Maxillomandibular Advancement

Contemporary Approach at Stanford

Stanley Yung-Chuan Liu, MD, DDS [a,*], Michael Awad, MD, FRCSC [b], Robert Wayne Riley, MD, DDS [a]

KEYWORDS

• Obstructive sleep apnea • Maxillomandibular advancement • Facial skeletal surgery • Counterclockwise rotation • Lateral wall stabilization

KEY POINTS

- Maxillomandibular advancement (MMA) demonstrates consistently high surgical success and modest cure rates for patients with obstructive sleep apnea (OSA).
- Indications for MMA as first-line surgical treatment include patients with preexisting dentofacial deformity, severe OSA, and airway collapse pattern (complete centric at velum, and complete at lateral pharyngeal wall) examined by drug-induced sedation endoscopy (DISE).
- MMA involves a counterclockwise rotation with the center at the maxillary buttress to maximize airway muscle tension and balance facial esthetics.
- Technique modifications from routine orthognathic surgery for MMA are important to address both surgical and patient related factors.

Video content accompanies this article at http://www.oralmaxsurgeryatlas.theclinics.com.

Introduction: nature of the problem

Since the authors' first review of 40 patients undergoing maxillomandibular advancement (MMA), a procedure pioneered at Stanford Hospital for the treatment of obstructive sleep apnea (OSA), MMA has remained one of the most effective and reliable surgical intervention for OSA, with its high surgical success rate.[1–5]

In the early years, MMA was part of a 2-phase algorithm where phase 1 (palate, nasal, tongue base procedures, hyoid advancement, and genioglossus advancement) was followed by phase 2 (MMA) in cases of treatment resistance. The earliest indications for MMA included severe OSAS, morbid obesity, severe mandibular deficiency, and failure of other forms of therapy.[6,7]

Today, selection criteria for MMA includes the use of dynamic examination, such as drug-induced sleep endoscopy (DISE). MMA is particularly effective in treating OSA patients with lateral pharyngeal wall and concentric velum collapse during DISE. Severe OSA patients with this collapse pattern tend to have low hyoid position, as shown with sleep MRI.[8] Because concentric collapse of the velum is contraindicated in upper airway (hypoglossal) stimulation, and lateral pharyngeal wall collapse is difficult to address with soft tissue pharyngeal procedures,[9,10] MMA can be a first-line recommendation in OSA patients with this dynamic airway collapse pattern.

MMA is also performed in OSA patients with dentofacial deformity. However, in patients with Class 1 skeletal relationship, MMA with airway-specific counterclockwise (CCW) rotation can be expeditiously performed with minimal orthodontic decompensation.

The role of MMA in reducing the burden of disease in OSA is an important distinction from previous representations where surgical cure was the primary outcome. A favorable outcome is one that mitigates patient symptoms and comorbid risk, with improved quality of life reflected by high levels of patient satisfaction. MMA need not be the only intervention; the authors have performed soft tissue pharyngeal surgery and hypoglossal nerve stimulation to achieve overall treatment success (cure).

There are ample texts that describe the basics of jaw surgery which involve Le Fort I and sagittal split osteotomies. This Atlas article focuses on key steps that define the Stanford MMA. These steps are founded on 3 decades of experience with Nelson B. Powell and Robert W. Riley. Contemporary extension of their philosophy from breathing-focused to bite (brevity of orthodontic treatment with surgery-first protocol) and beauty (balance of facial proportions including nasal form and function) by Stanley Y.C. Liu is also highlighted.

Disclosure Statement: The authors have nothing to disclose.

[a] Division of Sleep Surgery, Department of Otolaryngology, Stanford Sleep Surgery Fellowship, Stanford University School of Medicine, 801 Welch Road, Stanford, CA 94304, USA
[b] Division of Sleep Surgery, Department of Otolaryngology—Head and Neck Surgery, Stanford University School of Medicine, Stanford Hospital and Clinics, 801 Welch Road, Stanford, CA 95304, USA
* Corresponding author.
E-mail address: ycliu@stanford.edu

https://doi.org/10.1016/j.cxom.2018.11.011

Surgical technique

Preoperative planning

Appropriate patient selection begins with a thorough history, subjective questionnaires (Epworth Sleepiness Scale and Nasal Obstructive Symptom Evaluation), head and neck physical examination, polysomnography interpretation, and fiberoptic nasopharyngoscopy observation. Selectively DISE is used. These objective and subjective examinations can be used in combination with CT imaging to identify appropriate skeletal surgery patients and plan procedures.

The most unique aspect of today's Stanford MMA in preoperative planning is the center of rotation for the maxillomandibular complex (MMC). Although it is a CCW rotation, the center of rotation is uniquely placed to maximize both airway stability and facial esthetics. Additionally, the main reference points and movements for planning are (1) advancement from a point at the piriform rim just below level of the inferior turbinate, (2) degree of occlusal plane change dictated by the maxilla, and (3) postoperative position of the pogonion. If patients also exhibit dentofacial deformity, this is certainly addressed, but the general principle of movement, as described here remains consistent.

