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Research Protocol

# Surgical Feasibility Protocol for Le Fort I Multisegment Osteotomy: Analysis on Models

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## Abstract

Dentofacial deformities are alterations in the development of the maxillomandibular structures, which originate due to various causes such as endocrine, genetics, parafunctional habits, trauma, among others. The treatment of these anomalies is generally orthodontic-surgical. The Le Fort I segmental osteotomy is a recommended option to correct cases in which it is not possible to modify anomalies such as malocclusion, anterior open bite, severe proclination of the anterior sector through conventional orthodontic treatment, or for maxillary transverse deficiencies of up to 7 mm. Currently, it is a procedure of which there is fear of post-surgical stability and complications inherent to the surgery itself, which is why it is important to establish a protocol along with an analysis of models prior to this procedure, to serve as a guide for maxillofacial surgeons and orthodontists. We present a protocol as a test of surgical feasibility for maxillary segmental osteotomy and an analysis of the study models. We conclude that the existence and knowledge of a protocol that allows determining the surgical feasibility for the Le Fort I segmental osteotomy is important, which is why it should be considered a fundamental part of the planning both by the orthodontist at the beginning of the treatment and preparation of the patient. . as well as by the maxillofacial surgeon when planning the surgery itself. A correct determination of surgical feasibility allows us to determine the need for other surgical procedures in the first phase such as SARPE or MARPE and also achieve the protection of the roots in the osteotomy line.

***Keywords:*** *Orthognathic Surgery, Orthodontics, Segmentation, Lefort 1, Maxillofacial Surgery*

## Introduction

Dentofacial deformities are alterations in the development of the maxillomandibular structures. The causes of dentofacial deformities include several known syndromes, genetics, environmental and neuromuscular factors, trauma and tumors, among others. (1) Treatment is usually orthodontic-surgical, that is, it begins with a pre-surgical orthodontic stage, continues with an orthognathic/orthofacial surgery stage and culminates with post-surgical orthodontics to obtain satisfactory esthetic and functional results. (2)

Among the anomalies, several affect the anatomy, shape, inclination and size of the maxilla so that variables to be evaluated such as the curve of Spee as well as the width of the maxillary arch are altered, for which the most predominant surgical correction is the segmental osteotomy of Le Fort I(2), thus allowing the correction of transverse discrepancies, in addition to other discrepancies in the vertical and sagittal direction (3).

Le Fort I segmental osteotomy is recommended to correct cases where orthodontics alone is not able to correct occlusion, anterior open bite, severe anterior proinclination, and for maxillary transverse deficiencies up to 6 to 7 mm (2).

Nowadays, the surgical complications of the technique itself together with the postoperative stability of the segments after segmentation, generate that the lefort I segmental osteotomy is used with suspicion, considering that there are several factors that can contribute to the instability of the procedure, such as incorrect orthodontics, intra and postoperative complications, muscle activity, inadequate mobilization of the maxilla, surgical technique, quality of grafts, and stabilization of the segments. As for the risks or complications, there are sequelae such as dental damage, partial or total loss of the segment, pseudoarthrosis, oral fistulas, among others. (2) In addition to the above mentioned Proffit et al (4) evaluated the transverse widening of the maxilla as one of the least stable surgical corrections.

In view of the above, it is important to summarize and organize the information currently available, thus serving as a practical guide for maxillofacial surgeons and orthodontists regarding a clearer and more structured protocol for Le Fort I segmental osteotomy in patients with dentofacial anomalies, by means of analysis and model surgery, thus achieving adequate surgical predictability and defining the need for other previous surgical procedures such as surgically assisted rapid palatal expansion (SARPE) or microscrew assisted rapid palatal expansion (MARPE) and the planning of sufficient space between the dental roots according to the osteotomy line.

There are three consecutive phases that determine the outcome of orthognathic surgery: (5)

1) Preoperative diagnosis of the dentofacial anomaly and surgical planning.

2) Transfer from planning to surgery (commonly performed with surgical splinting), operative execution.

3) Postoperative relapse (influenced by muscular and soft tissue interference due to occlusal instability).

In order to distinguish at what stage specifically the deficiency occurs, it is important to independently inform the planning evaluation and long-term follow-up, thus identifying the cause of the poor outcome and improving surgical planning (3).

