RESEARCH PAPER

“Modified Oblique Le Fort III Osteotomy” New Concepts

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Abstract

Introduction The purpose of this study is to demonstrate the surgical technique for the correction of midfacial deformities; vertical excess and posteroanterior hypoplasia. This situation obligates the need to move the whole osseous structure in an oblique posteroanterior movement that should correct both midfacial deformities. This should also correct the lip incompetence while improving the malar projection on a profile view of the patient. We also present a mathematical formula that gives the angulation needed for moving the midface complex in a simultaneous vertical and posteroanterior direction. Once given the correct angulation for the desired oblique movement, the surgeon can reproduce this angulation with custom made surgical guides over the stereolithographic model, that can then be used during surgery to achieve the desired movement accurately. This technique exemplified on this paper will give maxillofacial surgeons a new and affordable tool for the correction of midfacial deformities in an accurate and easily reproducible manner and amplifying the surgical repertoire.

Materials and Methods Patients seen in the specialty hospital “Dr. Bernardo Sepulveda” National Medical Center XXI Century, IMSS, during the period from February 2013 to November 2014 with Modified Oblique Le Fort III osteotomies, with the application of two trigonometric formulas for the accuracy of the technique.

Conclusions The application of the formulas give accurate results as well as the enlargement of the upper airway and esthetic results.

Keywords Oblique modified · Le Fort III · Formula · Surgical guides · Stereolithographic model

Modified Oblique Le Fort III Osteotomy

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Introduction

The anatomical complexity of the bony structures of the middle third of the face conveys a high degree of difficulty when considering the surgical correction of dentofacial deformities. This has obligated the need to investigate on how the surgical technique can be simplified to save time, diminish blood loss and achieve the preoperative surgical goals. What this paper presents is our approach for achieving these surgical goals; simultaneous correction of midface hypoplasia and vertical excess, the mathematical formula for designing and elaborating custom made surgical guides over a stereolithographic model for a transoperative reference for the osteotomy lines that aid in both, avoiding critical anatomical landmarks such as the pterigopalatine fossa and reproducing the desired movement on the patient.

Several methods for reproducing midfacial movements accurately have been designed by other surgeons. Gateno, Teichgraber and Xia have developed a new technique in which they use computerized three dimensional reconstruction of the facial complex for planning the desired distraction movement in patients with midfacial hypoplasia, in which the computer program formulated the recipe for linear and angular changes necessary to achieve the desired outcome [1]. They based the desired position of the midface according to Mulliken's recommendations in using the sagittal relations of the cornea to the nasion, lateral rim and orbitale [1, 2]. These authors continued their studies and published a series of articles along with other researchers in which they refined and registered their results using computerized predictive surgery along with stereolithographic models and surgical splints. An article published in 2007 demonstrated the clinical feasibility of their method, treating patients with significant asymmetries in a single stage operation using surgical splints fabricated using CAD/CAM techniques [3]. In 2009 they published their computer aided surgical simulation planning protocol, which consisted of 5 steps: (1) Creation of computerized composite skull model; (2) orientation of composite skull model in natural head position; (3) analysis and quantification of the deformity; (4) simulation of surgery in computer; (5) transfer of computerized plan to patient [4]. It is noteworthy to mention that they stated that conventional two-dimensional (2D) cephalometric analysis was still being used by them as three-dimensional (3D) normative data is unavailable and interpreting it, is difficult. They also make their decisions regarding the anteroposterior projection, vertical position and inclination of the occlusal plane and mandibular plane in conventional 2D analysis without facebow transfer, using the patient's computerized tomography scan and dental model scanning [4].

The cephalogram is oriented to the Frankfurt horizontal plane and the articulated dental models are oriented to the axis-orbital plane, with a difference of approximately 8° that is responsible for a 15 % difference in maxillary projection between the planned and actual outcomes [4, 5].

Orthognathic surgery and its traditional planning methods have many inherent problems, such as the use of 2D landmarks on patients who may have facial asymmetry, the difficulty in establishing a 3D cephalometric norm and the accurate reproduction of model surgery on the patient, as well as the limitations provided by the soft tissue that include pressures exerted on the teeth by the lips, cheeks and tongue; limitations of the periodontal attachment; neuromuscular influences on mandibular position; contour of soft tissue facial mask; and lip-tooth relationships and anterior tooth display during facial animation [3, 5–11].