Prior to virtual surgical planning (VSP), Riley and Powell performed what is commonly described in the cosmetic maxillofacial literature as a single-splint technique.[11] This requires extensive experience to control the pitch, roll, and yaw of the MMC and is difficult to reproduce consistently by junior surgeons.

With VSP, surgical movements are planned, and 2 intermediate splints are usually produced to maximize the freedom to balance facial and airway position intraoperatively. Regarding the movement, a differential anterior impaction is performed with the rotation center in line with the buttress. CCW rotation has been described with centers at the anterior nasal spine (ANS) or posterior nasal spine (PNS). The buttress may seem like a peculiar landmark. The rationale is that when the maxilla is rotated in line with the buttress and the level of first molar is maintained, the CCW rotation actually brings the entire maxilla posterior to the original piriform rim. From here, an advancement of approximatley 3-mm to 5-mm anterior to the piriform translates to a final pogonion position approximately 12-mm to 18-mm anterior and 2-mm to 4-mm superior to its original position. The maxillary occlusal plane rotates in CCW direction by approximately 6° to 10°. Attention is given to correction of concurrent orthognathic problems if present (ie, mandibular asymmetry or class 2 or class 3 discrepancy). Notice that the surgery is not planned based on classic cephalometric measures, such as the SNA and SNB. The MMA movements, as described here advance and rotate the MMC to optimize airway and esthetic outcome.

In the representative VSP plan shown in Fig. 1, there is an occlusal plane change of 11° in a CCW fashion. This is planned via a 3-mm impaction at the piriform rim, while keeping the center of rotation at the buttress. The maxilla is then advanced just 5-mm anterior to the piriform rim. This movement results in a 12-mm advancement at the incisor, 7.6-mm advancement of the A point, 15.7-mm advancement of the B point, and a 23.5-mm advancement of the pogonion (Fig. 1).

This MMA patient in Fig. 2 underwent a similar movement. Due to the relatively small change at the midface coupled with piriformplasty and intraoperative septoplasty, his midfacial balance is not compromised. At the same time, note the significant advancement of the mandible, which is discernible both in the clinical photo and the immediate postoperative CT in the lateral view (Figs. 2 and 3).

Preparation and patient positioning

There are 2 important nuances to the positioning of the MMA patient compared with the orthognathic patient.

Classically, nasal RAE tubes are popular for orthognathic cases. OSA patients, however, tend to have longer airways. This requires a longer tube, but the longer RAE (Ring, Adair and Elwyn) tubes have larger diameter lumens. This significantly distorts the nasal anatomy such that intraoperative septoplasty and piriformplasty are difficult to perform with accuracy. Instead, the authors use the microlaryngoscopy tube (MLT), where there is adequate length, and thinner diameters, such as a 5.0 mm or 6.0 mm. The authors trim back the tube toward the nares and place a 120° reverse metallic attachment, followed in-line with an accordion extension.

Patients are not placed on a shoulder roll because this tends to further extend the neck. The authors leave patients in their

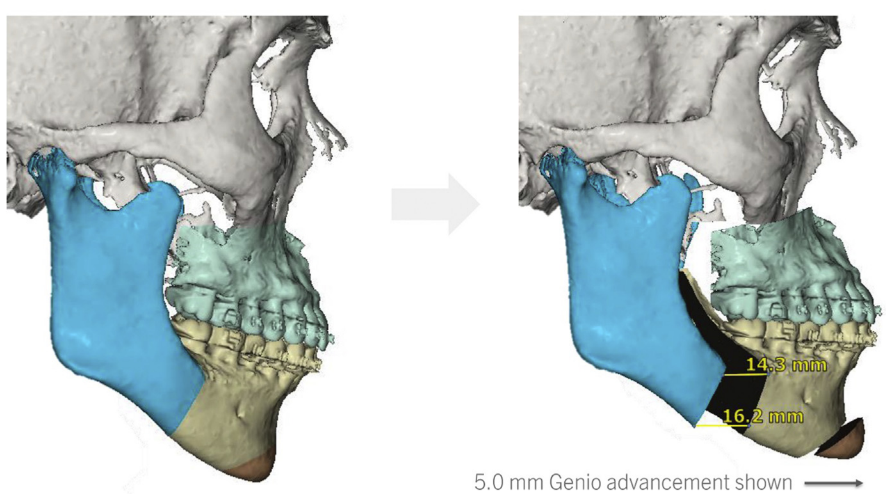

Fig. 1 VSP with CCW rotation centered at buttress (*left panel,* Before MMA; *right panel,* After MMA).

Fig. 2 MMA patient before (*left panel*) and after (*right panel*).

natural head position. This is important for control of the occlusal plane change (Fig. 4).

Anesthetic approach/sedation agent

Total intravenous anesthesia with agents such as propofol and remifentanil, is used. Although controlled hypotension with a target mean arterial pressure of 60 mm Hg is recommended for orthognathic procedures, in reality many MMA patients have significant cardiovascular comorbidities. Keeping the mean arterial pressure this low is both difficult for the anesthesiologist and contraindicated for some of the patients. The authors still aim for a brief period of controlled hypotension during maxillary down-fracture but most often are doing this at a mean arterial pressure of approximately 80 mm Hg. Total blood loss is approximately 250 mL to 350 mL for the procedure.

