How can we achieve maximum maxilla expansion using the maxillary multi-segmentation technique in orthognathic surgery?

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ABSTRACT

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| **Aims:** To describe maxillary multi-segmentation technique (MMST) during orthognathic surgery illustrated through a clinical case.  **Study design:** Original Research Article.  **Methodology:** Maxillary transverse deficiency is a complex etiological condition that can impact individuals of all ages. In patients with transverse maxillary deficiencies greater than 5 mm who have reached skeletal maturity, surgically assisted maxillary expansion (SAME) is the treatment of choice. The MMST offers an alternative for correcting dentofacial deformities in multiple planes in a surgical procedure. So, orthodontic considerations and surgical considerations were described and illustrated through a clinical case. A 42-year-old male e with dentoesqueletal deformities Class III due anterior-posterior and transverse maxillary and paranasal deficiency and anterior-posterior mandibular excess. The surgery was carried out through Le Fort I osteotomy in combination with a segmentary osteotomy and bilateral setback sagittal split osteotomy. Clinical and cone beam computed tomography post operatory controls were made during the first 3 months  **Results:** MMST demonstrated an excellent potential for transverse maxillary expansion of 14mm trans surgically, with preserved stability, with a three-month follow-up.  **Conclusion:** Our results can be considered highly stable in both the postoperative and long-term periods compared to adult patients undergoing surgically assisted maxillary expansion with tooth-borne expanders. We do not have clinical findings regarding SAME using an expander supported by the palatal bone. |

*Keywords: Maxillary Expansion. Multi-segmentation. Orthognathic Surgery)*

1. INTRODUCTION

Maxillary transverse deficiency (MTD) is a complex etiological condition that can impact individuals of all ages1. Spontaneous resolution of this condition is rare, emphasizing the need for careful attention in the diagnosis and treatment planning process. Considerations regarding the extent of the discrepancy, its origin (skeletal and/or dental), patient age, and potential association with other craniofacial deformities are crucial2.

The orthodontic-orthopedic technique of palatal expansion is recommended for patients who have not yet completed their bone maturation phase. During this phase, the midpalatal suture exhibits limited interdigitation, and an expander facilitates suture opening, resulting in effective maxillary expansion3-5.

In patients with MTD exceeding five millimeters (5mm) who have reached skeletal maturity, surgically assisted maxillary expansion (SAME) is the preferred treatment option6-7. Although this technique is effective, it primarily focuses on correcting deformities in the upper dental arch within the transverse plane. Additional surgical procedures may be required to address alterations in other planes.

The emergence of the maxillary multi-segmentation technique (MMST) provides an alternative for correcting dentofacial deformities in multiple planes. This technique enables the expansion of the maxilla in the transverse dimension, repositioning of palatal segments, and simultaneous correction of the maxillomandibular relationship in the sagittal and vertical directions8.

This study aims to present and discuss the MMST based on one case report, the author's 15 years of experience, and the results obtained by applying this technique.

2. methodology

**2.1 Orthodontic Considerations (ARIAL, BOLD, 11 FONT, LEFT ALIGNED)** –

While the treatment plan should be tailored to each patient, specific general guidelines should be followed to ensure successful treatment using pre-surgical orthodontics and specific osteotomy techniques with multiple maxillary segmentation. When there is a transverse discrepancy between the arches requiring corrective surgery, it is advisable to avoid prior orthodontic expansion to minimize the risk of relapse. Maxillary segmentation is often necessary during surgery to achieve optimal coordination between the dental arches and ensure proper alignment on the bony bases.

The same applies to cases with an anterior open bite, where attempts to close the bite with prior orthodontic treatment should be avoided. In case of open bite malocclusion, using segmented arches in orthodontic mechanics is ideal for preventing excessive extrusion of anterior teeth and minimizing vertical relapse after removing the fixed appliance. Creating a vertical step (fold) is necessary to maintain the anterior open bite when using continuous archwires.

In cases where an open bite has been previously treated with orthodontics, sectioning the arch at least two to three months before surgery is essential, allowing the teeth to adapt within the alveolar ridge and minimizing the risk of relapse. The arch should remain passive, without causing undesired tooth movements, during the final stage of surgical planning9.

