Current Concepts in Orthognathic Surgery

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Learning Objectives: After studying this article, the participant should be able to: 1. Identify skeletal differences that are treated with orthognathic surgery; describe the goals of orthognathic surgery; and understand modern virtual surgical planning of orthognathic movement of the mandible, maxilla, and chin. 2. Appreciate the surgical principles of maxilla- versus mandible-first surgery, and orthognathic surgery before orthodontic correction; and understand when an osseous genioplasty may be beneficial, and the potency of this bony movement. 3. Appreciate the utility of fat grafting as an adjunct to orthognathic bony movements, and demonstrate understanding of the utility of orthognathic surgery in the treatment of obstructive sleep apnea. 4. Be aware of associated complications and be able to critically assess outcomes following orthognathic surgery.

Summary: This CME article outlines the goals of orthognathic surgery, highlighting advances in the field and current controversies. The principles of the sequencing of osteotomies are discussed and literature is reviewed that may assist in decision-making as to maxilla-first versus mandible-first surgery. The emergence of "surgery first," in which surgery precedes orthodontics, is discussed and important parameters for patient candidacy for such a procedure are provided. The emerging standard of virtual surgical planning is described, and a video is provided that walks the reader through a planning session. Soft-tissue considerations are highlighted, especially in the context of osseous genioplasty and fat grafting to the face. The utility of orthognathic surgery in the treatment of obstructive sleep apnea is discussed. The reader is provided with the most current data on complications following orthognathic surgery and advice on avoiding such pitfalls. Finally, outcome assessment focusing on the most current trend of patient-reported satisfaction and the psychological impact of orthognathic surgery are discussed. (*Plast. Reconstr. Surg.* 141: 925e, 2018.)

Orthognathic surgery to reposition the maxilla, mandible, and chin provides for dramatic enhancement of facial balance and proportion. Orthognathic surgery serves two unrelenting masters, the soft tissue and the skeleton, with the functional and aesthetic goals of achieving level and class I dental occlusion, facial balance, and proportion. If cephalometric skeletal alignment is the *only* consideration in surgical planning, aesthetic inadequacy and patient dissatisfaction *may* result. Put differently, qualitative goals for the soft tissue dictate facial skeletal displacement.[1]

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Recently, concepts in orthognathic surgery have been reassessed, and emerge from advancements in preoperative planning and surgical methodology. Today, the mainstay surgical techniques incorporated into orthognathic surgery include Le Fort I osteotomy, bilateral sagittal split osteotomy, and osseous genioplasty.[2]

Current concepts further build on improved technical proficiency, improved perioperative safety profile, superior bone fixation materials,

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and a better understanding of bone healing and soft-tissue responses. Current controversies include sequence of treatment (maxilla first versus mandible first versus surgery first), traditional stone model versus modern virtual surgical planning, and adjunct procedures that serve to enhance bony movements.

SEQUENCE OF TREATMENT

Orthognathic surgical treatment may be divided into essentially two groups: (1) *surgery intermediate*, in which traditional orthognathic surgery is performed between preoperative and postoperative orthodontic courses; and (2) *surgery first*, in which orthognathic surgery is performed before orthodontic correction.[3] Of note, orthodontic preparation of braces (i.e., transition to heavier surgical wires) should be performed before performing occlusion impressions, as activity in the orthodontic wire may alter tooth position, and will affect splint fit and intraoperative positioning. The senior author's practice is to have heavy wires installed before surgery and occlusion impressions cast after wire transition. These impressions are digitized and overlaid onto the preplanning computed tomographic scan before fabricating intermediate and final splints. At the time of orthognathic surgery, the sequence of osteotomies is based on preoperative planning and model surgery. If a single jaw is being repositioned, a final splint is used to guide the occlusion of the jaw being moved relative to the remaining jaw. If both maxillary and mandibular osteotomies are planned, an intermediate splint is used to guide the movement of one relative to the other. Although classically the maxilla is repositioned first, followed by the mandible, the sequence can be reversed with the appropriate intermediate splint. The remaining jaw then is repositioned based on the final splint. Once the maxilla and mandible are in their final positions, the chin is assessed, and an osseous genioplasty is performed, as desired. It is important to consider third-molar extraction in the sequence of treatment. Extraction is often performed before orthognathic surgery, requiring a postoperative recovery period of several months. Alternatively, third-molar extraction may be performed concurrently with orthognathic surgery, and has been shown not to significantly increase operative time, not to increase the risk of adverse outcome, and not to negatively affect postoperative course.[4]