Although the authors' severe OSA patients are observed in the ICU for the first evening, all patients are extubated at the end of procedure. The authors work closely with anesthesia colleagues during extubation to help with nasal and oral suctioning. Postoperatively, the MMA patients are placed in light guiding elastics with no intraoral splint. This allows easy mouth opening in an emergent situation.

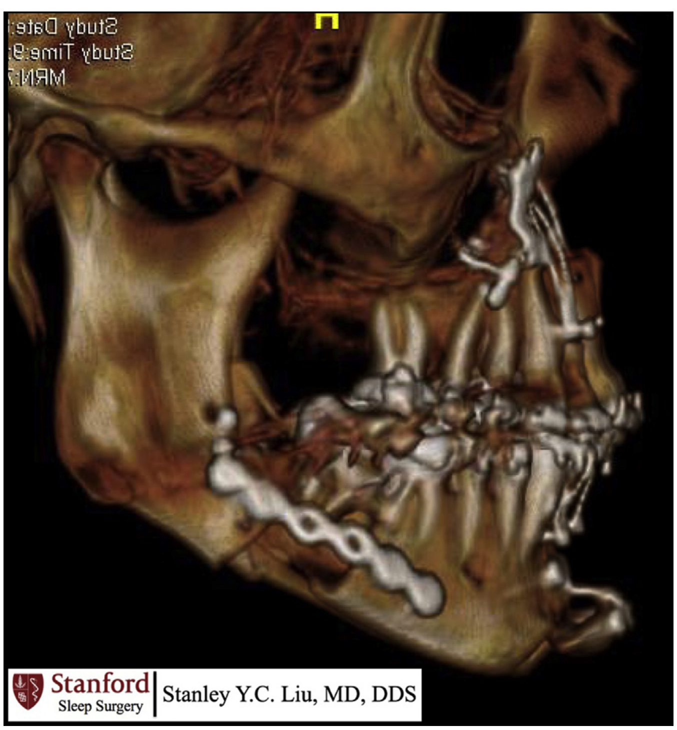

Fig. 3 Postoperative CT after MMA. Suspension wires are removed 6 weeks after surgery.

Surgical procedure

Approach to general aspects of MMA surgery is not discussed in detail. Instead, critical key steps are highlighted.

At the time of Le Fort I osteotomy, a wedge is created that determines the degree of CCW rotation. An appropriate degree of CCW rotation should not compromise incisor show in the final maxillary position.

The maxilla is never mobilized aggressively with instruments like the Rowe disimpaction forceps (Sklar Surgical Instruments, West Chester, PA). With a wire through the anterior nasal spine area to control the maxilla, lateral forces are applied concurrently to the posterior maxillary wall to mobilize the maxilla (Video 1). The usual anterior pull by the disimpaction forceps is especially ineffectively against previously operated soft

Fig. 4 Nasal intubation 120° metal connector.

palate. Large degree of torque by the disimpaction forceps is also uncontrolled, particularly in the average MMA patient, who tends to be an older adult.

With large CCW rotations, muscle tension associated with the maxilla and mandible is significant. For this reason, maxillomandibular fixation prior to rigid fixation is performed with the aid of suspension wires. The authors use suspension wires anchored to the alveolus with a 2.0-mm screw and through a hole by the piriform rim above the Le Fort osteotomy for the maxilla, and to the arch wire for the mandible. Maxillomandibular fixation prior to fixation with the use of 24-gauge wires on dental brackets or the arch bar would debond brackets or shift the arch bar. Minor discrepancy greatly affects accuracy of the final fixation.

The authors do not perform sagittal split osteotomy with instruments like Smith spreaders. Older patients tend to have little bone marrow space. With the need of longer osteotomy (anterior extent to the second premolar) for fixation after large advancements, the use of Smith spreaders lead to poorly controlled fractures. Instead, the authors focus on an accurate horizontal osteotomy just beyond the lingula, anterior osteotomy not past the inferior midline of mandible, and a wedging open of segments with 3 osteotomes in a sequential sandwiched fashion (Fig. 13).

Finally, with fixation, the authors use 2 to 3 bicortical fixation screws, coupled with a long 2.4-mm plate across the osteotomy site. The rigidity allows the patient a rapid return to function. Patients generally are not kept in a splint, and only light guiding elastics are used immediately after surgery. This allows MMA patients to breathe orally in the immediate post-operative period. By the end of the second week postoperatively, patients begin a pureed to soft diet. Minimal use of narcotic pain medications is expected.

Surgical steps

1. Le Fort osteotomy is followed by a wedge taken at the anterior piriform rim, with rotation center at the maxillary buttress (Figs. 5 and 6).

