Orthognathic Surgery—LeFort I Osteotomy

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Abstract

Orthognathic surgery is a complex type of facial surgery that can have a profound impact on a patient's occlusal function and facial aesthetics. Close collaboration between the maxillofacial surgeon and an orthodontist is required, and the surgical team must have a strong foundation in facial analysis and firm understanding of the maxillofacial skeleton to achieve surgical success. Herein, we review the maxillary LeFort I osteotomy as it pertains to orthognathic surgery, with particular attention to the indications, contraindications, preoperative assessment, surgical technique, and possible complications encountered.

Keywords

- orthognathic surgery
- LeFort
- dentofacial deformities
- osteotomy

Orthognathic surgery involves repositioning of the maxilla and mandible so that Angle class I dental occlusion is restored, dentofacial deformities are corrected, and aesthetic facial balance is restored in the anteroposterior, vertical, and transverse dimension.[1,2] Successful orthognathic surgery requires collaboration between orthodontists and maxillofacial surgeons to develop and execute an individualized, comprehensive treatment plan. The most frequent surgical procedure performed for correction of defects of the maxilla is the LeFort I osteotomy, both in its original form and with modern variations. The maxillary LeFort I osteotomy is a versatile and predictable surgical procedure that can be utilized to address and correct nearly all midface deformities, including anterior–posterior, vertical, transverse, and rotational discrepancies.

Timing of surgery with regard to orthodontic treatment has been investigated in recent years.[3] Furthermore, advances in technical proficiency and the introduction of virtual surgical planning (VSP) have revolutionized the way that orthognathic surgery is performed.[4] Herein, we review the role of orthognathic surgery with a particular focus on surgical interventions of the maxilla. Current concepts in orthognathic surgery, specifically the LeFort I maxillary osteotomy as it relates to the correction of dentofacial deformities, are further discussed below.

Indications

The main indications for orthognathic surgery are the correction of malocclusion, enhancement of facial aesthetics, and definitive treatment of refractory obstructive sleep apnea (OSA).[5] Maxillomandibular advancement remains one of the most efficacious and reliable surgical interventions for OSA and can achieve surgical success in 85.5% of patients.[6] Dentofacial deformities that can be corrected with orthognathic surgery include skeletal problems of the maxilla and/or mandible producing malocclusion, facial clefts, hemifacial microsomia, and posttraumatic jaw deformities. The goals of surgical intervention are to correct functional occlusal problems, improve facial balance, and increase the space of the upper airway. A LeFort I, specifically, is used to adjust the position of the maxilla and maxillary teeth in three dimensions, either alone or in concert with other interventions, to achieve these goals. It can be used to address maxillary hypoplasia or hyperplasia, vertical excess or deficiency, asymmetry, and transverse anomalies.

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Contraindications

There are relatively few true contraindications for orthognathic surgery. Patient-specific contraindications include a preadolescent age, as surgery performed before bony growth is complete that can theoretically disrupt and stunt overall growth. Specifically, separation of the nasal septum from the upper jaw during LeFort I osteotomy in a skeletally immature patient may hinder anteroposterior growth of the maxilla, and continued vertical growth of the mandible may result in secondary malocclusion. Additionally, systemic medical or psychiatric conditions that would prohibit general anesthesia or increase the likelihood of relapse or surgical failure should be strongly evaluated in patient selection and surgical workup.

Patient Assessment

Preoperative planning and a comprehensive patient assessment are arguably the most important aspects of orthognathic surgery.[7] Patient assessment should include a detailed medical history as well as a thorough extraoral facial and intraoral examination in both the frontal and profile view. Radiographic evaluation is important to augment and support clinical findings that include cephalometric evaluation in addition to three-dimensional analysis via either cone-beam computed tomography or traditional computed tomographic scans[8] (►Fig. 1).

Deformities or deficiencies of the midface can ultimately occur in all three spatial planes, oftentimes occurring simultaneously in multiple planes. As such, it is imperative in the initial surgical assessment and workup to evaluate deformities in all surgical planes (anteroposterior, transverse, vertical, and rotational).[9]

VSP has revolutionized orthognathic surgery over the last couple decades, as it allows for improved diagnostic ability and treatment precision.[10,11] Traditional surgical planning involves using clinical records, two-dimensional radiographs, photographs, and model surgery. Continued improvement of medical modeling software has allowed for the transfer of clinical information to a virtual platform that ultimately results in highly accurate surgical outcomes without making time-consuming models[11–13] (►Fig. 2).