Maxilla versus Mandible First

The decision regarding which jaw to reposition first in a bimaxillary operation remains controversial. Classically, surgeons have repositioned the maxilla first and mandible second. In such a classic sequence, the senior author (J.A.T.) prefers to begin with bilateral sagittal split corticotomies of the mandible, proceed to the maxilla and complete the Le Fort I repositioning, and then return to convert the mandibular corticotomies to osteotomies. The reasoning behind this sequence is that the mouth must be propped wide open to visualize the mandible adequately for the mandibular osteotomy, and this maneuver may unintentionally alter the previously repositioned maxilla held in place with microplates. Completing the sagittal splitting osteotomies does not require opening the mouth widely and therefore is less likely to alter the maxillary position.

Table 1. Indications for Mandible-First versus Maxilla-First Surgery

Mandible-first surgery	
	Counterclockwise rotation of the occlusal plane
	Segmental maxillary osteotomies
	Cleft maxilla
	Downgrafting of the posterior maxilla
	Large maxillomandibular advancements
	Anterior open bite
	Inability to accurately register bite
Maxilla-first surgery	
	Clockwise rotation of the occlusal plane
	Single-piece maxilla
	Rigid mandible fixation prior is not possible
	Maxillary impaction
	Small maxillomandibular advancements

With the rising popularity of virtual surgical planning, there has been renewed interest in "mandible-first surgery" in which surgeons complete the mandibular osteotomy, reposition and fixate the mandible, and then operate on the maxilla.[5] Borba et al. performed a systematic review of the mandible-first sequence in bimaxillary orthognathic surgery,[6] and identified six publications. These articles discussed mandible-first surgery in the setting of subjects that present with difficulties in maxillomandibular registration (e.g., mandibular hemihypertrophy, mandibular tumors, and hemifacial microsomia patients). Other specific examples that may warrant mandible-first surgery include cases in which downgrafting of the posterior maxilla is planned, when maxillomandibular fixation is impaired by a thick intermediate splint, when fixation of the maxilla is not rigid, or when concomitant temporomandibular joint surgery is planned.[6] For cases in which segmental maxillary osteotomies are planned, or for cases of a cleft maxilla (which behave similarly), mandible-first surgery is advocated (Table 1). In cases where mandible-first surgery is *feasible*, or advocated, it is still *possible* to perform the maxillary osteotomy first; it is up to the surgeon to determine his or her own comfort level with the techniques and sequencing.

Surgery First

Traditionally, orthognathic surgery involves significant preoperative and postoperative orthodontics to achieve adequate dentofacial correction, a time-consuming and potentially painful process.[7] Timing of surgery is dependent on successful preoperative orthodontic preparation, and patients may become dismayed by the length of treatment.[8] An important consideration is coverage of orthognathic surgery in the congenitally affected patient. Insurance companies decide on coverage for surgery relatively close to the surgical date, and may not commit to covering orthognathic surgery before, or during, orthodontic preparation. As such, the significant patient and orthodontist investment preoperatively may not result in insurance covering the planned orthognathic surgery.

An alternative to the conventional model of preoperative orthodontics is "surgery first," where orthognathic surgery is performed before orthodontic correction. Although considered a new concept, the idea of surgery first dates back almost 30 years, originally described as "building the house and then moving the furniture."[9] Only during the last decade have reports of successful surgery-first protocols been published with some degree of rigor, including selection and exclusion criteria.[10–13] Patients with crowding requiring tooth extraction, severe asymmetry, severe palatal constriction requiring expansion, active periodontal disease, or any form of temporomandibular joint disease are typically not candidates for the surgery-first approach. Planning for the surgery-first patient requires that the overall centric relation of the maxilla and the mandible first be corrected. Centric relation is defined as "the maxillomandibular relationship in which the condyles articulate with the thinnest avascular portion of their respective disks with the complex in the anterosuperior position against the shapes of the articular eminencies. This position is independent of tooth contact."[14] This partially resolves some of the soft-tissue imbalances that may hinder certain orthodontic movements. The patient has a greater degree of freedom in scheduling their surgical date given that presurgical orthodontic preparation is not required. However, presurgical bracket bonding, usually performed 1 week before orthognathic surgery, is required.