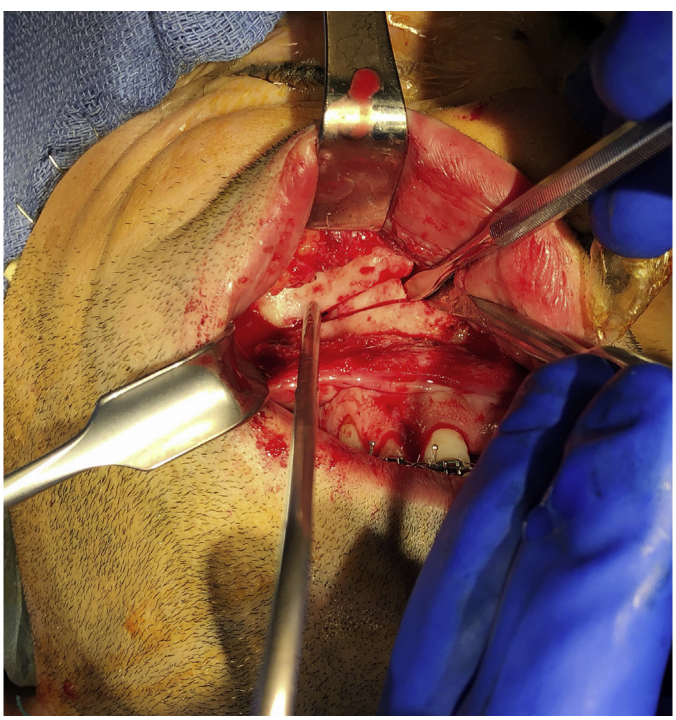

Fig. 5 Le Fort I wedge for counter clockwise rotation.

Fig. 6 Wedge removed.

2. A wire is passed through the anterior nasal spine to control the maxilla.
3. Specially designed gentle distractor is placed behind the posterior maxilla, anterior to the sphenoid bone (Video 1).
4. Descending palatine artery is identified and preserved (Fig. 7).
5. Maxillary mobility is ensured (Video 2).
6. Septoplasty is performed. The nasal floor is widened with a pineapple bur. The piriform rim is widened. The inferior turbinates are reduced with radiofrequency ablation, followed by outfracture. They are never resected entirely as classically described in orthognathic literature, to prevent atrophic rhinitis (Fig. 8, Video 3).
7. Frequently, OSA patients have chronic sinusitis with polyps. This is removed (Fig. 9).
8. Intermediate splint is placed, and measurements taken to ensure no cant has been introduced.
9. Preformed step-plates or custom plates are used to fixate the maxilla.
10. Suspension wires are placed, looping around a hole in the lateral piriform rim above the level of Le Fort I osteotomy, to a 11-mm or 13-mm screw placed in the alveolus. For the mandible, the wire wraps around the arch wire/arch bar, to a similar alveolus screw. These wires later are used to perform maxillomandibular fixation prior to

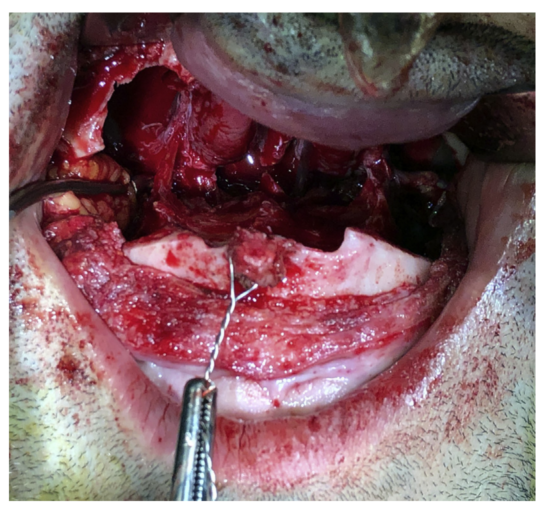

Fig. 7 Control of the maxilla via wire through anterior nasal spine. Descending palatine arteries are visualized bilaterally.

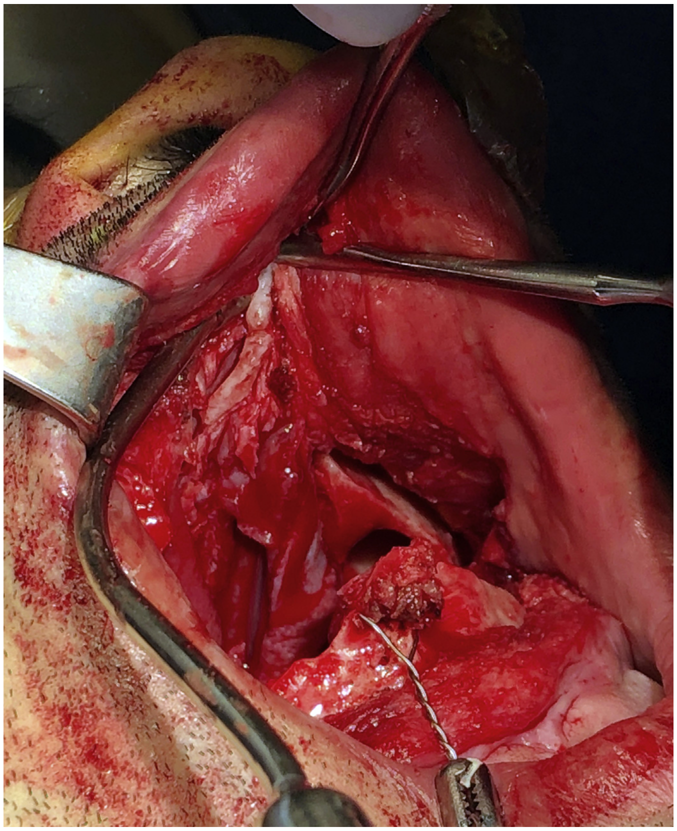

Fig. 8 Septum exposed.

application of mandibular bicortical screw and plates (Fig. 10).

