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REVIEW ARTICLE

MAXILLARY PROCEDURES IN ORTHOGNATHIC SURGERY: A REVIEW

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ABSTRACT

Orthognathic surgery which involves the surgical repositioning of maxilla & mandible is typically performed to correct skeletal discrepancies &improve facial esthetics, function & airway patency. This review aims to provide an overview of maxillary procedures commonly performed in orthognathic surgery, highlighting the surgical techniques & considerstiond involved in repositioning of maxill to achievr optimal function & esthetic outcomes.

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INTRODUCTION

Orthognathic surgery also known as corrective jaw surgery is a surgical procedure performed to correct a wide range of major dental irregularities including those of maxilla & mandible. In orthognathic surgery maxillary procedures play a crucial role in addressing maxilla related discrepanciessucha malocclusion. asymmmetry, functional issues. The goal of orthognathic surgry is to improve patients ability to bite, chew and speak as well ho address any concerns related to facial aesthetics and overall oral health. There are several conditions that may neccesitate orthognathic surgry including misaligned jaws, protudinfg or receding jaws. orthognathic surgery can have transformative impact on patients life improving both function and esthetics. By addressing underlying skeletal & dental tissuesc it can enhance facial harmony restore proper chewing function & alleviate TMJ disorders. Additionally for some individuals this can provide relief from obstructive sleep apnoea & other breathing problems related to jaw structure. This surgery is performed as an elective procedure, the surgical team should make every attempt to control blood loss and reduce the need for blood transfusion. Hypotensive anesthesia leads to decreased blood loss and overall improved quality of the surgical field. In a healthy patient, a mean arterial pressure (MAP) of 50 to 60 mm Hg is considered to represent a safe lower limit of induced hypotension. The reduced need for blood transfusion with hypotensive anesthesia potentially eliminates the risk for transfusion reaction or transmission of blood-borne pathogens. The main advantage of performing the maxilla first is eliminating the greater error in malocclusion and condylar position that occur after performing the mandible first. It is important for individuals considering krthognathic surgery to consult oral &maxillofacial surgeon & orthodontist if they are suitable candidates for procedures. The decision to undergo surgery is typically made after a thorough patients dental & skeletal condition, facial esthetics and overall treatment goals.

The Evolution of Orthognathic Surgery: Orthognathic Surgery is considered the gold-standard treatment to correct dento-facial deformities. Since the first procedure in the 19th century, a plethora of techniques were developed and modified. Virtual planning arises as an interesting tool to provide additional visualization, clarifying the procedure and give instruments to perform a precise surgical procedure. In conjunction with patient-matched implants, the surgeons have in their hands the best solution to provide the more precise result to the patients. The purpose of this journal is to review the literature regarding different types of surgical procedures related to an orthognathic surgery, regarding traditional and new tools.

Orthognathic surgery is considered medically necessary when BOTH of the following criteria are met:[59]

ANY of the following facial skeletal deformities is present:

Anteroposterior discrepancies:

- Maxillary/mandibular incisor relationship: overjet of 5 mm or more, or a zero to negative value (norm = 2 mm)
- Maxillary/mandibular anteroposterior molar relationship discrepancy of 4 mm or more (norm = 0– 1 mm)

Table 1. Some landmark dates in the development of orthognathic surgery. (Maxillary procedures)

Date	Clinician(s)	Discription
1859	von Langenbeck	Hemimaxillary osteotomy for access to nasopharyngeal polyp.
1868	Cheever	Maxillary osteotomy and downfracture at what is now termed the Le Fort I level for access to a nasopharyngeal polyp.
1921	Cohn-Stock	Segmental retroclination of the anterior maxillary dentoalveolus (procedure undertaken in 1920).
1927	Wassmund	Le Fort I osteotomy with the pterygomaxillary junction left intact; elastic forces were used to advance the maxilla.
1934	Axhausen	Le Fort I osteotomy with postoperative advancement using elastic traction.
1935	Wassmund	Segmental set-back of the anterior maxilla (2-stage procedure: first palatal approach; 4 weeks later buccal approach).
1949	Schuchardt	Staged Le Fort I osteotomy, followed by pterygomaxillary separation; external postoperative traction using a pulley and weights was used to advance the maxilla.
1949	Moore and Ward	Recommended horizontal transection of the pterygoid plates for maxillary advancement.
1954	Gillies and Rowe	Described a maxillary osteotomy in a cleft patient with advancement and use of autogenous bone grafts.
1954	Ivo Cupar	Described a single-stage anterior segmental maxillary osteotomy (intraoral approach).
1959	Schuchardt	Described a two-stage segmental impaction of the posterior maxillary dentoalveolus (Developed in mid-1950s).
1960	Kufner	Modified the Schuchardt two-stage posterior segmental maxillary impaction as a one-stage procedure.
1965	Obwegeser	Fully mobilized the maxilla; in a single step brought it into the predicted position.
1966	Wunderer	Segmental set-back of the anterior maxilla (1-stage procedure, palatal approach).
1969 to mid 1990	Bell	Investigations on the blood supply and revascularization following orthognathic procedures, particularly in the maxilla.
1985	Bennett and Wolford	Described the Le Fort I 'step' osteotomy, which prevented the potential ramping effect with maxillary advancement

Vertical discrepancies

- Presence of a vertical facial skeletal deformity which is two or more standard deviations from published norms for accepted skeletal landmarks
- Open bite with no vertical overlap of anterior teeth or unilateral or bilateral posterior open bite greater than 2 mm
- Deep overbite with impingement of palatal soft tissue
- Supraeruption of a dentoalveolar segment resulting from lack of occlusion when dentition in segment is intact

Transverse discrepancies

- Presence of a transverse skeletal discrepancy which is two or more standard deviations from published norms
- Total bilateral maxillary palatal cusp to mandibular fossa discrepancy of 4 mm or greater, or a unilateral discrepancy of 3 mm or greater, given normal axial inclination of the posterior teeth.