The use of stereolithographic models and computerized surgical planning has yielded better results in terms of accurately reproducing the surgical goals [12, 13]. Nevertheless, it is important to define which surgical procedures are most appropriate for each patient, what specific orthodontic treatment is necessary in conjunction with the proposed surgery and what will be the sequence in combining the orthodontics and surgery [14].

Materials

The specialty Hospital “Dr. Bernardo Sepulveda” of the National Medical Center XXI Century, IMSS (Mexican Institute of Social Security), is a public social security hospital that admits only adults and does not have an orthodontist, as it is not part of the social security provided in Mexico. This means that we receive patients referred from unknown practitioners and without being consulted by our staff first. Sometimes patients are referred with acceptable pre-surgical orthodontics and then we establish contact with their orthodontist and plan the best surgical treatment [15].

In this work, we demonstrate 3 patients (intervened between February 2013 and November 2014) who were operated using the OLFIIM described by García y Sánchez (1992).

Clinical analysis

During the first consult, a visual analysis is realized and syndromes are ruled out. We have seen that the so called “giant prognathisms”, is no other thing but a remarkable hypoplasia of the middle third of the face. It is very important to analyze the face as a whole and both profile

views, as well as facial musculature in resting position. The main problem lies within the inferior orbital rim as it is demonstrated in the soft tissue reconstruction in the lateral view, where the palpebral thickness is 0.5 mm (Fig. 1).

Determining Midface Posteroanterior Hypoplasia

Based on the profile analysis by Epker, the infraorbital rim should be 0 to 2 mm anterior to the globe. We also evaluate the malar, infraorbital and paranasal prominence [14]. We then proceed to determine if there is vertical maxillary excess and midface posteroanterior hypoplasia (Figs. 2, 3, 4).

Fig. 1 Soft tissue reconstruction in the lateral view

Fig. 2 Frontal view of the patient with labial incompetence

On cephalo-caudal and caudo-cephalic views in Fig. 5a, b, the maxillo-malar hypoplasia is remarkable, but without nasal dorsum hypoplasia. Because of this, these patients require an oblique osteotomy, to correct hypoplasia and displace the middle third of the face, in a postero-anterior direction while at the same time, diminishing the vertical excess. It is named modified because the nasal bones are normal, as seen in Figs. 3 and 4.

The required advancement the patient showed is 7 mm longitudinally.

Determining Vertical Maxillary Excess

Vertical maxillary excess can be ruled out if facial proportionality is normal, there is no lip incompetence. Other parameters we take into consideration are: Is lip length normal with philtrum and commissure height at the same

Fig. 3 Postero-anterior hypoplasia of the medial facial third

Fig. 4 Infraorbital rim at -7 mm of the supraorbital rim

level? Are there reverse upper lip characteristics at rest? Is there excessive upper lip animation during smile? Is crown height adequate [16]?

We calculate the amount of superior repositioning of the midface (I) in accordance to Bell's studies in which the distance from the inferior margin of upper lip to the edge of maxillary incisor is E, then 2 mm (desired maxillary-incisor exposure) is subtracted from E. Then we add the compensation for shortening the upper lip associated with superior repositioning (20 %) [19]. This gives us the following mathematical formula: $I = (E - 2)/0.8$.

The clinical analysis must corroborate the E distance by measuring it directly over the patient, measuring the lip incompetence and the distance from stomion superior to the upper incisal border as shown in Fig. 6a, b.

(E was 5 mm) $-2 = 3/0.8$ gives the need of a maxillary upper displacement of 3.75 mm. So we decided an upper movement of 4 mm.

Another criteria we take into account to determine the maxillary upper displacement is the amount of gingival exposure during smile, as shown in Fig. 7a, b. The measured gingival exposure was 4 mm from the upper incisor cervix to stomion superior.

The patient presented an overjet of 8 mm as shown in Fig. 8. So the patient needs to have his maxilla advanced 7 mm and the mandible set back 3 mm.

Many ways can be designed to compensate this extreme discrepancy, a Le Fort I, with a mandibular set back, but it has several drawbacks:

Fig. 5 **a** Cephalo-caudal view, **b** caudo-cephalic view

Fig. 6 **a** Clinical analysis, **b** cephalometric analysis

Fig. 7 **a** Gummy smile,
b gingival exposure was 4 mm

Fig. 8 8 mm overjet

- (a) The vertical excess is corrected, but the patient would still have a severe midface hypoplasia.
- (b) The mento-cervical distance would diminish unaesthetically.
- (c) The upper airway distance would stay diminished as the total subapical maxillary osteotomy without nasal floor does not alter the upper airway.