11. Assessment of degree of maxillary advancement achieved (Video 4).

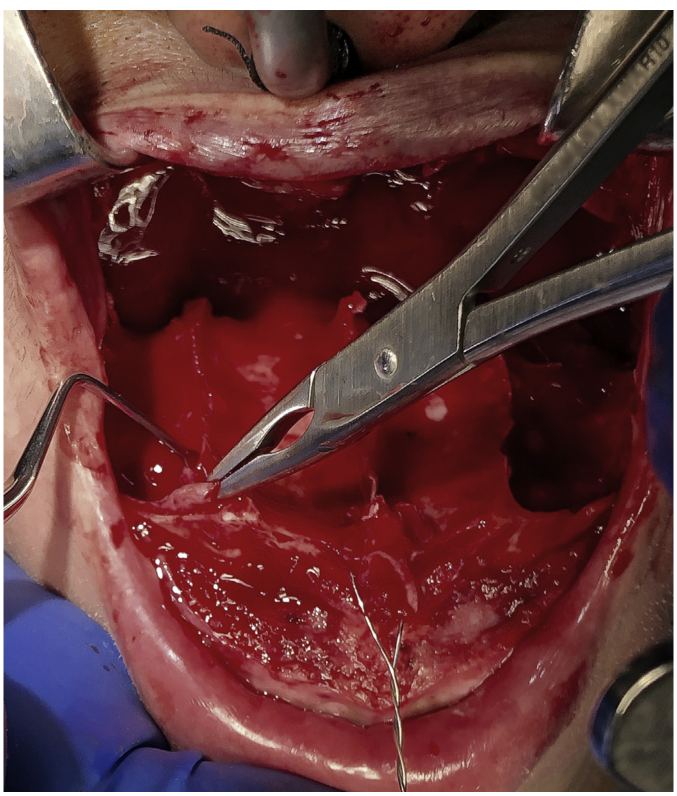

Fig. 9 Removal of maxillary sinus polyp.

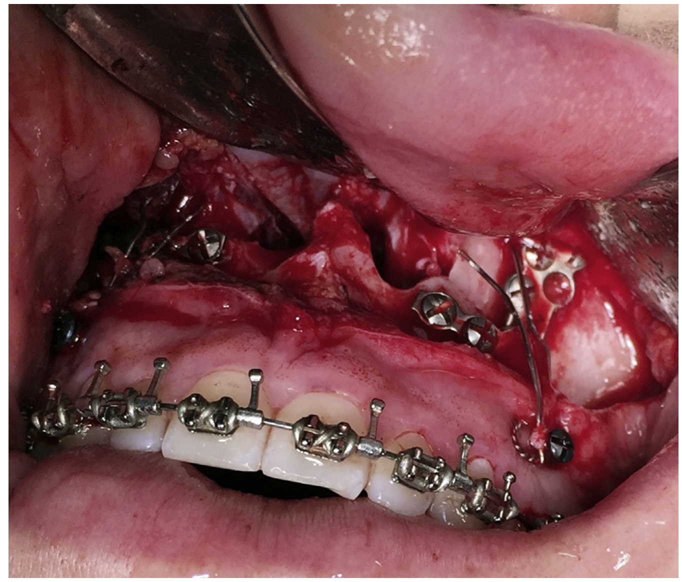

Fig. 10 Maxillary suspension wire.

12. If genioglossus advancement is planned, this precedes sagittal osteotomy. The authors prefer VSP-guided genial osteotomy that includes the inferior border of the anterior mandible, with superior extension to the genial tubercles. This ensures both capture of the genioglossus and suprahyoid muscles. Generous mentalis muscle cuff is important for coverage of the advancement plates and significant advancement of the bone graft (generally 7—9 mm) (Fig. 11).
13. Medial wall toward the lingula is burred down with a pineapple bur. This ensures a clear path to the lingula and

Fig. 11 Genioglossus muscle visualized as VSP planned genioglossus-genioplasty osteotomy is advanced.