Asymmetries

- Anteroposterior, transverse or lateral asymmetries greater than 3 mm, with concomitant occlusal asymmetry

ANY of the following functional impairments is present:

- Persistent difficulties with mastication and swallowing after causes such as neurological or metabolic¬ diseases have been excluded
- Malnutrition, significant weight loss, or failure-to-thrive secondary to facial skeletal deformity
- Speech dysfunction directly related to a jaw deformity as determined by a speech and language pathologist
- Myofascial pain secondary to facial skeletal deformity that has persisted for at least six months, despite conservative treatment such as physical therapy and splints
- Obstructive sleep apnea when ALL of the following criteria are met:
- Criteria for positive airway pressure (PAP) met and individual has proved intolerant to or failed a trial of PAP
- Mandibular repositioning appliance (MRA) or tongue-retaining appliance has been considered and found to be ineffective or undesirable
- Craniofacial disproportion or deformities

Anatomical consideration

Blood supply: Blood supply is essential for the healing of osteotomies. Bell and Levey[13] 1969 and 1970 have shown in a study that periosteum is necessary for maintaining the blood supply to the teeth of a mobile jaw segment. Even when the labial periosteum is raised, care should be taken not to cause any tension or tears. However, it is important that the distance between the osteotomy and apices of the teeth is at least 5 mm. keeping this distance minimizes tooth and pulpal injury, and a mobile segment will have greater vitality to survive by increased vascular supply.

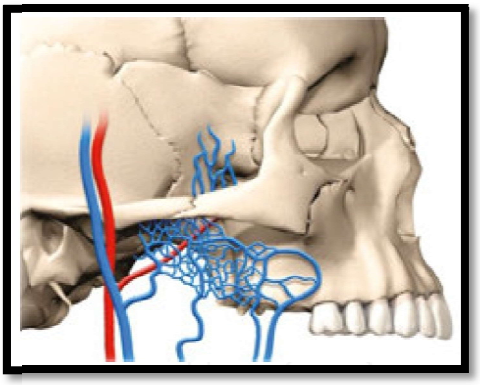

Figure 11. Prominent vessels to consider in orthognathic surgery are the posterior superior alveolar (PSA) artery, greater palatine artery, maxillary artery, pterygoid venous plexus, inferior alveolar artery, and buccal artery

It is advised to handle the soft tissues with care so that adequate collateral blood supply to the osteotomized segment is maintained and injury to other vital structures is avoided. Prominent vessels to consider when planning orthognathic surgery are the posterior superior alveolar (PSA) artery, greater palatine artery, maxillary artery, pterygoid venous plexus, inferior alveolar artery, and buccal artery. ***Nerves:*** Bradycardia and asystole may occur during downfracture or mobilization of the maxilla due to the trigeminal cardiac reflex. This can happen as a result of manipulation of the central or peripheral portions of the trigeminal nerveduring mobilization of the maxilla.[81]AlPatients who undergo Le Fort II and III osteotomies may experience infraorbital nerve sensory dysfunction.

Muscles: Muscles are, as mentioned earlier, important in orthognathic surgery. On the one hand, they are essential for blood supply to the segments, and on the other, they have an impact on relapse. Surgery can affect muscles in two different ways; they can change the length and direction of function. The muscles that can be affected by orthognathic surgery are the suprahyoid group of muscles and the masticatory muscles.

Maxillary osteotomies

Le Fort I osteotomy: It is a surgical procedure involves cutting & repositioning the maxilla.

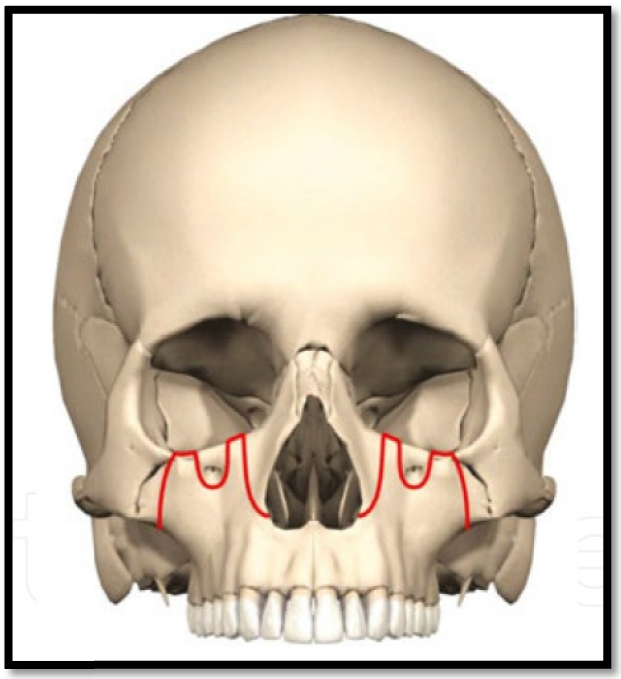

Figure 12. In some cases, a high Le Fort I osteotomy is required for advancement of the entire midface to improve the extraoral profile

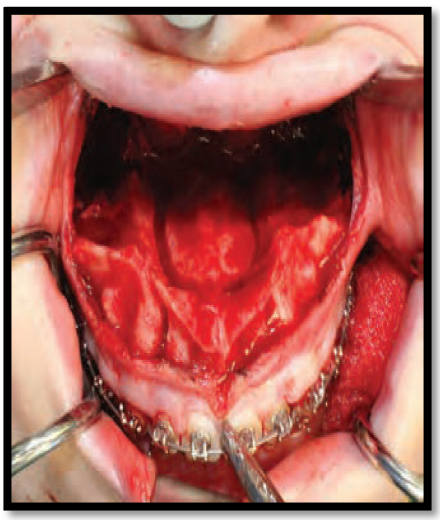

Fig. 13A.