The decision to perform an OLFIIIM was established to correct both midface hypoplasia and vertical maxillary excess. Once the clinical analysis is established, we proceed to register the case on photographs [17, 18]. We do not attempt to leave the patient with normal or standardized cephalometric measurements, because we consider that there are many variables concerning each person, such as ethnicity and presurgical orthodontic preparation, but rather try to balance the facial components and proportions of each patient.

Once the width from the upper eyelid's skin is obtained, we get a distance of 7 mm between the eyelid and the inferior orbital rim's soft tissues, a 8 mm overjet, it is decided that the midface should be advanced 7 mm and displaced upwards 4 mm. Based on these results, we proceed to obtain the degrees needed for the oblique osteotomy, as seen in Fig. 9.

Fig. 9 Obtention of the degrees needed for the oblique osteotomy

The amount of desired posteroanterior movement of the midfacial complex is determined by the horizontal distance between a perpendicular line to the zygomatic's arch upper border, to a vertical line that goes through the upper eyelid to the infraorbital rim on the profile analysis; and the cephalometric prediction tracing.

When the desired distance in millimeters of superior and anterior repositioning of the midfacial complex is determined, we use our own formula:

Thanks to applied trigonometry [23], to resolve how many millimeters of advancement in an oblique direction would determine how many millimeters would the midface complex ascend, the following resolution is given:

A: point located at the inferior border on the temporozygomatic suture

B: end of the osteotomy at the orbital rim.

Fig. 10 Trigonometric formula for the obtention of α (α = angulation for the total advancement and impactation of the oblique movement)

Fig. 11 3D CT scan to obtain exact proportions

C: a point in the body of the zygomatic bone that is to be moved in the desired anterior and superior direction.

a: desired superior repositioning (along y axis) in millimeters, along an imaginary line perpendicular to the zygomatic arch's upper border.

b: desired anterior repositioning (along x axis) in millimeters along an imaginary line, parallel to the zygomatic arch's upper border.

c: represents the oblique osteotomy (hypotenuse) on the body of the zygomatic bone, determined by the angle α .
 α : the angle at which the c line must be traced against the b line for achieving the desired anterior and superior repositioning (Figs. 10, 11).

The α angle is given by the following formula:

Fig. 12 Surgical guides over stereolithographic model

Fig. 13 Subciliary approach

This mathematical formula will give us the degree of angulation needed for the oblique osteotomy (hypotenuse), needed for this angulation to correct the vertical excess.

Therefore, if we are to move the midfacial complex 4 mm along the y axis and 7 mm along the x axis, we should introduce the following data, exemplified step by step:

Step 1:

$$\alpha = 4/7$$

Step 2:

$$\alpha = \tan^{-1}(0.571)$$

Step 3:

$$\alpha = 29.74^\circ$$

The degrees needed for the advancement of 7 mm in oblique osteotomy are determined and the surgical guides are made at an angulation of 30° [20] (Fig. 12).

Step 2: Rectified the impactation movement with 30° by using the following trigonometric formula,

$$\alpha = \sin 7 \text{ mm} = 0.121$$

$$\alpha = 0.121 \times 30^\circ = 3.65 \text{ mm}$$

Once a surgical treatment is feasible, the patient has dental casts mounted on a semi-adjustable articulator with the help of a face-bow. Model surgery is performed and surgical splints are fabricated [20].

Surgical Technique

Following the technique previously described by García y Sánchez [21], the OLFIIIM is adapted to achieve the surgical goals; and modified in 2013 in the publication “Surgical Guides for Modified Oblique Le Fort III Osteotomy” where the osteotomy design is detailed [20]. The zygomatic, orbital and nasomaxillary osteotomies are performed via subciliary approach as described by Ellis [22]. These are non syndromic patients, so wider exposures for higher osteotomies are not needed, the only thing is that they have a remarkable midface hypoplasia and the eye is more exposed on its inferior portion (Figs. 13, 14).

The zygomatic bone is dissected almost fully, from its lateral portion to the inferior orbital rim and 1.5 cm upwards along the lateral orbital rim, without reaching the fronto-zygomatic suture. The amount of dissection needed

depends on the angulation needed for the oblique osteotomy.

The orbital floor dissection must be taken to the inferior orbital fissure and 5 mm along the lateral wall. The medial limit would be up to the nasolacrimal duct and the infraorbital nerve is exposed too. Then, the nasomaxillary buttress is exposed up to the piriform rim (Fig. 15).