On the other hand, previous orthodontic preparation is crucial for the success of orthognathic surgery. Detecting and correcting existing dental compensations allows skeletal discrepancies to be fully addressed. At the start of treatment, it is important to clearly establish presurgical orthodontic goals, which may not always include full arch leveling, space closure or ideal interdigitation.

Orthodontic preparation guides the skeletal movements possible during surgery (20).

The goal of preparation involves creating a preoperative tooth discrepancy at least as great as the skeletal discrepancy so that the occlusion serves as a guide for the surgeon to optimally position the skeletal parts during surgery. Since normal physiologic processes tend to compensate for the skeletal problem, significant tooth movement is usually required to achieve the desired esthetic and balanced result for the patient. (21)

## Protocol

In this protocol on study model, developed by the authors, it is intended to control in the different directions of space, the distances that will be affected in the various critical points during the Le Fort I to multisegment osteotomy, which will determine the feasibility of the procedure not beyond the anatomical limits determined by the oral mucosa and the distance between the bone segments, and subsequently the stability between the osteotomized segments.

### 1. Marking of reference points and lines

**Point marking (Fig. 1):**

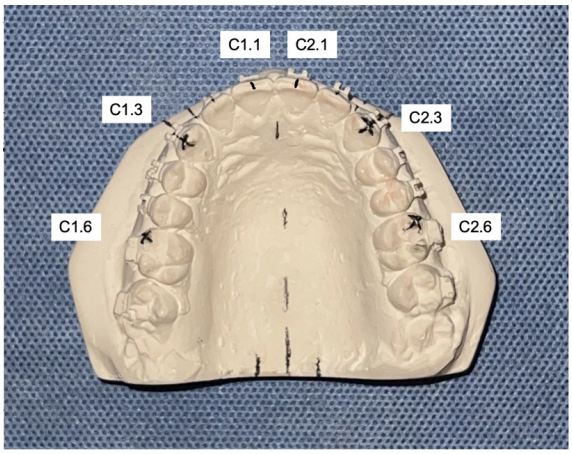


***Fig 1.*** *Point marking.*

- Most prominent point of the mesio vestibular cusp tooth 1.6 (MV16).
- Most prominent point of the mesio vestibular cusp tooth 2.6 (MV26)
- Most prominent point of cusp of tooth 1.3 (C13)
- Most prominent point of cusp of tooth 2.3 (C23)
- Midpoint of bracket slot of tooth (vestibular side) (B12)
- Midpoint of bracket slot of tooth 1.3 (vestibular side) (B13)
- Midpoint of bracket slot of tooth 2.2 (vestibular side) (B22)
- Midpoint of bracket slot of tooth 2.3 (vestibular side) (B23)

**1.2 Line marking (Fig. 2 and 3):**

- Vertical line to cervical with starting point at B12 (LV12).
- Vertical line to cervical with starting point at B13 (LV13).
- Mid vertical line between teeth 1.2 and 1.3 projected cervically
- Vertical line to cervical with starting point at B22 (LV22)
- Vertical line to cervical with starting point at B22 (LV22)
- Vertical line to cervical with starting point at B23 (LV23)
- Mid vertical line between teeth 2.2 and 2.3 projected cervically
- Palatal midline in axial plane
- Line parallel to palatal midline in axial plane 5 mm to right
- Line parallel to palatal midline in axial plane 5 mm to left