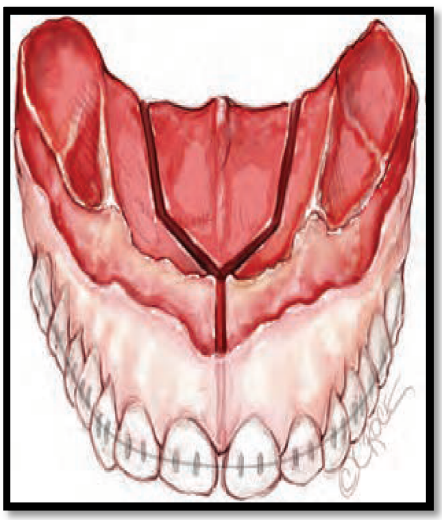

Fig. 13B.

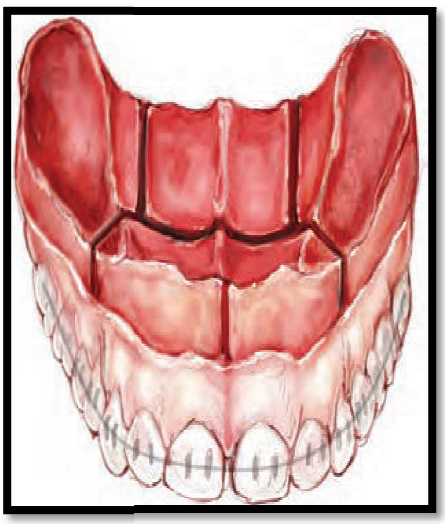

Fig. 13C.

(A) U-shaped palatal osteotomy following downfracture of the Le Fort I maxillary osteotomy. (B) Palatal osteotomy with midline osteotomy. (C) Palatal osteotomy with bilateral para-midline osteotomies

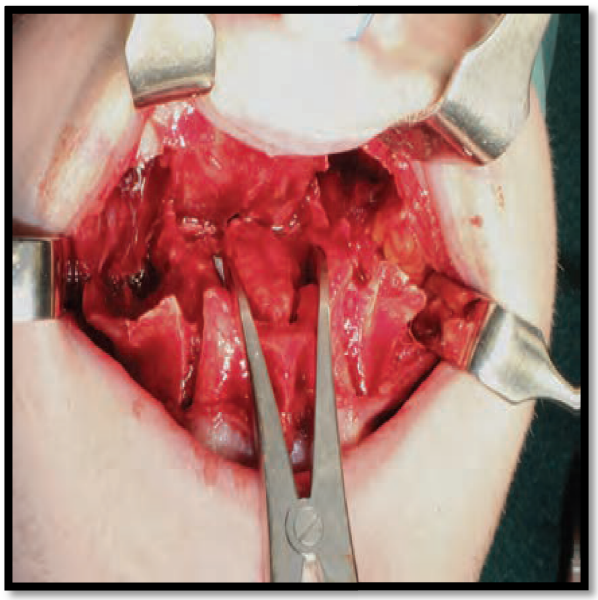

Fig. 14A

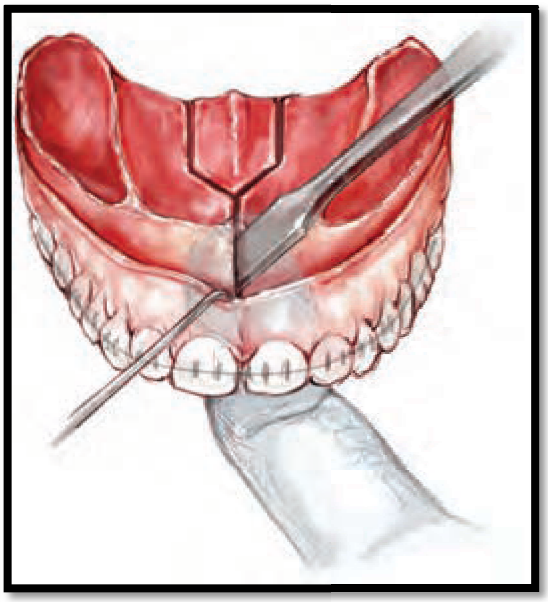

Fig. 14B.

(A) Mobilizing midline osteotomy with osteotome and finger placed on palatal mucosa. (B) Mobilizing osteotomy segments with spreader