Fig. 16 Orbital floor cut with piezoelectric

Fig. 14 Infraorbital nerve is localized to protect it

Fig. 17 Contour of the orbital floor cut

Fig. 15 Orbitozygomatic guide

Fig. 18 Infraorbital nerve is preserved

Once the surgical guide is placed, the orbital floor osteotomy is made along the surgical guide's contour, as seen on Figs. 15, 16 and 17 with a piezoelectric tip, the

Fig. 19 Reciprocating short saw positioned with the orbitozygomatic guide

Fig. 20 Reciprocating short saw is angled approximately 45° with respect to the bone surface

Fig. 21 This cut is angled such that it avoids an unwanted fracture on the zygomatic bone

infraorbital nerve is preserved as shown in Fig. 18, which is an image of an osteotomy performed on a cadaver.

Once the osteotomy is completed, the oblique osteotomy is performed with a reciprocating saw using a short blade as shown in Figs. 19, 20 and 21. Once the blade is positioned, it is angled approximately 45° with respect to the bone surface, and resting over the surgical guide.

The same procedure is done on the contrary side (Fig. 22). Once the cuts are finished, the medial osteotomies are performed also in an oblique fashion (Fig. 23).

The next step involves a intraoral circumvestibular approach similar to the one used for conventional Le Fort I osteotomies (Figs. 24, 25). The variants to this approach are a dissection that is carried up to the orbital border and the complete dissection of the zygomatic bone with the help of the subciliary approach. The lateral nasal wall is

Fig. 22 Cuts are finished bilaterally

Fig. 23 Layout of the osteotomies

Fig. 24 Intraoral circumvestibular approach

Fig. 27 Pterygomaxillary fossa guide

Fig. 25 Nasal floor dissection

Fig. 28 L" shape guide stop

Fig. 26 Cadaver view of the dissection

Fig. 29 Rowe guide

Fig. 30 Rowe forceps are placed with palatal protector

Fig. 31 Downfracture modified Le Fort III

Fig. 32 **a** Presurgical frontal view, **b** postsurgical frontal view

dissected at the level of the inferior turbinate, without reaching it (Fig. 23). The internal part of the piriform rim is dissected up to the nasal floor and the nasal floor is dissected sideways from the nasal septum, from the anterior nasal spine to the posterior nasal spine and the septum is cut just like in a Le Fort I osteotomy.

Next, the circumvestibular incision is prolonged sideways, approximately 1.5 cm to dissect the pterygomaxillary fossa for placing the surgical guide. In Fig. 26, this extension is shown on a cadaver.

The pterygomaxillary fossa dissection must be careful and gentle, with complete subperiosteal dissection and with a sharpened dissector, 5 or 6 mm in diameter, as well as aiding yourself with soaked gauzes wrapped around the dissector. The next step is placing the surgical guides,

Fig. 33 **a** Presurgical right lateral view, **b** postsurgical right lateral view

Fig. 34 **a** Presurgical gummy smile, **b** postsurgical smile without gingival exposure

Fig. 35 **a** Presurgical occlusion, **b** postsurgical occlusion

Fig. 36 **a** Presurgical air way 3.76 cm, **b** postsurgical air way 4.44 cm confirming the advancement of 6.8 mm (7 mm)

Fig. 37 **a** Presurgical height of 7.94 cm, **b** postsurgical height of 7.55 cm confirming the impactation of 3.9 mm (3.75 vs 3.65 mm)

Fig. 38 **a** Presurgical projection, **b** postsurgical projection of the thrills

which allow a safe osteotomy, staying away from the maxillary artery, and the pterygoid plexus (Figs. 27, 28). To achieve the osteotomy of the fossa, first, a curved Tessier osteotome is used to separate the pterygoids from the maxilla. Then the cut is made on the most visible part of the tuberosity using an oscillating 12 mm saw, angled at 105° up to the hidden face of the pterygomaxillary buttress, then a 7 mm saw at 105° is placed instead, avoiding damage to the soft tissues.

The same procedure is performed on the other side, the Rowe forceps are placed and the craniofacial disjunction is

performed. The protector is placed so that forces are distributed equally along the palate and thus avoiding an unwanted fracture of the palate (Figs. 29, 30). This protector must have 2 canals for placing the palatal clamp of the Rowe forceps.