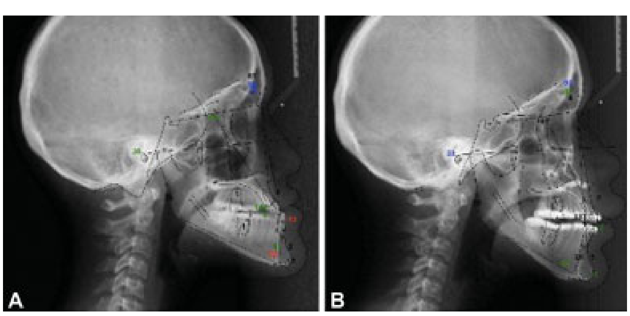

Fig. 1 Lateral cephalogram preoperative and planned postoperative.

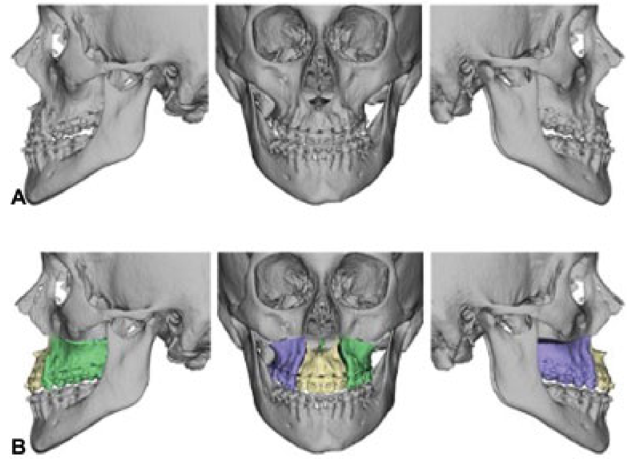

Fig. 2 Virtual surgical planning of preoperative and postoperative maxillary position.

Special Considerations: Cleft Palate

Patients with cleft deformities will typically present with a complex deformity in all the aforementioned planes, thus displaying a discrepancy in overall facial width, height, and length. Additionally, patients with cleft deformities also present with significant asymmetries, general maxillary deficiency, and occlusal cants that often necessitate bimaxillary surgery as opposed to single jaw skeletal correction.[7,10] Certain features that are unique to cleft patients and may impact planning and surgery include the potential need for alveolar cleft grafting, possibility of congenitally missing dentition, and a significant arch-width discrepancy.[7]

Surgical Treatment: Maxillary Osteotomies

Traditional LeFort I Osteotomy Technique

After appropriate workup, the patient is brought to the operating theater and placed in supine position with mild neck extension. General anesthesia is induced, and the patient is intubated with a nasal endotracheal tube to allow for uninhibited intraoperative confirmation of occlusion. The maxillary vestibule is infiltrated with local anesthesia, typically 1% lidocaine with 1:100,000 epinephrine. A nasal decongestant may also be used.

First, a Kirschner wire (K-wire) is inserted into the nasion and used to reference the starting position of the maxilla in a vertical dimension. Alternatively, the medial canthus may be used as an external reference. Internal references are unreliable for orthognathic surgery.[10]

A full-thickness incision is made through the labial mucosa at least 5 mm superior to the mucogingival junction with either a #15 blade or fine-tip electrocautery. The lateral extent of the incision does not need to extend beyond the maxillary first molar bilaterally. A subperiosteal dissection is carried superiorly and laterally to completely expose the piriform rims and zygomaticomaxillary buttresses bilaterally. The area of the anterior nasal spine is often tenacious and, as such, care must be taken to avoid perforation of the nasal mucosa. The nasal mucosa is elevated, starting laterally at the piriform aperture and moving medially.

Following soft tissue elevation and complete exposure, the planned transverse osteotomy is marked and traced; osteotomies should remain at least 5 mm superior to the apex of the maxillary dentition to avoid disruption of tooth roots. VSP can be utilized for this stage of the procedure; it has allowed for preplanning of osteotomies, creation of cutting guides to enhance osteotomy accuracy, and fabrication of splints. While surgeon preference plays a significant role in the execution, the osteotomy is typically completed with a reciprocating saw or a piezo blade from lateral to medial.

Once the osteotomy is completed bilaterally, a curved osteotome is used to separate the junction of the pterygoid plates and the maxillary tuberosity. Next, a straight osteotome may be used to ensure complete separation at the piriform and zygomatic buttress. A transverse septal osteotomy across the maxillary crest may also be used to elevate the base of the nasal septum.

The maxilla is then down-fractured with manual pressure in an inferior direction. Any remaining bony interferences inhibiting desired repositioning can then be visualized and removed. Next, the descending palatine vessels should be evaluated; some surgeons advocate prophylactic clipping or cauterization of these vessels to prevent postsurgical bleeding, but this remains controversial, as ligation of these vessels could theoretically compromise palatal vascularity and lead to devastating bony necrosis. Ligation of the descending palatine arteries has not been definitively shown to compromise palatal blood supply in large studies, however, as the maxilla receives a significant vascular supply from its soft tissue pedicle.[10,14]

Next, the patient is placed into intermaxillary fixation (IMF) with a surgical splint. Using the K-wire as a reference, the maxilla is placed in its desired vertical position. Typical fixation of the maxilla includes four midface plates placed at the piriform rims and zygomatic buttresses bilaterally, thereby restoring the vertical buttresses of the face (►**Fig. 3**).