Another important consideration is creating sufficient space between the segmented teeth' roots to prevent injuries during osteotomies by diverging the roots. After pre-surgical orthodontic treatment, it is recommended to use the largest possible rectangular stainless steel archwire, typically 0.019 x 0.025" or 0.021 x 0.025" sectioned according to the treatment plan. Surgical hooks can be placed in the interdental spaces10.

Suppose brackets with hooks are on posterior teeth (from canines to posterior teeth). In that case, the authors suggest using hooks only between the upper and lower central incisors, which can be added during surgery, to avoid significant discomforts such as food retention and buccal mucosa trauma.

Before surgery, upper and lower plaster models are obtained and scanned for 3D virtual planning. A semi-adjustable or fully adjustable articulator, such as the Galletti, simulates the surgery in plaster models to achieve a stable occlusion. Based on this planning, a surgical guide is made of acrylic resin, occlusal coating, and palatal reinforcement — this guide precisely positions the osteotomized segments during surgery.

**2.2 Surgical Considerations**

The Le Fort I maxillary osteotomy is the most utilized surgical method for correcting dentoskeletal deformities involving the middle third of the face. The procedure begins with a buccal incision in the oral mucosa, approximately five millimeters above the attached gingiva, extending from the premolar region to the other side. The subperiosteal plane exposes the maxillary bone and the piriform opening. Careful detachment of the mucous membranes of the floor, nasal sides, and septum is performed, taking precautions to avoid lacerating the nasal mucous membranes.

A Molt detacher is used to protect the nasal mucosa. Then, a high quadrangular Le Fort I osteotomy is performed, along with the disjunction of the pterygomaxillary and septal sutures. Before the mobilization of the lower maxilla, vertical interdental osteotomies are made according to the orthodontic surgical plan. These osteotomies are typically performed between the lateral incisors and canines, occasionally between canines and first premolars, as well as between the central incisors.

The osteotomy must be performed meticulously, drawing a sulcus with a conical drill, ensuring that deepening will not cause root injuries. After creating a groove in the alveolar cortex using the drill or a Piezo surgery tip, the osteotomy is completed using a narrow osteotome (7mm) - spatula chisel. The chisel should be well sharpened, and the assistant surgeon's index finger should be placed on the palatal mucosa to feel the proximity of the chisel through the bone, thereby preventing any tissue damage.

Subsequently, the lower mobilization of the maxilla is performed using manual force applied to the anterior region of the maxilla. Gauze is interposed between the glove and the gingival mucosa to increase friction. Howe's forceps, or any other instrument, is rarely necessary for this maneuver.

For maxillary advancement, a modified cleft lip and palate periosteum reamer is used. The maxilla is anteriorly pulled until entirely tension-free for occlude with the mandibula.

A Y-shaped or three-piece segmentation is performed, with the segments joining in the septal region and extending along the midline to the posterior nasal spine (Figure 1).

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**Fig. 1. Y-shaped or three-piece segmentation.**

A bilateral parasagittal incision is required before the osteotomy. The incision should be approximately 1,5 cm distant from the cervical region of the posterior teeth (Figure 2A), extending from the distal canine to the first molar (about 2cm) (Figure 2B).

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**B**

**A**

**Fig. 2. (A) Palatal incision and (B) extension for distal canine**

Through this incision, the detachment of the palate is initiated, surpassing the palatal suture from the region where the two interdental osteotomies meet the posterior nasal spine.

The modified Molt detacher is used to palate mucoperiosteal detachment. This step requires utmost caution to prevent perforation of the palatal tissue, particularly in the region of the palatal suture where the mucosa is thinnest throughout the palate and around the posterior nasal spine. This unilateral detachment makes it feasible to perform maxillary expansions exceeding 15 mm.

In the subsequent step, the broadest section of the Molt detacher is inserted into the incision, placing it centrally in the palate to safeguard the palatine mucosa during the osteotomy of the palatal suture. This osteotomy starts from the posterior nasal spine and continues until it reaches the two interdental osteotomies in the anterior region. It can be accomplished using a straight reciprocating saw or an ultrasonic blade (Figure 3).