Equally important to the experience of the surgeon in surgery first are the experience and expertise of the orthodontist.[15] Although the postoperative orthodontic course is often shorter than the combined preoperative and postoperative orthodontic course required for conventional surgery, the magnitude of the dental movement can be daunting.[15–17] Current literature reports an average postoperative orthodontic course of 45 weeks. Transient demineralization of the tooth-bearing bones following surgery is argued to improve orthodontic efficiency.[18] To take advantage of this regional acceleratory phenomenon, postoperative orthodontics should begin no later than 2 weeks after surgery.[18]

In what is the most comprehensive study to date, Yang et al. performed a systematic review and meta-analysis to assess the current evidence on stability, efficacy, and surgical results of surgery-first versus conventional surgery.[19] Ten nonrandomized controlled studies including 513 patients were identified. Subjects that underwent surgery first benefited from shorter total treatment duration compared with those that underwent conventional surgery. Postoperative stability of the mandible or maxilla, surgical movement, and postoperative occlusion were similar in both groups. The authors concluded that surgery first offers an efficient alternative to conventional surgery, with shorter total treatment duration, similar reliability, similar complication rates, and longer postoperative orthodontic time.[19] These findings corroborate those of Choi et al., who have published extensively on their experience with the surgery-first approach.[20–23]

VIRTUAL SURGICAL PLANNING

Perhaps nothing has been more revolutionary in orthognathic surgery than virtual surgical planning. Imaging advancements have allowed for improved diagnosis and treatment planning because of better visualization of preoperative, intraoperative, and postoperative phenotypic changes. Advancements in high-resolution, low-radiation computed tomographic imaging have enabled the practical use of computer-aided design/computer-aided modeling or virtual surgical planning for operative planning that includes preplanning of osteotomies, fabrication of cutting guides to improve osteotomy accuracy, and fabrication of intermediate and final splints.[24–26] Figure 1 illustrates an example of virtual surgical planning use for a patient with osteogenesis imperfecta and a severe class III occlusion. Virtual