The patient is then released from IMF and occlusion again confirmed. Following irrigation, soft tissue closure is done with a standard midline V-Y closure technique.[9] V-Y closure is achieved by retracting the midline superior vestibular mucosal flap superiorly and anteriorly with a single skin hook, bringing the medial edges of the transverse incision together that are then vertically sutured. The remainder of the vestibular incision is then closed; this technique allows for increased median tubercule pucker and lengthening of the upper lip. ►**Figs. 4** to **7** represent comparative preoperative and postoperative photos and imaging.

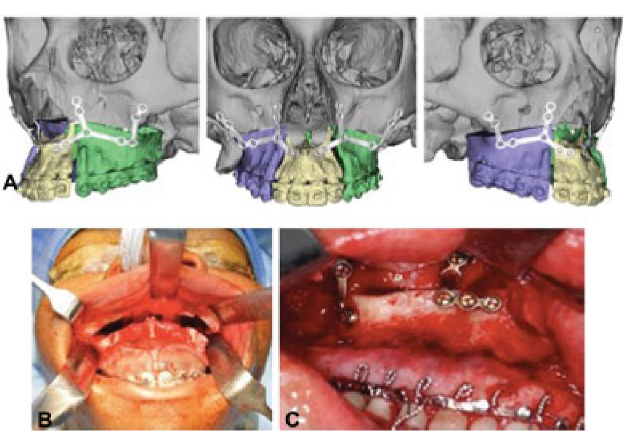

Fig. 3 Intraoperative views of osteotomies and fixation.

Fig. 4 Preoperative and postoperative clinic photos, patient A.

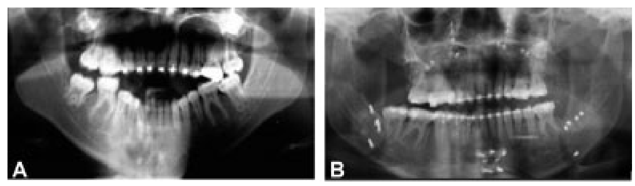

Fig. 5 Preoperative and postoperative panoramic radiographs, patient A.

Surgical Modifications

To address deformities of the upper midface and zygomas, osteotomies may be modified based on the individual case characteristics.[9,10] Vertical interdental osteotomies can be added to the general transverse osteotomy, thus creating multiple segments of maxilla and allowing multiple planes of movement in each individual segment. Multipiece maxillary LeFort I osteotomies are indicated when there is a transverse palatal deficiency or abnormalities in multiple planes of occlusion. Studies by Bell and Levy have demonstrated adequate revascularization of maxillary segments with preservation of surgical stability, predictability, and safety compared with the traditional single transverse LeFort I.[14] Furthermore, Posnick et al found no increased incidence of perioperative complications among patients who had a LeFort I plus multiple vertical osteotomies compared with those who only had a traditional LeFort I.[15]

Some patients that present with palatal width deficiency may benefit from a surgically assisted rapid palatal expansion (SARPE) procedure, which can be completed in a single stage or two-stage approach. The decision between a SARPE and multipiece maxillary osteotomy depends upon physician preference, maxillary morphology, arch length, and

Fig. 6 Preoperative and postoperative clinic photos, patient B.

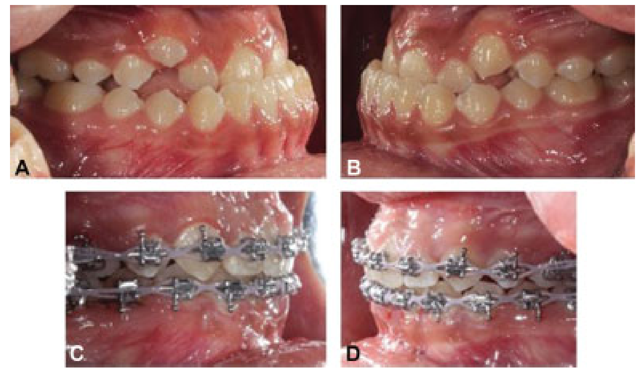

Fig. 7 Preoperative and postoperative intraoral photos, patient B.

the degree of desired expansion. SARPE is considered in patients with significant transverse discrepancies with a high palatal vault and now vertical or anteroposterior abnormalities, while multipiece maxillary osteotomy is ideal for manipulation of dual or multiple occlusal planes in the maxillary arch. Most notably, the main limitation of the SARPE procedure is a high incidence of reported relapse.[11,14]