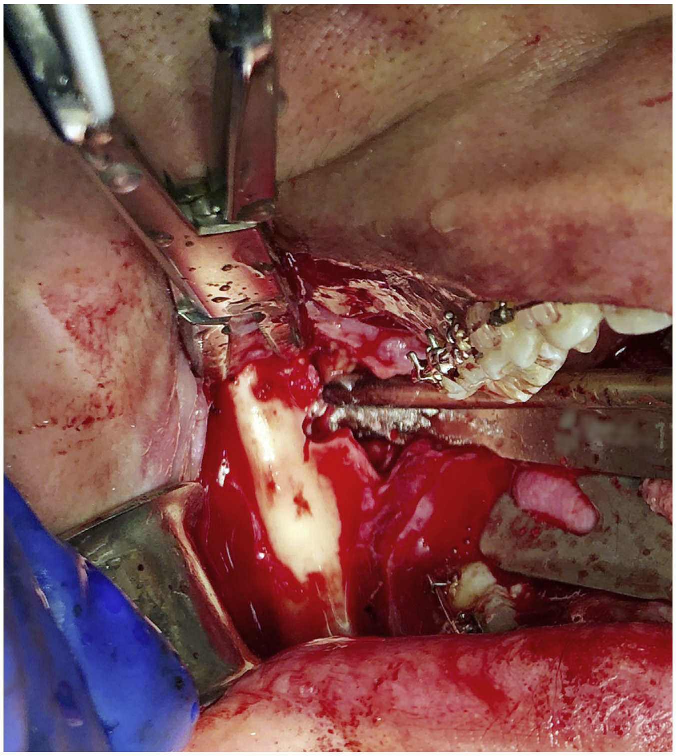

Fig. 12 Ramus medial exposure with groove.

visualization during the split to prevent uncontrolled fracture toward the condyle (Fig. 12).

14. Reciprocating saw is used to make the osteotomy, with the exception of the anterior osteotomy. The osteotomy needs to be long to ensure adequate bony overlap for fixation in large advancements (mandible usually advancing 12—15 mm measured at the pogonion). The anterior osteotomy is performed with a long-shank fissured bur to control the depth. The goal is to not overextend toward the lingual side. Classically described extension to the lingual side makes for an easy split but excessively thin bone on the posterior dentate segment for fixation.
15. Mandibular sagittal split begins with a full horizontal osteotomy to just past the lingula, followed by confirmation of osteotomy through the inferior border of mandible at the anterior, and the fragments are gently wedged open with osteotomes. No spreaders are used.
16. After final splint is applied with maxillomandibular fixation performed both around suspension wires and banded molar teeth, transfacial trocar approach is used for the first 2 or 3 positional screws. Mandibular plate is used to bridge what is usually a 1.2-cm to 2-cm gap (Figs. 13 and 14).
17. The final splint is removed to ensure stable occlusion without condylar sag and with bilateral canine guidance in excursive movement.
18. 3-0 Vicryl sutures are used to close the mandibular incisions. 3-0 chromic sutures are used for the V-Y cinch (where applicable) and maxillary incision.
19. Elastics are used in class 2 fashion in the molars but are kept light enough such that the patient can still breathe orally during the first week when nasal and sinus congestion is significant. Patients are not kept in a splint unless segmental osteotomies are absolutely required.

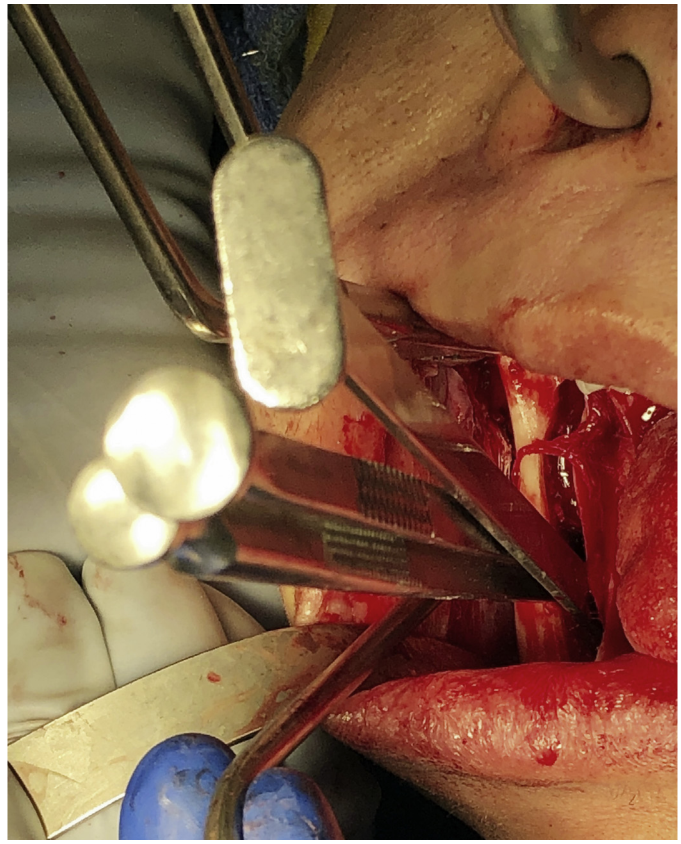

Fig. 13 Condylar and dentate segments wedged apart sequentially with three osteotomes.

Potential complications

The reported complication rate of MMA in literature is low.[12–14]

Intraoperative

During maxillary down-facture, injury to the descending palatine artery can occur. Care should be taken to remove bone associated with the palatine process of the maxilla to identify and preserve the neurovascular bundle. Although in the orthognathic literature it is well established that integrity of the descending palatine artery is not necessary, the authors have seen in older patients with severe OSA minor and temporary signs of inadequate perfusion. Hence, in general, the authors preserve the descending palatine arteries.