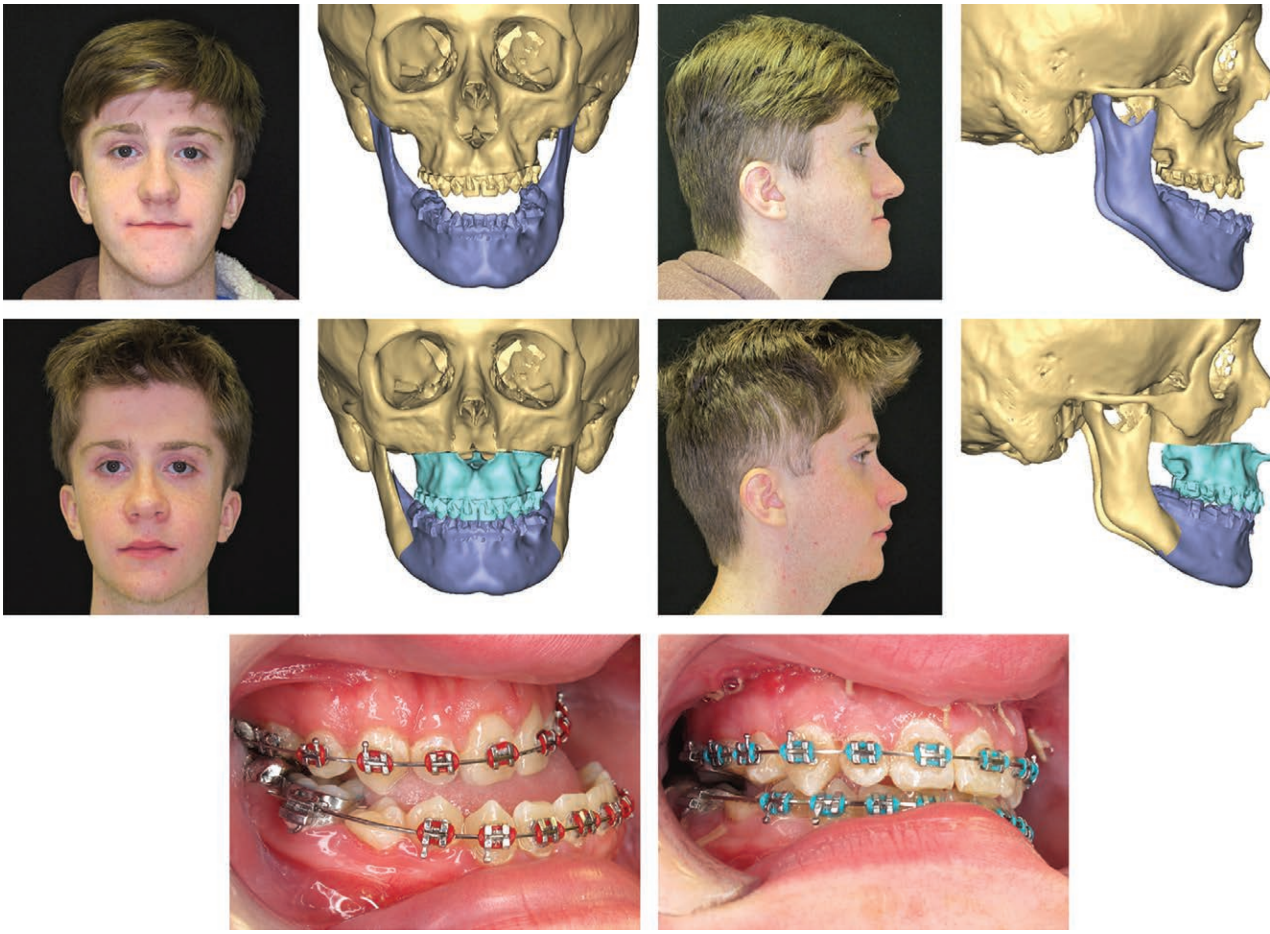

Fig. 1. A 17-year-old male patient with osteogenesis imperfecta and class III occlusion. (*Above*) Preoperative anteroposterior and lateral clinical and planning images. (*Center*) Postoperative anteroposterior and lateral clinical and planning images (after a maxilla-first Le Fort I procedure with 1.1-mm disimpaction and 10.0-mm advancement at the central incisors, bilateral sagittal split osteotomies with 1.4-mm advancement, and 10.8-mm impaction at the central incisors). (*Below*) Preoperative and postoperative occlusal views.

surgical planning for orthognathic surgery has been shown to be accurate to within 1 mm and has a well-documented time savings relative to traditional stone model fabrication/planning.[27,28] Not only have preoperative planning times been reduced significantly with virtual surgical planning, but also operative times and the accuracy of osteotomies and fixation have been reported to be shorter and increased, respectively.[29] (**See Video, Supplemental Digital Content 1**, which displays a real-time video of virtual surgical planning of an orthognathic case for a 44-year-old man with obstructive sleep apnea and class I occlusion. This video is available in the "Related Videos" section of the full-text article on PRSJournal.com or at ***http://links.lww.com/PRS/C784***.)

The next generation of virtual surgical planning allows for fabrication of custom cutting guides and fixation plates or for stereolithographic models to be printed for prebending of fixation plates. Such tools would allow for greater accuracy in reproducing virtual surgical planning osteotomies and repositioning, and provide for a time savings associated with placement and removal of intraoperative splints. In a series of 10 patients, Mazzoni et al. measured their outcomes with virtual surgical planning and three-dimensional printing of customized surgical cutting guides and titanium fixation plates.[30] In assessing the virtually planned maxillary position relative to the actual maxillary position postoperatively, they found it to be highly accurate, with overlap errors of less than 2 mm in 100 percent of patients. This study is among a handful that confirm the feasibility of virtual surgical planning and custom-fabricated cutting guides and titanium plates.[31–33] Although custom-fabricated plates are cost-prohibitive for everyday use currently, there is sure to be an eventual and significant reduction in cost over time that will enable more widespread use.

OSSEOUS GENIOPLASTY

Osseous genioplasty is a powerful tool with which to restore facial balance between skeletal, soft-tissue, and dental components of the face. In contrast to Le Fort I and bilateral sagittal split osteotomy, genioplasty has few functional benefits, and so the decision to operate is guided by the patient's desires and goals, and the surgeons' subjective opinion and experience. Although cephalometric analysis should remain a guiding principle in decision-making, clinical soft-tissue analysis may itself be adequate.

Several factors should be critically analyzed in both the anteroposterior and lateral/profile planes when evaluating a patient for genioplasty. On anteroposterior analysis, asymmetries to the mandible and chin may dictate the need for genioplasty. Facial proportion may require adjustment of lower third facial height, necessitating either reduction or augmentation of the chin. Incisor show and mentalis strain should also be analyzed, along with lip competence. On lateral/profile analysis, the cervicomental angle, the nose-chin and lip-chin relationships, and the labiomental fold should each be considered when planning movement of the chin.

Being able to predict the soft-tissue change following bony movement has always been a challenge. San Miguel Moragas et al. performed a systematic review of English and non-English articles in an effort to determine useful soft tissue–to–hard tissue ratios for planning the magnitude of sliding genioplasty, osseous chin contouring, and alloplastic chin augmentation.[34] As expected, they found a high variability in soft tissue–to–hard tissue ratios regarding genioplasty. However, they found that variability narrowed if data were stratified according to confounding factors, such as the type of incision, extent of muscle detachment, and degree of advancement and vertical movement.[34] They reported that advancement and extrusion movements of the chin segment show, respectively, ratios of 0.9:1 of sPg:Pg horizontally and 0.95:1 of sMe:Me vertically. Setback and impaction movements show, respectively, ratios of −0.52:1 of sPg:Pg horizontally and −0.43:1 of sMe:Me vertically. These data may be a useful reference in surgical planning of genioplasty.