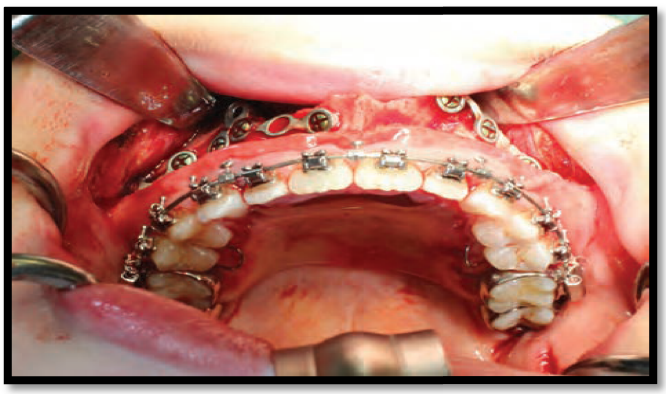

Figure 15. Palatal Splint wired in situ splint and intermaxillary fixation

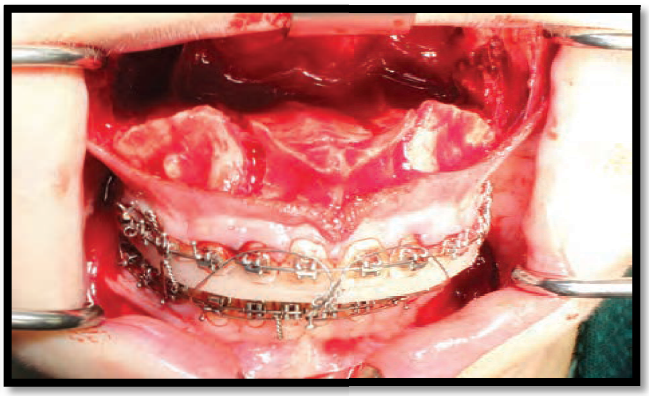

Fig. 16. Positioning of segments into occlusal

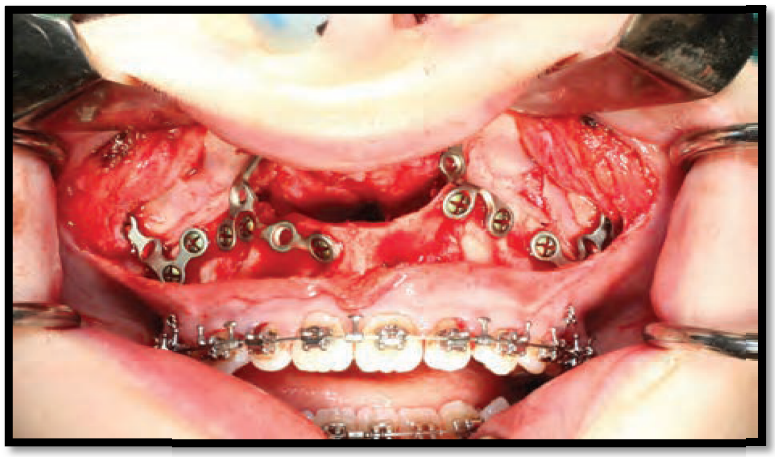

Fig. 17. Fixation with bone plates and screws incorporating interdental osteotomy sites

Le Fort II: The indication for this osteotomy is when a forward, downward movement of the nasal and maxillary complex is necessary for correction of the midface. This osteotomy is performed in the upper midface, between the frontal facial unit and above Le Fort IThe approach has its place where there is a need for the correction of nasomaxillaryhypoplasia.[88,125] This osteotomy is also called a pyramidal naso-orbital maxillary osteotomy. The Le Fort II osteotomy includes the naso-orbital ethmoidal (NOE) fracture line, the zygoma laterally, and internal part of the orbit. This osteotomy was first presented by Henderson and Jackson in 1973. Surgically, an incision is performed obliquely to the paranasal region extending to the infra-orbital rim to the medial canthus and over the nasal bone. The Le Fort II osteotomy is relatively rare because it is not required as often (only in 2% of dentofacial anomalies cases, such as in Apert, CrouzonTreacher Collins syndromes). Other indications are a skeletal classIII malocclusion in combination with maxillary-zygomatic deficiency, maxillary-alveolarpalatal cleft deformity, and nasomaxillary deficiency.[39]The osteotomy allows lengthening of the nose along with the movement of the upper jaw in selected cases where this effect is desired.

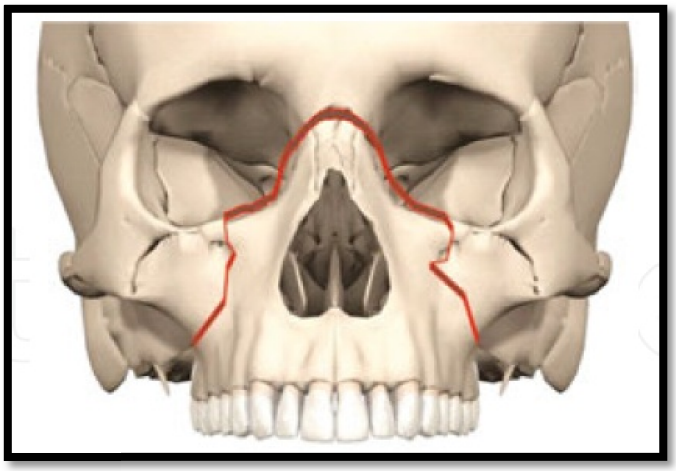

Figure 18. Le Fort II osteotomy is performed in the upper midface, between the frontal facial unit and above Le Fort I.

Steinhauser, 1980, described three different surgical approaches namely anterio-, pyramidal, and quadrangular osteotomies.[123]

Le Fort III: Sir Harold Gillies and colleagues presented the Le Fort III osteotomy for the first time in 1951. The technique was improved by Paul Tessier in 1967 making five different variations mainly regarding the osteotomy of the lateral wall of the orbit.[127] The Le Fort III procedure is designed to move the entire midface forward including the portions of the eye sockets to get a more balanced appearance in whom facial disharmony results from panfacial hypoplasia. This technique is used in various craniofacial syndromes such as Apert, Crouzon, Treacher Collins, etc.