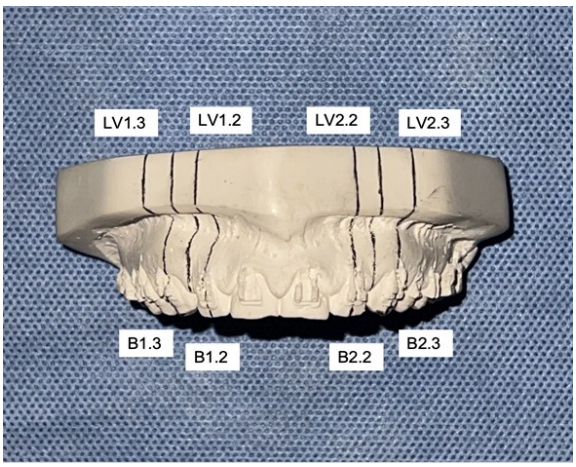


***Fig 2.*** *Line Marking.*

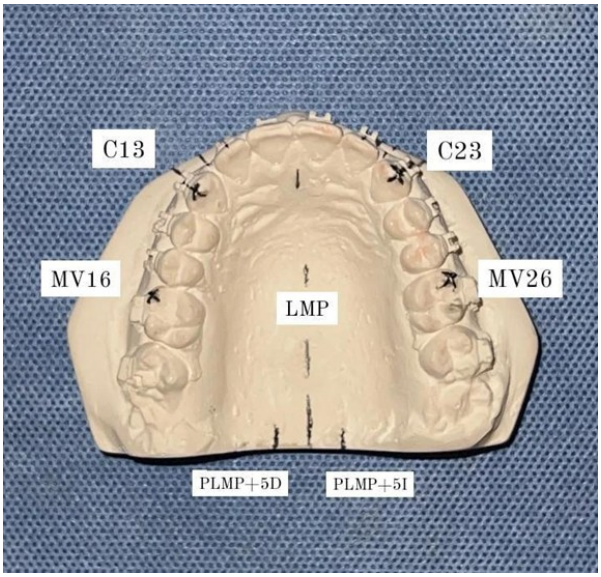


***Fig 3.*** *Line marking.*

**2. Measurement of pre-surgical distances:**

Note distances in measurement table (Fig. 13).

- Distance C13-C23 (Fig. 4)
- Distance MV16-MV26 (Fig. 5)
- Distance C11-C21
- Distance B12-B13 (Fig. 6)
- Distance LV12- LV13 (Fig. 7)
- Distance B22-B23 (Fig. 8)
- Distance LV22 -LV23 (Fig. 9)
- Distance line parallel to right LM to distance line parallel to left LM (10 mm)


***Fig 4.*** *Distance C13-C23*


***Fig 5.*** *Distance MV16-MV26*


***Fig 6.*** *Distance B12-B13*


***Fig 7.*** *Distance LV12- LV13*


***Fig 8.*** *Distance B22- B23*


***Fig 9.*** *Distance LV22- LV23*

### 3. Model surgery

First the cut is made with a saw or fine rotary instruments in the palatal midline in the posterior palatal 2/3 of the plaster model, and two vertical cuts in the midlines between teeth 1.2 and 1.3 and 2.2 and 2.3 without taking the dental crowns of these teeth.

Then the cuts are joined in the upper palatal axial plane, forming an anterior triangle represented by the premaxilla, which in its most posterior point joins the palatal midline cut.

Finally, the delicate fracture and separation of the previously cut segments is performed to obtain 3 independent segments as follows:

1) Right upper jaw, which contains the teeth 1.3 towards posterior.

2) Left upper jaw, which contains the teeth 2.3 towards posterior

3) Premaxilla, containing teeth 1.2,1.1,2.1,2.1,2.2

If a medial maxillary osteotomy is planned, a planned cut should be made in the model following the mid-sagittal plane between teeth 1.1 and 2.1.

The segment models should be worked independently and placed in the best occlusion or in occlusal advantage with the antagonist lower model and fixed with hot silicone (Figs. 10, 11, 12).

Once the best position of the 3 independent segments has been determined, the 3 segments are fixed on the cutting lines with silicone or wax to obtain a solid upper jaw block (Fig. 13).

*Fig. 10*

*Fig. 11*

*Fig. 12*

**4. Post surgical measurements**

To perform the final measurements, we must separate the models so that after the material has hardened, we proceed to detach it from its antagonist and to perform the post-surgical measurements.

For the post-surgical measurements, the measurements must be repeated in the same previous points, to obtain in this way the discrepancy (increase or decrease between the pre and post-surgical lines and points).

In general, between points B12 and B13, as well as points B22 and B23, there should not be an increase of more than 1 to 1.5 mm maximum, and between the pre-determined lines parallel to the palatal midline, there should be an increase of 2 to 3 mm per side maximum, with a total of 4 to 6 mm maximum of palatal widening, which could determine the need for SARPE or MARPE. The same should be considered for post-test measurements of segmentation at the C13-C23 and MV16 AND MV26 distance.