Video 1. Supplemental Digital Content 1 displays a real-time video of virtual surgical planning of an orthognathic case for a 44-year-old man with obstructive sleep apnea and class I occlusion. This video is available in the "Related Videos" section of the full-text article on PRSJournal.com or at ***http://links.lww.com/PRS/C784***.

FAT GRAFTING

Skeletal changes are not always reflected in the changes of the soft tissue following orthognathic surgery. Contour irregularities exist, and with significant skeletal movements, the stretching of the tissue envelope results in a reduction in the shape and volume of the soft tissue. Autologous fat grafting has become a popular adjunct procedure for soft-tissue augmentation in these settings[35] (**Level of Evidence: Therapeutic, IV**). In addition to camouflaging bony and soft-tissue contour irregularities, fat grafting is especially powerful in patients with underlying soft-tissue abnormality such as Parry-Romberg syndrome, hemifacial microsomia, and facial clefting.[36] Its availability is often abundant and harvest uncomplicated.[37] Adipose-derived stem cells within the graft have also been reported to improve overlying dermis, reduce postoperative edema, and soften preexisting scars.[38,39] For patients with cleft lip, the senior author (J.A.T.) routinely injects fat within the upper lip at the time of orthognathic surgery (Fig. 2). We are currently analyzing the long-term effect of this technique.

ORTHOGNATHIC SURGERY FOR THE TREATMENT OF OBSTRUCTIVE SLEEP APNEA

Orthognathic surgery has emerged as one of the most effective interventions in the treatment of obstructive sleep apnea.[40,41] Mandibular advancement pulls forward the base of the tongue, improving the patency of the velopharyngeal airway.[42,43] Advancing the maxilla anterosuperiorly tightens the soft palate, opening the velopharynx.[44] Although these movements may