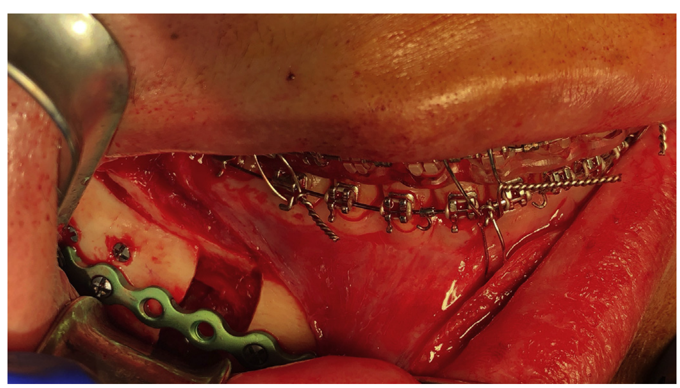

Fig. 14 Position screw and plate.

Ways to prevent buccal plate fracture or other types of uncontrolled split in OSA patients undergoing MMA have specifically been addressed in the surgical techniques section of this article.

Early postoperative

The most serious complication is airway obstruction, which should be acutely recognized. The authors' moderate to severe OSA patients spend the first evening in the ICU after extubation in the operating room. The authors do not band the jaws of post-MMA patients tightly nor place them in a splint. By not using a splint postoperatively and only using light guiding elastics, patients are allowed to orally breathe while congested and have easy access to suctioning when needed.

Malocclusion may occur as an early or late sequela of MMA surgery and may be correctable with orthodontics or requires revision surgery. Malocclusion with condylar sag can be addressed with repeat plating and careful attention paid to seating of the condylar segment.

Given the significant advancement, wound dehiscence is often seen at the site of mandibular incisions. Small dehiscence routinely closes with attentive clinical follow-up, washout, and home care instructions. Significant dehiscence with formulation of granulation tissue most often occurs over the area of dead space between the 2.4-mm mandibular plate and the mandibular advancement gap. Again, home care and washout are indicated, and hardware removal when the mandible is stable solves the problem.

Late postoperative

Malunion of the mandible can occur in the late postoperative period, necessitating bone grafting with a revision procedure. This is rare and can result from either a fracture or from inadequate fixation early on.

Hardware issues relating to chronic sinusitis, acute infection, or persistent pain secondary to maxillary and mandibular hardware are recognized in the orthognathic literature.[15,16] In the authors' population, hardware removal rate approaches 15%. Mandibular hardware is most commonly removed.

Relapse of the maxilla or mandible requires revision surgery. Depending on the degree of relapse, bone grafts from the symphysis (if no genioglossus advancement was performed) or the calvarium are good options.

Based on a review of more than 370 MMA patients from Stanford, approximately 18.7% underwent functional or esthetic nasal surgery approximately 1.5 years after surgery.[17] This rate has decreased to less than 5% in the recent 120 patients with judicious midfacial contouring and intraoperative septoplasty and inferior turbinate reduction with outfracture.

Clinical results in the literature

MMA consistently demonstrates high surgical success rate and moderate cure rate, and this is well described in several systematic review and a meta-analysis. A systematic review in 2010 performed by Holty and colleagues[1] described 627 adult patients with OSA across 22 diverse patient groups. They reported a mean apnea-hypopnea index (AHI) reduction from 63.9 to 9.5 events per hour. An update to this meta-analysis was performed by Zaghi and colleagues[5] in 2016, which included 518 patients across 45 studies. They reported success and cure rates of 85.5% and 38%, respectively. When compared with continuous positive airway pressure (CPAP), both Riley and Powell, of Stanford, and Vicini of Forli, Italy, independently showed MMA to be as effective based on the AHI and Epworth Sleepiness Scale in evidence level 2 and level 3 studies.[18,19]

Because the risk of cardiovascular comorbidity in severe OSA patients is much greater than that of healthy controls, MMA has shown to significantly reduce blood pressure.[20] This also has significant implications for the strong association between OSA and stroke.[21]

MMA compares favorably to CPAP with regard to improvement in sleep quality. Although the increase in rapid eye movement sleep is comparable between CPAP and MMA, MMA has shown additional decrease in wakefulness after sleep onset, a measure for sleep disturbance. A patient treated with MMA can restore sleep architecture comparable to a younger, healthy individual.[22]

Summary

MMA is one of the most defining operations for the treatment of OSA. It is characterized by predictably high success rate with low morbidity. The unique center of rotation for CCW movement maximizes skeletal advancement leading to airway stability. Proper contouring of the midface and intraoperative septoplasty maintain midfacial esthetics and improve nasal function. In the era of tissue-sparing palatopharyngoplasty, transoral robotic surgery, and upper airway stimulation of the hypoglossal nerve, MMA augmented by these interventions confers a higher chance of cure than ever in the history of sleep surgery.

Supplementary data

Supplementary data related to this article can be found online at https://doi.org/10.1016/j.cxom.2018.11.011.