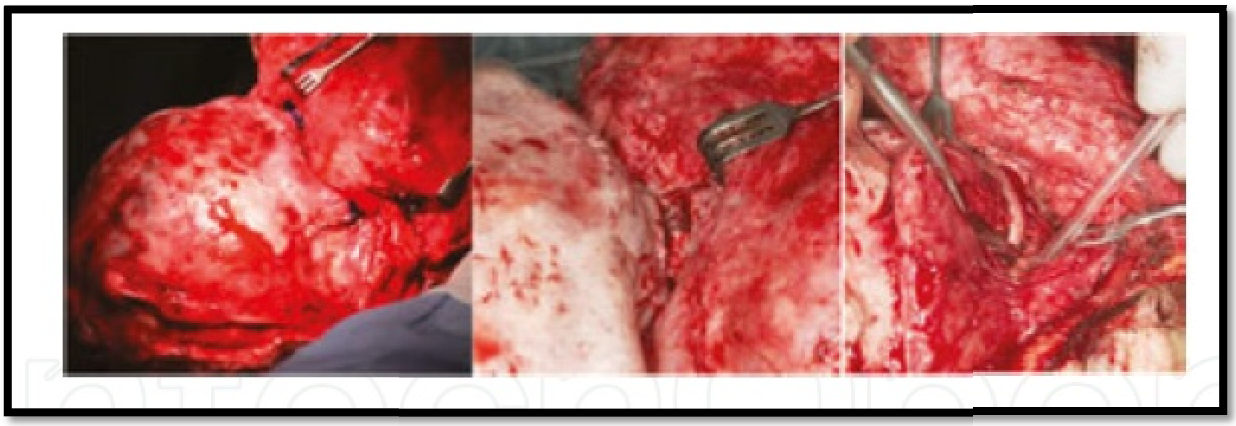

Figure 19. The dissection of the supraorbital rim includes decompression of the supraorbital nerve by an osteotomy on the supraorbital rim to release the nerve. The incision extended to the lateral orbital rim, nasion, and through the zygomatic arch via a coronal incision

Those patients who have a total retrusion of the midface often have a retrusion of the nose, cheeks, inferior orbital rims, and upper lip. Patients with Crouzon, Apert's, and Pfeiffer's syndrome often have a hypoplastic nose. In some cases, it will be necessary to complete a Le Fort III with a Le Fort I osteotomy to make the appropriate adjustment for optimal aesthetics and occlusion. One more detail to keep in mind is the intercanthal distance and level of attachment of the medial and lateral canthal tendons. Epker et al[40] suggested that this method is more aesthetic, and function of the lacrimal sac is better when dystopia of the medial canthal tendons or telecantism does not exist.

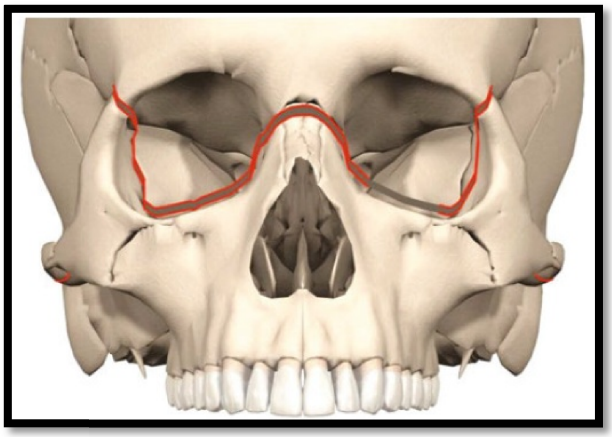

Figure 20. Le Fort III The incision extended to the lateral orbital rim, nasion, and through the zygomatic arch via a coronal incision, through an intraoral incision back to the pterygoidomaxillary junction that is detached using a chisel.

External versus Internal Distractors for Le Fort II and III: Distractors come in various shapes and forms, but they can generally be classified as either internal distractors or external distractors (halo-like devices).

The main advantage of an internal distractor: It is less conspicuous and impacts less the patient's daily activities. These devices are relatively small and less intrusive for patients and families. Major disadvantages include uniplanar distraction vector, inability to manipulate the distraction vector postoperatively, and a slightly increased infection rate.[92] Internal devices require a second procedure under anesthesia for removal, which can also be challenging. In 1997, Polley[104]was the first to describe the use of an external "halo-type" distractor for Le Fort III distraction. Although rigid, external devices allow for easy adjustment in the postoperative period, often in more than one vector. This allows for "orthodontic" adjustment of the distracted segment in multiple vectors to maximize its final position. Additionally, halo-type distractors provide a central "pull" rather than a peripheral "push," which serves to further unfurl facial concavity often present in syndromic patients. The ability to minimize buried hardware, especially in the region of the bony regenerate, helps to minimize infectious complications as well as maximize bone formation. Generally, they are easy to apply and easy to remove. Disadvantages include the psychosocial discomfort of wearing a large external device, risk of accidental dislodgement, possible infections around the pin sites, scars in the scalp, and the risk of penetration transcranially of the fixation pins.[96]

Anterior segmental maxillary osteotomy: This technique is applied when repositioning of the premaxilla in a vertical plan is required such as for frontal open bite, to retract the anterior teeth, when orthodontic treatment cannot accomplish the desired movement (e.g., when teeth are ankylotic or when a deep bite is present). Cohn-stock[29] was the first surgeon who reported this technique. A mucosal incision is applied in the buccal side of the maxilla above the roots of the incisors. This incision is extended to the distal section of the first bicuspid bilaterally.