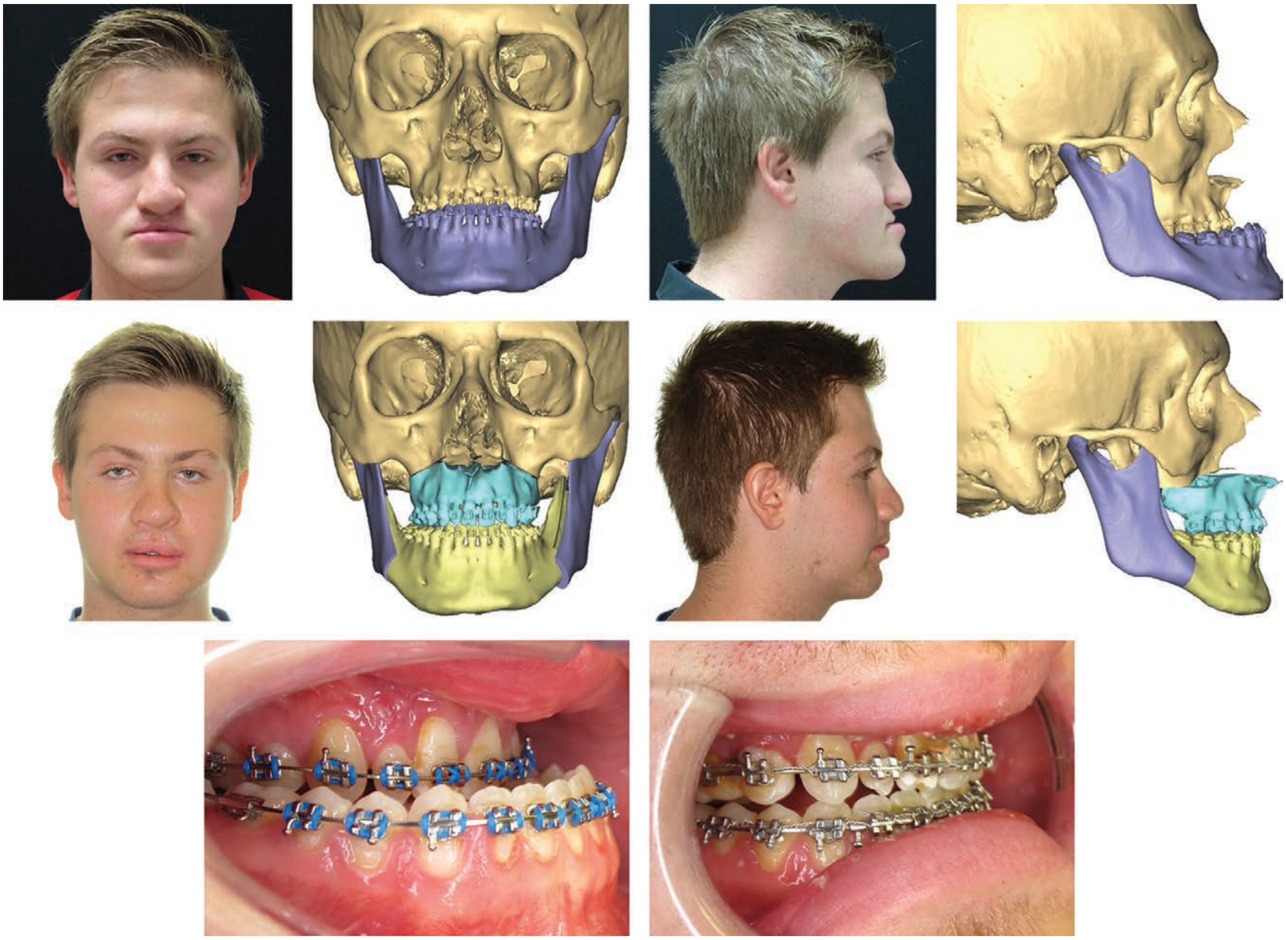

Fig. 2. A 17-year-old male patient with a bilateral cleft lip and class III occlusion. (*Above*) Preoperative anteroposterior and lateral clinical and planning images. (*Center*) Postoperative anteroposterior and lateral clinical and planning images (2 weeks after maxilla-first Le Fort I procedure with 2.9-mm disimpaction and 9.0-mm advancement at the central incisors, bilateral sagittal split osteotomies with 7.5-mm setback and 6.8-mm disimpaction at the central incisors, and fat grafting to the upper lip). (*Below*) Preoperative and postoperative occlusal views.

be performed individually, combining the two results in enlargement of the retropalatal and retrolingual airway.[45,46] A meta-analysis performed by Caples et al. found that obstructive sleep apnea patients undergoing maxillomandibular advancement have a consistent and significant reduction in apnea-hypopnea index.[47] They found that surgery results in an average apnea-hypopnea index reduction of 87 percent, compared to 34 percent for radiofrequency ablation of the palate and/or tongue and 33 percent for uvulopalatopharyngoplasty. Relapse following maxillomandibular advancement surgery has been reported to range from 10 to 20 percent; however, apnea-hypopnea index remains stable despite skeletal and soft-tissue relapse.[48] Orthognathic surgery has therefore been demonstrated to provide the most consistent reduction in apnea-hypopnea index for patients with obstructive sleep apnea (Fig. 3).

CURRENT DATA ON COMPLICATIONS

Orthognathic surgery involves multiple steps, tissue planes, and instrumentation. As such, there is risk of multiple complications, including bleeding, infection, scarring, malunion, nonunion, bad split of the bilateral sagittal split osteotomy, bony or dental relapse, neurologic injury, neuropathic pain, adverse effects on nasal aesthetics, temporomandibular joint dysfunction, necrosis of bony segments, respiratory stress, trigeminocardiac reflex, pseudoaneurysm, tooth injury, venous thromboembolism, blindness, and psychological changes. Within this section, we focus on the most common of these, drawing from the most current literature.

With extensive bony osteotomies, severe bleeding can occur, especially during the Le Fort I osteotomy if the internal maxillary artery is lacerated. Although such bleeding should be addressed promptly, caution should be taken in the use of hemostatic agents, as hemostatic therapies have been shown to cause aseptic necrosis in rare instances.[49] Recent studies have noted that extensive surgery and reduced body mass index are associated with increased intraoperative blood loss.[50] Such patients may be candidates for hypotensive anesthesia using sevoflurane, which has been shown to effectively reduce bleeding and optimize the visual field during surgery.[51]

The rate of a "bad split" during bilateral sagittal split osteotomy is reported to be approximately 2.3 percent.[52] Causes and risk factors include inadequate vertical osteotomy at the inferior border, horizontal osteotomy performed too high above the lingula, exertion of excess force when separating the proximal and distal segments, and impacted third molars. Removal of third molars at the time of orthognathic surgery versus 6 to 9 months prior remains controversial, with data divided.[53–55]

