of the first molar teeth. Having split the bone using the Obwegeser technique we perform bilateral mobilization of the anterior segment of the lower jaw together with the lower dental arch. Then we move the fragment forward and slightly autorotate in order to achieve maximum occlusion. The occlusion is again temporarily fixed by postoperative splint and rigid intermaxillary fixation. Anterior motion of the lower jaw expands the retrolingual area and removes potential obstructions at this level. To fix all mandibular fragments in the new position we use bilaterally two titanium mini-plates and four to six titanium mini-screws. Postoperative rigid intermaxillary fixation is not necessary and in principle we do not perform it. Instead, we use light neutral elastic intermaxillary fixation. Finally, we perform genioplasty according to Kölle with our tenon and mortise modification whereby we achieve even greater expansion of the retrolingual area by anterior advancement of the mm. genioglossus. This sliding osteotomy of the chin is also fixed by titanium mini-plates.

Due to possible alteration of the upper airway by oedema we closely monitor the patient the first 24 hours after the surgery at the postoperative recovery unit.

In the postoperative period, fluid diet must be supplied for three weeks followed by three-weeks of the soft diet.

Should there be no improvement in the ventilation parameters following the surgery, some authors recommend also GAHM (genioglossus advancement and hyoid myotomy) or UPPP (uvulopalatopharyngoplasty) in the second phase or both interventions concurrently.

Mandibular advancement

During this operation, only mandible is moved anteriorly. The natural growth deficit of the mandible is thus compensated. The mandible is moved anteriorly after bilateral sagittal split osteotomy of the ramus as describe above. Together with the mandible also the extraglossal muscles are moved resulting in widening of the upper airway.

As the hypoplastic mandible is almost always accompanied by a wrong position of individual teeth, it is necessary to decompensate this malocclusion before the mandibular advancement with the orthodontic therapy (fixed orthodontic appliances). This therapy involves removal of compensatory angle of upper and lower teeth by fixed orthodontic apparatuses. This process is called decompensation and its main task is to fix teeth in both jaws in ideal positions. The mutual maximum intercuspitation is then reached by mandibular advancement. Figure 2 demonstrates the change of dimensions of the upper airway on lateral cephalograms and photos after orthodontic decompensation and



Figure 2 – Patterns of upper airways on lateral cephalograms and photos of the patient before treatment, after the orthodontic decompensation and after the mandibular advancement.

mandibular advancement. As demonstrated also by our work [10] this operation expands not only the retrolingual space, but also the retrovelopharyngeal space as the soft palate is more vertical and it tilts from the dorsal nasopharyngeal wall.

Discussion

As it has been repeatedly stressed the maxillo-mandibular advancement treatment is reserved for cases of severe OSAS and for patients whose upper airway dimensions have been affected by an anomaly of their facial skeleton. The main advantage of this treatment is the possibility of widening both the retrolingual and velopharyngeal space with the possibility of extending also the nasal cavity volume. Its high success rate (approx. 94.7–100%) is an advantage. That is why some authors recommend this method as the only acceptable surgical technique for OSAS treatment [11]. Based on our opinion and experience, mild and moderate OSAS can be quite successfully treated with other surgical techniques such as GAHM or UPPP [7].

On the other hand, this method is quite demanding for the surgeon and it results in a change of the patient's facial type. The change in appearance is quite dramatic. Figure 3 shows lateral cephalograms of the patient before and after the maxillo-mandibular advancement. The postoperative cephalometry values indicate a