Sequencing of Treatment

Advances in orthognathic surgery have called into question the timing for surgery regarding the overall treatment for the patient.[16] This can be divided between "surgery intermediate" and "surgery first." In the case of the latter, surgery is done prior to any orthodontic correction. Advances in orthodontic simulation via dental models and planning software allow for this "surgery first" technique, which is gaining popularity.[11] Peiró-Guijarro et al, in a large comparative study, found "surgery first" patients completed their treatment ~6 months sooner than those in which conventional orthodontics were used prior to surgery.[17] Cases that would prohibit the "surgery first" technique include those with a significant amount of dental compensation, defined as the natural attempt to achieve normal interarch relationship with varying skeletal discrepancies, as well as severe craniofacial deformities that rely on decompensation to establish a definite surgical plan.[17,18]

When considering bimaxillary surgery, one of the continued areas of controversy lies in determining whether to move the mandible or maxilla first. Completing the mandibular osteotomy and fixating it prior to maxillary surgery have come into favor in recent years. Cases in which addressing the maxilla second is particularly beneficial include multipiece maxillary LeFort I osteotomies, where multiple planes of occlusion will be addressed and corrected, significant maxillary advancements, and large counterclockwise rotations. Performing the mandibular surgery first in these cases is advantageous because of improved splint stability and lack of bony interferences. The mandible should also be moved first whenever temporomandibular joint surgery is needed.

Overall, however, there remains no firm consensus as to which order is superior and, as such, sequencing of double jaw surgery is often left to the discretion of the operating surgeon.[19–22]

Movements and Stability

Following maxillary LeFort I osteotomy, whether traditional single piece or multipiece, the final desired position of the maxilla will ultimately be altered in any or all of the previously mentioned planes. As determined by Proffit et al, the predictability and long-term stability of the various maxillary movements is well documented and has significantly influenced how orthognathic surgery is planned and performed today. Transverse and anteroposterior movements of the maxilla are quite robust, for example, whereas the least predictable and stable movements of the maxilla are widening and bringing the maxilla down. It is imperative to graft any osseous gaps at the time of surgery in these cases.[23]

Complications

Orthognathic surgery is a complex procedure and is not without complications. These can include bleeding, infection, scarring, malunion or nonunion, skeletal relapse and malocclusion, neural injury, temporomandibular joint dysfunction, and poor aesthetic results. Hemorrhage is one of the most common complications after LeFort I osteotomy with an estimated incidence of 5.25%.[24–26] Postoperative epistaxis is rare, but it may result from a traumatic nasotracheal intubation or from traumatic stripping of the nasal mucosa. In these cases, the epistaxis typically resolves without further intervention. However, significant epistaxis can occur from injury to the internal maxillary artery or its branches. If injury to these vessels is encountered, the vessels must be identified and either clipped or cauterized with bipolar cautery under direct visualization. In the case of severe hemorrhage, up to 30% of patients undergoing surgery may require a blood transfusion; however, in recent years, this has decreased to ~9%.[27,28] Factors associated with increased blood loss include extensive surgery, a prolonged operating time, and a lower body-mass index.[29] Patients who are at risk of bleeding may benefit from hypotensive anesthesia, intraoperative tranexamic acid administration, and piezosurgery, which have each been associated with reduced intraoperative blood loss.[30–32]

Infection is rare in patients undergoing orthognathic surgery; however, it may necessitate hardware removal in certain situations.[33] A randomized control trial showed that 3 days of postoperative antibiotics had a statistically significantly decreased rate of surgical site infections compared with 1 day of postoperative antibiotics in patients undergoing orthognathic surgery (7.0 and 17.6%, respectively) with a high rate of surgical site infections in patients undergoing mandibular bilateral sagittal split osteotomy (71%). The authors determined that the number needed to treat was 10, and suggested that the benefits of the extended regimen may not outweigh the risks, recommending this extended regimen in patients undergoing mandibular bilateral sagittal split osteotomy.[34]

Aseptic necrosis of the maxilla is a rare but devastating complication. There may be partial to total loss of the advanced maxilla from devascularization or excessive tension on the maxillary segment.[35,36] Management includes serial debridements, antibiotics, hyperbaric oxygen, and autologous or free bone grafting.[36]

The most common unanticipated nerve injured during LeFort I is of the infraorbital nerve, and typically presents due to neuropraxia caused by excessive tension on the soft tissue.[37] Most patients recover sensation completely after neuropraxic injury over several weeks to months without further intervention.

Conclusion

Orthognathic surgery is an essential treatment in the correction of both functional and aesthetic dentofacial deformities. New concepts ("surgery first") and technology (VSP) have driven the evolution of orthognathic surgery into the modern era, making it a more precise and reliable surgery. However, intimate knowledge of facial analysis, bony anatomy and jaw function, careful surgical planning, and close partnership between the orthodontist and maxillofacial surgeon remain the cornerstone of successful orthognathic surgery.

Conflict of Interest
None declared.

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