Although rare, bony necrosis may be a devastating complication.[56] The bony segment at highest risk for necrosis is the central maxillary segment in patients with bilateral cleft lip and palate.[57] Reports of necrosis of the maxilla are rare and range from partial-thickness or segmental necrosis to full loss of a segment.[58] Treatment includes débridement, antibiotics, hyperbaric oxygen therapy, iliac crest bone graft, and in extreme cases vascularized bone.[59] Reports of osteonecrosis of the mandible are even more rare and have not been reported in over 25 years.[56] Technical advancements in minimizing soft-tissue dissection, and more principled advancement of bone in a single movement, have effectively eliminated mandibular necrosis as a concern.[56]

Multiple factors affect the potential for relapse following orthognathic surgery, including muscle-related physiologic effects, changes in the position of dentition after surgery, condylar position at the time of intraoperative fixation, and type of fixation. The creation of gaps between bony segments after bilateral sagittal split osteotomy is to be expected; however, bony interference between segments may be causally related to relapse, changes in the position of condyles or articular disks, and condylar resorption. Similarly, forced fixation can lead to changes in condyle position, condylar morphology, and relapse.[60] Attention should be paid to bending the distal segment posterior to the last molar, performing a bone graft in the area of particularly wide segment gaps, and bending plate fixation versus traditional free bicortical screw fixation, each of which has been show to reduce the rate of relapse.[61,62]

Mandibular setback osteotomy can lead to changes in the physiologic equilibrium of the pterygomasseteric sling, which may subsequently affect the functioning of the muscles of mastication. These changes in the muscles tend to rotate the proximal segment counterclockwise to set it back to its original position. The efficacy of bilateral sagittal split osteotomy decreases with an increase in the counterclockwise rotation of the proximal segment.[63] The angle of osteotomy can change the length of the pterygomasseteric sling, and reduction of pterygomasseteric tension can lower the rate of relapse after surgery. Postoperative relapse can be prevented by minimizing the rotation of the proximal segment, either by ensuring complete detachment of the pterygomasseteric sling at the time of surgery, superior repositioning of the posterior maxilla, or mandibular angle resection.[64–66]

Neurologic injuries mainly affect the infraorbital nerve, incisive nerve, mental nerve, and inferior alveolar nerve. Old age is a risk factor for permanent hypoesthesia. Hypoesthesia occurs in 4.8 percent of patients younger than 19 years, 7.9 percent of patients aged 19 to 30 years, and 15.2 percent of patients aged 31 years or older.[67] The reported rate of inferior alveolar nerve injury varies widely because of the lack of standardized assessment and reporting methods. Furthermore, subjective evaluation has been the most common method for assessing neurosensory deficit. Agbaje et al. attempted to review the incidence of inferior alveolar nerve injury in bilateral sagittal split osteotomy, but were unable to report a true incidence, and concluded that the observed wide variation in the reported incidence is attributable to a lack of standardized assessment procedures and reporting.[68] When performing the bilateral sagittal split osteotomy, distance between the ascending ramus posterior border and facial nerve approaches less than 10 to 20 mm, and is therefore at risk of being directly compressed or damaged. The rate of facial nerve paralysis is reported between 0.17 and 0.75 percent.[69] If functional recovery does not occur within 4 to 8 months, reexploration should be performed, at which point one must consider direct repair, nerve grafting, or reanimation surgery.[69]

It is important to keep in mind the effect of maxilla repositioning on nasal morphology.[70,71] Widening of the alar base width, frequently observed following surgery, may be minimized by performing a modified alar cinch suture that independently tightly anchors the bilateral alar fibroareolar tissues in the medial direction.[72,73] Nasotracheal intubation may make clinical

Fig. 3. A 44-year-old man with obstructive sleep apnea and class I occlusion. (*Above*) Preoperative anteroposterior and lateral clinical and planning images. (*Center*) Postoperative anteroposterior and lateral clinical and planning images (8 weeks after a maxilla-first LeFort I procedure with 5.0-mm impaction and 8.6-mm advancement at the central incisors, bilateral sagittal split osteotomies with 9.6-mm advancement and 4.6-mm impaction at the central incisors, and 8.0-mm advancement 0.4-mm impaction sliding genioplasty). (*Below*) Preoperative and postoperative occlusal views.

assessment of the nasal deviation difficult, given pressure and displacement of the septum caused by the tube. Nasal deviation may also occur during maxillary repositioning with inadequate septum reduction. A reduction of at least 3 mm is recommended to prevent such deviation in cases involving vertical maxillary impaction.[74]