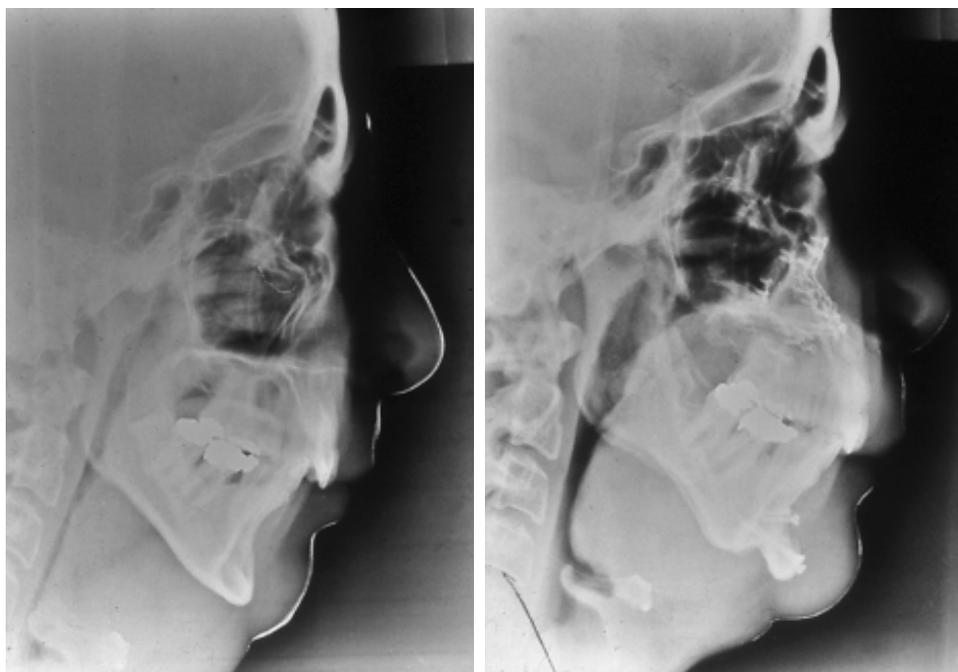


Figure 3 – Lateral cephalogram of the patient before and after the maxillo-mandibular advancement.

significant bimaxillar protrusion. Our patient accepted the change very well and in a positive manner, may be also thanks to a significant improvement of his general state. However, it can be stated that in general the change is always aesthetically acceptable [12, 13] due to the mechanism of the surgery representing a reverse face lift (soft facial tissues are not stretched on the facial bones, but the facial bones are pressed against the soft tissues). The decision-making process is certainly made easier by the use of predictive simulation programmes allowing simulating a probable postoperative appearance of the patient. Due to extensive movement of the fragments caution should be applied in particular in slim patients with a thin layer of soft facial tissue envelope. In this case, a very unsightly deficiency of labial closure could develop.

Postoperative monitoring at the postoperative recovery unit is also very important. Patients suffering from OSAS are frequently polymorbid and thus it is important to take their overall condition into consideration when indicating a treatment. Risks according to ASA 3 and 4 represent, in our opinion, a contraindication. In these patients we indicate a non-surgical therapy using CPAP. We also believe that obesity with BMI over 29 kg/m² represents a contraindication [14].

References state severe postoperative oedema in the upper airway requiring a long-term intubation or even tracheotomy as a possible complication. Later complications include mainly a relapse [15] resulting in a loss of the maximum occlusion. Some authors use bone inlays between osteotomies.

Frequently described complications are dysfunctions of the temporo-mandibular joint. Kerstens et al. [16] in his publication on the influence of orthognathic surgery on the temporo-mandibular joint states, that in 11.5% of patients out of a total of 480 he observed development of new symptoms evidencing different types of temporo-madibular dysfunctions. On the other hand, 2/3 of patients who suffered from some type of temporo-mandibular dysfunctions before the surgery had no problems after the orthodontic surgery. Similar results can be found also in a study by White and Dolwick [17] describing 7.9% of new postoperative temporo-mandibular dysfunctions in 296 treated patients, but almost a 90% success rate in removing preoperative temporo-mandibular defects. The truth is that despite significant efforts we were unable to find a valid study on this complication particularly in OSAS patients after MMA. However, this complication must be taken into account in the future and the patient must be informed about it within the preoperative informed consent.

Recent references mention cases of performing maxillo-mandibular advancement gradually through the distraction osteogenesis [18]. The principle of the operation remains the same, osteotomy is performed as mentioned above, but the fragments are not moved anteriorly, but distractors are attached to the bones. They represent simple devices based on a principle of expandable bolt. Bones in the place of the osteotomy are gradually moved away by sequence

rotations of the bolt and a new bone is formed. Fragments are moved away at a rate of approx. 1 mm per day and activation of the distractors occurs approx. one week after the osteotomy. At this time, callus is already being created in between the bony fragments. The callus has two useful characteristics: it is flexible and preserves its ability to turn into bone. The authors state that by gradual movement of the face bones in anterior direction they can better control the impact of the advancement on the upper airway. The patient is connected to a polygraph every night and respiration parameters in sleep are monitored. Thus, it is possible to precisely set the scope of movement of the face bones necessary to reach normal respiration parameters and to eliminate the risk that the movement resulting from the maxillo-mandibular advancement (approx. 10 mm) is insufficient or – on the other hand – too large. Thus, the facial changes are not as profound as sometimes observed after the classical maxillo-mandibular advancement.

Probably, one can challenge the argument of insufficiency of the 10mm advancement, as all the studies on maxillo-mandibular advancement state a very high success rate (94–100%). We also know from our own experience that patients with severe OSAS tolerate hypoxia very well and a sudden removal of the upper airway obstruction does not immediately result in improvement of respiration parameters in sleep. Thus, the monitoring the immediate effect of the distraction of facial skeleton by a polygraph is not the most precise one and can lead to false negative readings.

Conclusion

Based on available references and oral sources, maxillo-mandibular advancement is indicated for the therapy of patients suffering from OSAS with a defect of their facial skeleton. Patients must be informed in advance that the surgery would result in a change of their facial type.

Encouraged by this data from the references we can recommend this surgical method as an alternative to non-surgical therapy by positive airway pressure in upper airway in patients suffering from severe OSAS and with an existing facial skeleton defect.

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