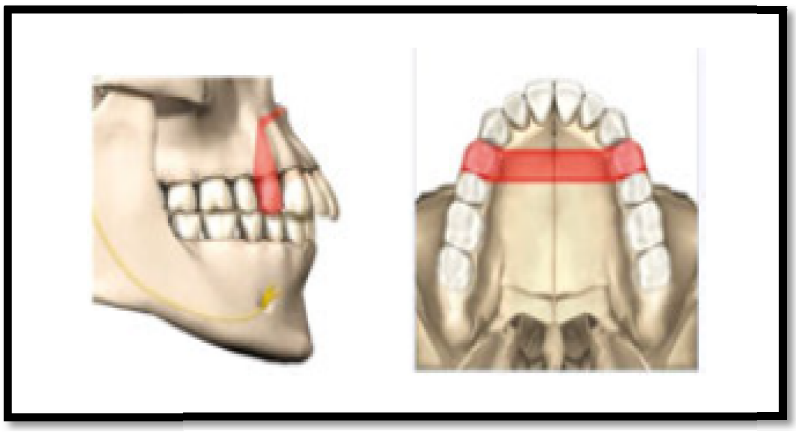

Figure 21. Anterior segmental maxillary osteotomy can be done either by performing a Le Fort I osteotomy or by a restricted buccal vestibular incision, allowing direct access to the anterior lateral maxillary walls, piriform aperture, nasal floor, and septum

The anterior segmental maxillary osteotomy can cause some complications such as oronasal or oroantral fistula, damage to the teeth, loss of vitality of teeth, complication with the maxillary sinus and nasal cavity, un-favorablenasolabial aesthetics, and nasal septal deviation. The most common complication with anterior segmentation is a retraction of gingiva in the anterior segment and relapse during the early healing phase.

Posterior maxillary segmental osteotomy: The technical difficulties concerning approaches to the posterior maxillary segmental osteotomy have been emphasized. The indications are mainly uni or bilateral posterior open bite. The cut is performed at the buccal vestibular section of the posterior maxilla 5 mm above the root apices. The access to the bone is made through a horizontal cut in the buccal vestibule extending from the second molar to the distal aspect of the canine. The incision continues vertically to the papillae at the distal aspect of canine and distal aspect of the second molar. It is preferable to extract the molar in advance some months before this approach.

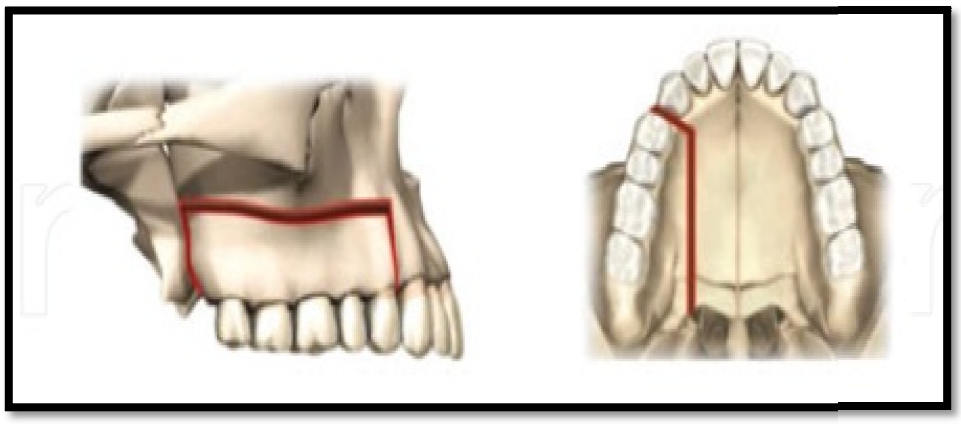

Figure 22. The cut is performed at the buccal vestibular section of the posterior maxilla 5 mm above the root apices

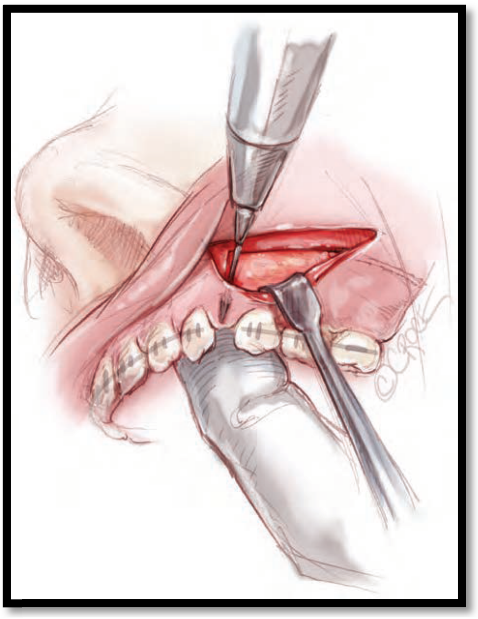

Fig. 23. Exposure of posterior maxillary region with vertical and horizontal buccal osteotomy cuts

Combination of anterior and posterior maxillary osteotomy (Horseshoe osteotomy): Paul Tessier[127] reported this procedure for midface hypoplasia. It has also been described and further developed by West and Epker 1972, Hall and Roddy 1975, Wolford and Epker 1975, West and McNeil 1975, Hall and West 1976, and Maloney 1982. Palatal parasagittal osteotomies are performed with a piezoelectric device. The hard palate is untouched staying in position. The method creates a three-piece maxilla with the central nasal portion left undisturbed. This is a complicated technique since multiple areas of bone contacts exist. The indication is maxillary alveolar hyperplasia or transverse hypoplasia without a vertical component. The method has more or less been replaced by the traditional Le Fort I osteotomy.

Figure. 24. The horseshoe osteotomy; this method has more or less been replaced by the traditional Le Fort I osteotomy.

Wassmund technique

Preserves both buccal & palatal pedicle.
Buccal as well as anterior vertical incision
Transpalatal osteotomy through buccal vertical incision.