Postoperative infection rates are historically low. Among 2521 patients who underwent orthognathic surgery, the rate of infection was 8 percent.[75] However, when antibiotics (cefazolin or cephalexin) are administered perioperatively, the rate of infection drops to 1 percent.[76]

INFORMED CONSENT

The complexity of orthognathic surgery, and the myriad potential complications previously discussed, warrants a comment on surgical consent.[77] As for any operation, surgical consent is a process, and not simply a form. Informed consent starts with first contact, and continues thereafter. The process requires an understanding of patient goals and expectations, and alignment of those goals and expectations with what is actually possible to achieve with orthognathic surgery. The traditional surgical consent, which is physician led, and often includes a list of complications, falls short of true informed consent. Studies have shown that the recall rate of details discussed before orthognathic surgery is less than 50 percent.[78,79] Instead, an interactive discussion, directed by both the surgeon and the patient, is needed to ensure that the patient understands what they are embarking upon.

Video 2. Supplemental Digital Content 2 displays an interview with a 44-year-old man with obstructive sleep apnea and class I occlusion 8 months after maxilla-first Le Fort I impaction and advancement, bilateral sagittal split osteotomy advancement and impaction, and advancement and impaction sliding genioplasty. The patient discusses his reasons for seeking surgery and his experience through the process. This video is available in the "Related Videos" section of the full-text article on PRSJournal.com or at ***http://links.lww.com/PRS/C785***.

OUTCOME ASSESSMENT

Standard outcomes (i.e., stability of fixation, quality of bone healing, accuracy of bony movement, and final occlusion) have long been reported for orthognathic surgery.[80] Furthermore, fewer complications and decreased length of stay have been reported to be associated with high-volume centers, defined as those in the 90th percentile of case volume or higher (>31 cases/year).[81] Although modern methods of assessment such as three-dimensional soft-tissue analysis following surgery provide an added tool for critical evaluation of results,[82] the current trend in outcome reporting has swung from surgeon-reported outcomes to patient-reported satisfaction and assessment of the psychological effect of surgery.[80] (**See Video, Supplemental Digital Content 2**, which displays an interview with a 44-year-old man with obstructive sleep apnea and class I occlusion 8 months after maxilla-first Le Fort I impaction and advancement, bilateral sagittal split osteotomy advancement and impaction, and advancement and impaction sliding genioplasty. The patient discusses his reasons for seeking surgery and his experience through the process. This video is available in the "Related Videos" section of the full-text article on PRSJournal.com or at ***http://links.lww.com/PRS/C785***.)

A review of 998 patient-reported outcomes and satisfaction following orthognathic surgery was performed by Pachêco-Pereira et al.[8] Although various different psychological assessment tools were used in each of the studies, and although there was a large variation in sample size (range, 44 to 505 patients) and age (range, 15 to 72 years), the authors concluded that primary factors associated with patient satisfaction were final overall aesthetic appearance, perceived social benefits, the type of orthognathic surgery (bimaxillary surgery versus maxilla or mandible alone), sex of the patient, and changes in the patient's self-perception following treatment. Factors associated with dissatisfaction were the length of treatment, sensation of functional impairment and/or dysfunction after surgery, and perceived omitted information about surgical risks. The authors acknowledged clear limitations of their review, including memory bias, differences in response to questions solicited in person versus over the phone or through mail, and a lack of validity or reliability of the outcome metrics used. Given these limitations of the available evidence, conclusions drawn should be considered cautiously. The utility of the FACE-Q following orthognathic surgery may help better validate and standardize patient-reported outcomes and satisfaction; however, there are few studies to date that have used this tool.[83]

The effect of orthognathic surgery goes beyond objective cephalometric correction of facial and dental disproportion and malocclusion. The final result is not only assessed by the surgeon and the patient, but also by anyone that interacts with the patient. There is tangible improvement following surgery that alters publicly perceived personality traits and emotions. A new technology that allows for rapid data collection and surveying of the general public (i.e., crowdsourcing) has already been used to determine how preoperative and postoperative images of orthognathic surgery patients are perceived.[84] Subjects are perceived significantly more favorably after orthognathic surgery in 12 countenance categories; they are seen as more dominant, trustworthy, friendly, intelligent, attractive, and happy, and less threatening, angry, surprised, sad, afraid, and disgusted. Future outcome studies will likely make a concerted effort to combine standard surgical outcome metrics with critical assessment from surgeons, patients, and the general public.

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PATIENT CONSENT

Parents or guardians or the patient provided written consent for use of the patients' images.

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