References

1. Holty JE, Guilleminault C. Maxillomandibular advancement for the treatment of obstructive sleep apnea: a systematic review and meta-analysis. Sleep Med Rev 2010;14(5):287—97.
2. Liu SY, Huon LK, Iwasaki T, et al. Efficacy of maxillomandibular advancement examined with drug-induced sleep endoscopy and computational fluid dynamics airflow modeling. Otolaryngol Head Neck Surg 2016;154(1):189—95.
3. Prinsell JR. Maxillomandibular advancement surgery in a site-specific treatment approach for obstructive sleep apnea in 50 consecutive patients. Chest 1999;116(6):1519—29.
4. Riley RW, Powell NB, Guilleminault C. Maxillary, mandibular, and hyoid advancement for treatment of obstructive sleep apnea: a review of 40 patients. J Oral Maxillofac Surg 1990;48(1):20—6.
5. Zaghi S, Holty JE, Certal V, et al. Maxillomandibular advancement for treatment of obstructive sleep apnea: a meta-analysis. JAMA Otolaryngol Head Neck Surg 2016;142(1):58—66.
6. Riley RW, Powell NB. Maxillofacial surgery and obstructive sleep apnea syndrome. Otolaryngol Clin North Am 1990;23(4):809—26.
7. Riley RW, Powell NB, Guilleminault C. Obstructive sleep apnea syndrome: a surgical protocol for dynamic upper airway reconstruction. J Oral Maxillofac Surg 1993;51(7):742—7 [discussion: 748—9].

8. Liu SY, Huon LK, Lo MT, et al. Static craniofacial measurements and dynamic airway collapse patterns associated with severe obstructive sleep apnoea: a sleep MRI study. Clin Otolaryngol 2016;41(6):700—6.
9. Vanderveken OM, Maurer JT, Hohenhorst W, et al. Evaluation of drug-induced sleep endoscopy as a patient selection tool for implanted upper airway stimulation for obstructive sleep apnea. J Clin Sleep Med 2013;9(5):433—8.
10. Soares D, Sinawe H, Folbe AJ, et al. Lateral oropharyngeal wall and supraglottic airway collapse associated with failure in sleep apnea surgery. Laryngoscope 2012;122(2):473—9.
11. Yu CC, Bergeron L, Lin CH, et al. Single-splint technique in orthognathic surgery: intraoperative checkpoints to control facial symmetry. Plast Reconstr Surg 2009;124(3):879—86.
12. Blumen MB, Buchet I, Meulien P, et al. Complications/adverse effects of maxillomandibular advancement for the treatment of OSA in regard to outcome. Otolaryngol Head Neck Surg 2009;141(5):591—7.
13. Camacho M, Liu SY, Certal V, et al. Large maxillomandibular advancements for obstructive sleep apnea: an operative technique evolved over 30 years. J Craniomaxillofac Surg 2015;43(7):1113—8.
14. Li KK, Riley R, Powell N. Complications of obstructive sleep apnea surgery. Oral Maxillofac Surg Clin North Am 2003;15(2):297—304.
15. Falter B, Schepers S, Vrielinck L, et al. Plate removal following orthognathic surgery. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;112(6):737—43.
16. Schmidt BL, Perrott DH, Mahan D, et al. The removal of plates and screws after Le Fort I osteotomy. J Oral Maxillofac Surg 1998;56(2):184—8.
17. Liu SY, Lee PJ, Awad M, et al. Corrective nasal surgery after maxillomandibular advancement for obstructive sleep apnea: experience from 379 cases. Otolaryngol Head Neck Surg 2017;157(1):156—9.
18. Riley RW, Powell NB, Guilleminault C. Maxillofacial surgery and nasal CPAP. A comparison of treatment for obstructive sleep apnea syndrome. Chest 1990;98(6):1421—5.
19. Vicini C, Dallan I, Campanini A, et al. Surgery vs ventilation in adult severe obstructive sleep apnea syndrome. Am J Otolaryngol 2010;31(1):14—20.
20. Islam S, Taylor CJ, Ormiston IW. Effects of maxillomandibular advancement on systemic blood pressure in patients with obstructive sleep apnoea. Br J Oral Maxillofac Surg 2015;53(1):34—8.
21. Yaggi HK, Concato J, Kernan WN, et al. Obstructive sleep apnea as a risk factor for stroke and death. N Engl J Med 2005;353(19):2034—41.
22. Liu SY, Huon LK, Ruoff C, et al. Restoration of sleep architecture after maxillomandibular advancement: success beyond the apnea-hypopnea index. Int J Oral Maxillofac Surg 2017;46(12):1533—8.

Further readings

Liu SY, Huon LK, Powell NB, et al. Lateral pharyngeal wall tension after maxillomandibular advancement for obstructive sleep apnea is a marker for surgical success: observations from drug-induced sleep endoscopy. J Oral Maxillofac Surg 2015;73(8):1575—82.

Prinsell JR. Primary and secondary telegnathic maxillomandibular advancement, with or without adjunctive procedures, for obstructive sleep apnea in adults: a literature review and treatment recommendations. J Oral Maxillofac Surg 2012;70(7):1659—77.

Riley RW, Powell NB, Guilleminault C. Obstructive sleep apnea syndrome: a review of 306 consecutively treated surgical patients. Otolaryngol Head Neck Surg 1993;108(2):117—25.

Waite PD, Wooten V, Lachner J, et al. Maxillomandibular advancement surgery in 23 patients with obstructive sleep apnea syndrome. J Oral Maxillofac Surg 1989;47(12):1256—61 [discussion: 1262].