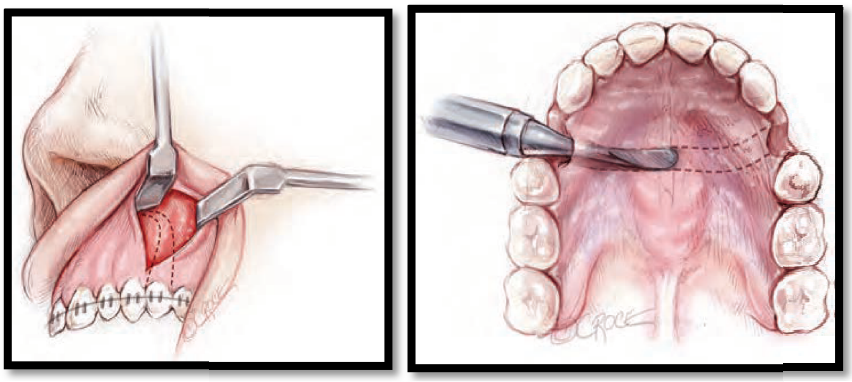

Fig. 25 (a) Exposure of buccal aspect of maxilla and outline of osteotomy cuts. (b) Dissection of palatal mucosal tunnel withperiosteal elevator

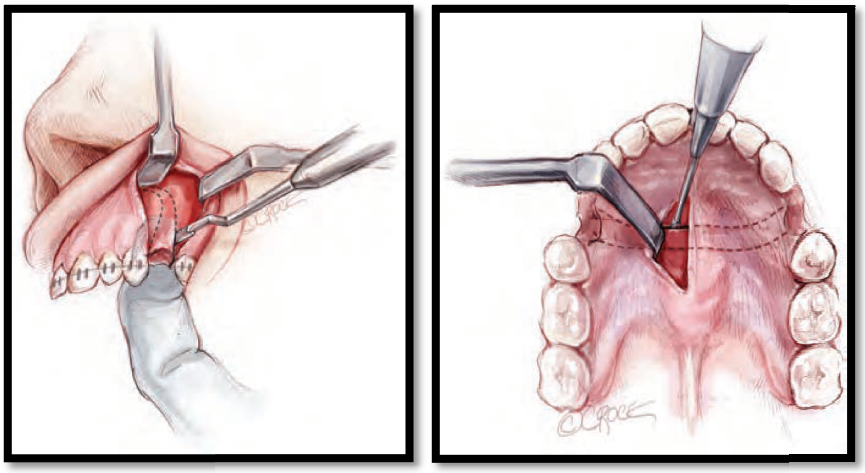

Fig. 26.(a). Buccal osteotomy cuts and bone removal is performed in region of extracted tooth. (b) Midline palatal incision forexposure of bone in the midline is required to complete palatal osteotomy cuts.

Wunderer technique

- Relies on intact buccal pedicle
- Transpalatal incision combined with buccal vertical incision
- Modification: Midline vertical incision combined with buccal vertical incision.

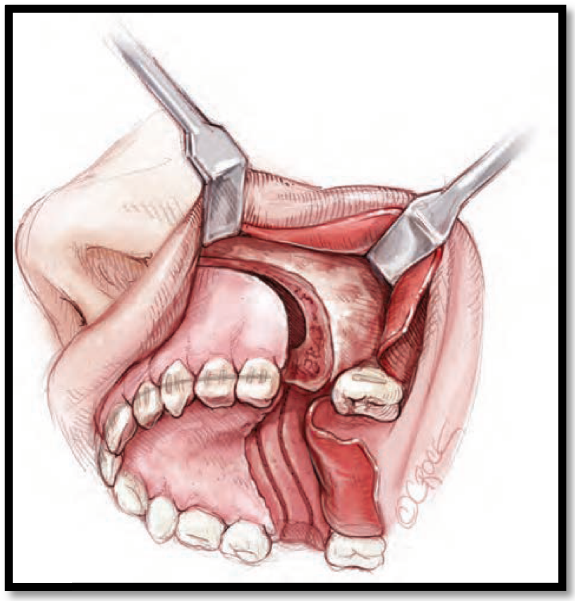

Fig. 27. Palatal incision with elevation of palatal flap to expose palatal bone for osteotomy and removal of segment of bone

Cupar's Technique[69]*:* Cupar's technique in 1954 is the most preferred approach by many surgeons as it allows access for bone removal under direct visualization through the nasal floor. Horizontal osteotomy followed by vertical buccal osteotomy

Anomalies and craniofacial syndromes including cleft lip and cleft palate in maxillary procedures in orthognathic surgery[19] : Craniofacial syndromes fall into two major categories-those associated with craniosynostosis, and those associated with clefts. Each has a different set of potential complications requiring a unique approach for surgical management. Craniosynostosis is a congenital disorder in which one or more of the cranial sutures fuses prematurely. The most common syndromes associated with this condition include Crouzon, Apert, Pfeiffer, Muenke, and Saethre-Chotzen syndromes. Surgical management of these children requires a multidisciplinary approach and close involvement of the family. Operations must take into consideration the growing potential of the bony structures. Common syndromes associated with clefts include Pierre Robin, Treacher Collins, Nager, Binder, and Stickler syndromes. Many of these children have severe airway issues requiring immediate address before operative reconstruction. As with syndromes associated with craniosynostosis, the key to management is a multidisciplinary approach focused on the right timing.

Cleft lip and cleft palate in maxillary procedures in orthognathic surgery[48]: Cleft lip and palate deformities are amongst the most common congenital anomalies of the face. Cleft lip and palate surgery as well as orthodontic treatment are amongst the therapeutic possibilities for recovering patients' esthetics and function. In patients with cleft lip and palate, some occlusal deleterious situations such as teeth crowding and unilateral crossbite with segments collapse, open bite on the affected side and retrusion of the maxilla, are identified. After the growth spurt, orthognathic surgery is indicated to correct skeletal and dental discrepancies in patients who present dentofacial deformity. Hirano and

Suzuki[56] described potential aspects which are responsible for maxillary retrusion in adult cleft patients: Unfavorable muscular action due to scars caused by early surgeries in lip and palate, pharyngeal flaps and absence of teeth, which reduces occlusal stability.