It is important that, when repositioning the maxillary segments in lower model occlusion, the physiological position of the interdental papilla and the contact points of the adjacent teeth at all interdental osteotomy sites is maintained, since, if dental gaps remain or if the cervical margins are not aligned, there is a greater likelihood of periodontal sequelae. (6)

*Fig. 13*

## Discussion

Maxillary segmentation is necessary to achieve a stable occlusion, an ideal curve of Spee, an adequate arch width, as well as to successfully close diastemas, incline incisors, among other modifications that are not correctable by conventional orthodontics. It is essential that this procedure be evaluated and planned from the beginning of orthodontic treatment, since it provides the opportunity to correct skeletal anomalies through the basal bone instead of solving with "orthodontic compensation" (dental camouflage thus generating an unstable occlusion and periodontal repercussions in the long term). It is important to reconfirm the need for segmentation, pre-surgical model planning with proper execution at surgery. (7) Current methods of model planning and the use of prefabricated splints are considered the standard of care for segmental bimaxillary and maxillary osteotomies. (6)

Among the challenges involved in orthodontics itself and the surgical repositioning of the jaws, there are important factors such as surgical healing, related to the health and physical conditions of each patient, the philosophies of the orthodontist and maxillofacial surgeon, the long-term difficulties of maintaining a stable occlusion, among others. Although there is always the possibility of dental and skeletal relapse, if biomechanical and esthetic principles are respected, dentofacial deformities and malocclusions can be successfully corrected in most cases. (8)

Determining the surgical feasibility prior to and during orthodontic treatment is crucial to evaluate the need for disjunctor. This will depend in large part on the skeletal maturity of the patient, and the magnitude of the discrepancies (9).

Indications for SARPE include failure of orthodontic expansion. Transverse maxillary deficiencies that are greater than 5 mm in a skeletally mature patient are a factor to consider. (10) When these are less than 5 mm and in growing patients require orthodontic or orthopedic expansion. (9) When they are larger than 7 mm and in adult patients SARPE is fully indicated as the result is stable. When this treatment is prior to a LeFort osteotomy, a time of 4 to 6 months post-surgery is considered reasonable for a correct bone healing and revascularization of the segments (10, 11).

It has been demonstrated that the 3-segment osteotomy has greater advantages than the 2-segment osteotomy. (12) Among the main advantages is the smaller size and number of interdental spaces between lateral incisors and canines (11), avoiding diastema between 1.1 and 2. 1, and also less risk of generating root damage in the central incisors (13), preventing and avoiding the loss of interincisive papilla, less risk of nasal septum suffering deviation and minimizing columella widening, a much more symmetrical expansion can be generated and with a greater magnitude at posterior level, a lesser loss of the vestibular bone table (with less bone and periodontal stress), which entails the opportunity to change the torque of the anteroposterior segments (14), and thus achieve more esthetic and periodontally beneficial results. (11) (13)

In those cases in which wide expansion is planned, fixation elements should be used. This post-surgical management is a critical factor for a predictable outcome in orthognathic surgery. Unfortunately, inadequate management by the orthodontist and maxillofacial surgeon can lead to poor results. Poor post-surgical orthodontic management can ruin the success of the surgery. It is essential that both specialists have the ability to implement the protocols and a timely strategy to obtain the best possible results (16).

Among the types of maxillary splints that can be used are palatal and occlusal. When the maxilla and mandible are one piece and the teeth occlude adequately, a final splint is generally not necessary in single or double jaw surgery. Palatal splinting provides excellent stability and can be produced by virtual surgical planning. The interdigitation of both arches can be observed since this splint does not interfere in the occlusion, which is an advantage over the occlusal splint that prevents this visualization, generating the possibility of malocclusion. The orthodontist and/or surgeon should check the patient every week, or more frequently during the first two months after surgery to verify progress and occlusal stability. If the occlusion is stable, it is probably not necessary to use elastics and thus reduce the frequency of controls. An alternative is also the use of a palatal bar (16).