The patient's forehead is held strongly and the surgeon must make a slight traction on the forceps, while assistant surgeons spot the movement along the zygomatic bone, to make sure it is moved as a whole and symmetrically. At the same time, a loud “crack” is heard and again, assistant surgeons verify that the

Fig. 39 **a** Presurgical CT scan, **b** postsurgical CT scan control

midface complex is moved as a block. Various movements are performed in all directions for approximately 3 min (Fig. 31).

Finally, the surgical occlusal template is placed, previously fabricated on the semiadjustable articulator. This

template reproduces the upward and forward movement of the maxilla.

Final result of the applied formula on the patient Figs. 32, 33, 34, 35, 36, 37, 38 and 39 with accurate results.

Fig. 40 Pre and post control

Fig. 41 Pre and post treatment

Fig. 42 **a** Presurgical occlusion, **b** postsurgical occlusion

Fig. 43 **a** Presurgical occlusion, **b** postsurgical occlusion

Fig. 44 **a** Presurgical air way 3.40 cm, **b** postsurgical air way 4.34 cm confirming the advancement of 9.4 mm

Case #2

Male patient aged 23, with severe midface hypoplasia, orbital dystopia, facial asymmetry, laterognathia and mandibular prognathism.

The treatment was OLFIIM of 6 mm advancement 6 mm impaction plus a conventional Le Fort I osteotomy for 4 mm of advancement and 6 mm impaction, sagittal bilateral osteotomies for the correction of 5 mm

laterognathia and 3 mm mandibular retroposition, 7 mm advancement genioplasty, placement of left body and ramus alloplastic implant (Figs. 40, 41, 42, 43, 44).

Case #3

Male resident of Mexico City, aged 24. The surgical goals were a 4 mm superior and 7 mm anterior repositioning of the midfacial complex. Besides moving the middle third of the face, he also received bilateral intraoral vertical osteotomies on the mandible and an advancement genioplasty of 5 mm (Figs. 45, 46, 47, 48, 49, 50).

Most deformities in Latin America are characterized by a vertical maxillary excess. So a maxillo-malar hypoplasia combined with a vertical excess will have a greater incidence than syndromic patients.

By using the Bell impaction formula on the vertical maxillary excess, the exact calculation of two trigonometric formulas is added; calculating the angle of the zygoma oblique osteotomy “ α ” (this can vary no more than 40 degrees and not less than 30 degrees with respect to the lower attachment of the temporal zygomatic suture, with horizontal and vertical intersection of the first orbital rim). The second calculation will be checking the impaction movement through another trigonometric formula.

The pre manufacture and design guidelines of osteotomies will be held fully symmetrical making predictable technique for any OLFIIM.

Fig. 45 Midface anteroposterior hypoplasia

Fig. 46 Presurgical and postsurgical control

Fig. 47 **a** Pre surgical, **b** pre surgical Le Fort III, **c** final occlusion

Fig. 48 **a** Presurgical occlusion, **b** postsurgical occlusion

Fig. 49 **a** Presurgical 3D reconstruction, **b** postsurgical 3D reconstruction

Conclusions

The OLFIIIM, here described, shows an evolution in terms of surgical concepts, the same way as amended osteotomy techniques described by Bell and Epker. Stressing that it

develops OLFIIIM of different versions or sub-modifications in order to treat anatomical changes according to the needs of each patient.

The OLFIIIM, is designed for patients without syndromic midface alterations having maxillomalar

Fig. 50 **a** Presurgical air way 3.92 cm, **b** postsurgical air way 4.55 cm confirming the advancement of 6 mm

hypoplasia and a normal nasal projection therefore the osteotomy does not affect positioning of the anatomical region of the nasal bones. Another advantage in conjunction with a maxillomalar hypoplasia which can be used in the treatment of maxillary excess vertically no more than 6 mm.

The OLIIM, is a totally predictable technique, and can simultaneously perform the bimaxillary surgery depending on the grade of mandibular deformity associated with each patient and will require one to two surgical corrections of such deformity.

Therefore consider it an exceptional technique.

- Give greater proportion terminal facial esthetics, than just high-maxillary advancement.
- Symmetric and predictable forward move and impaction.
- Wide nasopharyngeal airway significantly increasing the diameter of the rear wall of the pharynx and muscles of the soft palate.
- Correction default inferior orbital rim, avoiding the placement of malar implants that may cause further damage to the bone structure.
- Without use of bone grafts, consolidation of the zygoma is very safe and strong.
- The zygomatic arch still keeps its anatomy and bone contact surface.
- The application of the formula gives accurate results.

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