DISCUSSION

A review of the literature demonstrated that the majority of previous research that has evaluated the postoperative soft tissue changes following orthognathic surgery focused on either the immediate inflammatory response following surgery or the longer-term changes that occurred as a result of surgery. The typical time scale were comparisons of presurgicalfaces with the postsurgical result 1e3 years later. Few studies have attempted to evaluate the soft tissue changes after the initial peak of inflammatory response. Kobayashi et al[76] (1990) investigated the three-dimensional soft tissue changes in 28 patients in whom mandibular prognathism was corrected by mandibular setback procedures. They reported that, the magnitude of volumetric change in the anterior mandibular region was proportional to the posterior movement of the mandible. Landes et al[80] (2002) investigated the osseous and soft tissue changes in 45 patients. Of these, 6 were mandibular advancements, 20 mandibular setbacks, 33 maxillary advancements, 9 maxillary setbacks, 13 maxillary impactions, 11 maxillary elongations and 10 setback genioplasties were performed. They reported that the soft tissue changes were greater following mandibular advancement 105% response than following setback with maxillary advancement with 66% in setback. Day and Lee[35] (2006) found continued movement of the upper lip, lower lip, mental region, and chin over 6months, by assessing cephalograms taken immediately postsurgery, 2 months postsurgery, and 6 months postsurgery. Their findings were significant (p\0.001) at the labiomental fold and pogonion and in the relationship between the upper and lower lips to the aesthetic plane. A 3 year follow-up visit demonstrated further changes occurring in these regions. They reported that in patients having bimaxillary surgery, greater changes throughout the initial 4 month period and this suggests that the soft tissues are continuing to settle.

Hemorrhage after LeFort I surgery was described in 9.09 % evaluated articles. The most serious hemorrhage during or after Le Fort I osteotomy happens as a consequence of pterygomaxillary separation.[40] The risk of arterial bleeding from the posterior maxilla usually arises from the descending palatine artery or less frequently from the maxillary artery and its branches. Serious hemorrhage from the pterygoid venous plexus occurs less frequently. The patterns of fracture of the pterygoid plates in conventional pterygomaxillarydysjunction seem to have a greatinfluence on the occurrence of bleeding. According to a trial by Regan et al., the tuberosity osteotomy technique reduces the likelihood of an unfavorable fracture of the pterygoid plates.[100] Based on the given studies, hemorrhage was indicated as the most common complication in maxillary surgery.[50] In contrast to the incidence of the manageable hemorrhage, the life-threatening postoperative hemorrhage after Le Fort osteotomy is rare and varies between an incidence of 0 and 0.7 %.[103] A combination of conservative and surgical treatment is initiated in most cases of life-threatening hemorrhage. Conservative treatment consists of controlling bloodpressure and administering intravenous fluids and blood transfusion. The surgical approach includes simple nasal packing, revision osteotomy, and ligation of the branches of external carotid artery.[50]

CONCLUSION

- Some advantages include earlier healing time, less relapse, decrease in intermaxillary fixation time, and the prospect of immediate opening of the mouth which resulted in return to earlier functioning.
- Anterior maxillary subapical osteotomy or posterior subapical osteotomy rarely produces significant postsurgery pain. However, facial edemas canhe excessive, and abrasion of the mucosa of the lips from retraction at surgery is common.
- Thedisadvantages were the higher risk of nerve disruption and the need for post-surgical removal of the bone plates and screws.
- Although orthognathic surgery has gained a generalized acceptance for maxillomandibular deformity correction, several limitations are associated with acute advancement of osteotomized bone segments. Large skeletal discrepancies require such extensive bone movements that the surrounding soft tissues might not adapt to their new position, resulting in relapse or compromised function and esthetics.
- There were no complications inserting the removable splint postsurgically, including pain, discomfort, or time-consuming procedure. Stable and secure splint fixation was obtained before the distraction procedure and the desired treatment goals were obtained in all patients.
- Traditional orthognathic surgery is limited in being able to correct the anatomical anomalies at a young age and distraction of the craniofacial skeleton, as part of a staged approach, has been a most beneficial additional option for managing craniofacial deformities. To produce stable and aesthetic results, distraction in combination with traditional orthognathic surgery, remains the best approach in skeletal correction to achieve a functional occlusion and good facial balance.
- Distraction osteogenesis resulted in a stable position of the maxilla and movement upwards in vertical plane, however in case of orthognathic treatment sagittal relapse and a continued postoperatively downward movement was registered.
- In mild maxillary deficiency a one stage orthognathic surgery is preferable. However, in patients requiring moderate to large advancements with significant structural deficiencies of the maxilla or in growing patients the distraction technique is preferred.
- With the ability of increasing the palatal and arch length, avoiding changes in palatopharyngeal depth, and preserving palatopharyngeal closure function, anterior maxillary segmental distraction has great value in the treatment of maxillary hypoplasia.
- There exist a large number of varied complications associated with orthognathic surgery procedures. Regardless, complications may occur after every surgery, and surgeons are obligated to minimize the risk of complications. The oral and maxillofacial surgeons, the orthodontist, and the operating team must prevent such complications during the preoperative, intraoperative, and postoperative periods to increase the safety of orthognathic surgery procedures. The permanent increase of surgery technique, methods of orthodontic treatment, and experience is absolutely needed. Despite during our research, we found many studies reporting complications in orthognathic surgery.
- Complications with anterior or posterior maxillary subapical osteotomy are rare. When they do occur, persistent periodontal defects in osteotomy sites between teeth and loss of blood supply to teeth adjacent to osteotomy cuts are reported most frequently

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