Malocclusion following segmentation of the maxilla by Le Fort I osteotomy includes: recurrence at the osteotomy site, fibrous union at the site, remodeling at the segment sites, among others. In general, dental causes appear later. The cause of recurrence at the osteotomy site is difficult to identify, but is related to: inadequate mobilization of the segmental maxilla before fixation, incorrect bone contact at the osteotomy site after fixation, non-rigid fixation of the plate and screw, excessive occlusal forces during early healing (8).

Post-surgical complications include infection, which can be identified by increased temperature, swelling more frequently unilateral and gradually worsening, erythema and induration in the area, purulent nasal or oropharyngeal drainage, increased pain, muscular trismus, bad odor and taste, increased sensitivity of upper teeth, facial swelling. This complication must be investigated early, taking cultures, irrigation and antibiotherapy if indicated (15).

Another complication, less common, is dental discoloration, most often caused by an interdental osteotomy, associated with rupture of the pulp canal vessels, producing hemorrhage or pulp necrosis, whose treatment is endodontics and subsequent intracameral bleaching, or rehabilitation by means of veneer/crown. (15) Dental ankylosis that occurs after surgery can also be caused by an interdental osteotomy, or by a decrease in the vascularization of a segment, which would cause loss of the periodontal ligament, thus causing ankylosis. When this happens, the tooth stops responding to orthodontic mechanics and functions as an “anchor” pulling the adjacent teeth towards the ankylosed one, thus causing a malocclusion. This tooth must be separated from the arch.

It can be crowned, bonded or osteotomized to reposition it in an optimal occlusal fit. (15) On the other hand, early instability of occlusion can be observed with the presence of TMJ edema, inadequate surgical stabilization, inadequate surgical positioning of the jaws, hypertrophy of the TMJ tissues due to splints, condylar displacement during surgery, orthodontic instability. TMJ edema occurs immediately after surgery, displacing the condyle and mandible forward, generating a posterior open bite, it is necessary to evaluate the use of vertical elastics. (15)

Another skeletal and occlusal instability after surgery is TMJ pathology, if there was excessive trauma that caused damage to the joint, resulting in overloading or intentionally creating posterior open bites. The most common problem is condylar resorption, which include adolescent internal condylar resorption, idiopathic, reactive arthritis, autoimmune connective tissue diseases (rheumatoid arthritis, lupus, scleroderma, ankylosing spondylitis, among others). In adult patients with pathologies of this magnitude, i.e. pathologies of temporomandibular joint resorption, more predictable results can be obtained over time through the use of personalized total joint prostheses. (16) (17) (18) (19)

The success in the final result will be obtained by prognosticating, identifying and managing early all post-surgical problems, including infection, early and late recurrences (16) (18).

## Conclusion

A critical analysis at the beginning of treatment by the orthodontist is essential and should include a detailed clinical evaluation, photographs, radiographic and cephalometric imaging, which will allow the best treatment approach to be determined for the patient's specific needs, i.e. orthopedics, conventional orthodontics or pre-surgical orthodontics as appropriate.

Our pre-surgical evaluation protocol for Lefort I osteotomy gives the orthodontist the opportunity to determine the most appropriate way to correct maxillomandibular transverse differences either through Lefort I segmentation or the application of previous treatments such as orthopedics, SARPE or MARPE, depending on the patient's age and stage of growth. Early planning facilitates a comprehensive approach to treatment and contributes to improved orthodontist-patient communication.

Similarly, for the maxillofacial surgeon, this protocol is beneficial and essential to analyze tissue behavior, prevent recurrences, and guarantee the stability of the fragments after surgical treatment. The feasibility of surgical treatment may vary depending on the region analyzed. In general terms, between points B12 - B13 and B22-B23, a maximum increase of 1 to 1.5 mm should not be exceeded. In relation to palatal widening, between the predefined lines parallel to the palatal midline, a maximum increase of 2 to 3 mm per side is advised, in short, a total of 4-6 mm maximum palatal widening. These limits are crucial to ensure optimal results, both esthetic and functional in orthognathic surgery.

Finally, we would like to emphasize that continuous communication between the orthodontist and the maxillofacial surgeon is essential to carry out joint evaluations and to consider devices such as palatal bars and splints in the treatment to ensure the stability of the fragments in the short, medium and long term.

## Conflict of Interest

None declared.

## Acknowledgment

None.

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