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**Fig. 3. Complete osteotomy - posterior nasal spine until two anterior interdental osteotomies.**

After achieving total mobilization of the three osteotomized segments, it is crucial to enhance the mucoperiosteal detachment around the posterior nasal spine by performing an osteotomy of the suture towards the anterior region, following the trajectory of the interdental osteotomies' intersection (Figure 4).

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**Fig. 4. Mucoperiosteal detachment around the posterior nasal spine.**

This procedure is necessary to prevent laceration of the palatal mucosa during the placement of the surgical guide, as the occlusion of the teeth in the segments may exert tension.

The surgical guide (acrylic resin) has perforations in the embrasures of all teeth to secure it to the leveling arch of the fixed appliance using a metallic ligature, such as Aciflex 2-0.

In the semi-adjustable articulator, to create the final surgical guide, the incisal pin is elevated to increase the thickness of the acrylic resin to prevent distortion and material fracture caused by expansion-induced tension. In the fully adjustable articulator, where no incisal pin is present, the bite is opened using a screw located at the posterior part of the articulator for the same purpose.

This type of surgical guide is essential for significant expansions exceeding 10mm. In addition to providing occlusal coverage for the teeth, a palatal bar is incorporated using the same material.

The palatal bar can be constructed using a large-caliber steel wire, preferably 1.2mm in diameter or thicker, to reduce volume and minimize postoperative discomfort for the patient. When building the trans palatal bar, whether with resin or a metallic trans palatal bar, it is recommended to maintain a minimum distance of 5mm between the bar and the palatal mucosa. This distance is crucial because the palatal mucosa moves against the bar as the expansion increases. Compression of the mucosa can lead to tissue necrosis both at the compressed site and in the area between the palatine papilla and the bar, compromising blood supply to the anterior portion of the segmented maxilla and resulting in partial or total necrosis.

When addressing excessive inclination of the anterior teeth, either with or without closing the open bite, the author prefers the "Y" osteotomy over the "H" osteotomy. This preference arises from the risk of palatal tissue laceration at the site of the transverse osteotomy in the "H" technique, which can result in the formation of an oronasal fistula. The difficulty or failure to detach the palatal mucosa in the posterior region of the osteotomized anterior segment, where the transverse osteotomy intersects with the lateral osteotomies, contributes to this risk.

The surgical guide, which covers the entire occlusal surface of the upper teeth with palatal reinforcement, although more uncomfortable for the patient, provides predictable results in achieving a better interocclusal relationship. The key is to ensure that the osteotomized segments occlude perfectly within this plate and that it aligns with the lower arch. Before securing the guide to the upper dental arch, it is necessary to suture the relaxing incision made to access the detachment of the palatal mucosa using Monocryl 5-0 to prevent postoperative bleeding. If the suture is performed after fixing the surgical guide, it becomes impossible to suture the incision below the trans palatal bar.

Rigid fixation is then carried out, preferably using two Lindorf plates in the anterior region and two "L" plates in the posterior region, anchored on the zygomatic pillar.

The choice of Lindorf plates is recommended due to their superior fixation of the osteotomized segments despite being more challenging to adapt. However, they provide better initial stability, particularly in cases requiring significant expansion. The walls of the maxillary sinuses become more fragile and thinner with more significant expansion, creating larger bone gaps. Therefore, the broader and thicker Lindorf plates, with increased bone contact and a higher number of screws (usually 10-11 in each plate), result in minimal mobility throughout the postoperative period compared to fixation using four "L" plates with four screws each.

After fixation, the surgeon may use bone grafts or substitutes in the osteotomy sites. Bone segments harvested from the nasal septum or turbinates can fill the interdental gaps, palatal suture, and maxillary sinus walls. Block grafts such as Bio-Oss® and Interpore 200 Hydroxyapatite® can also be employed. Careful tissue handling is crucial to avoid periosteal injuries and ensure adequate vascular supply to all bone segments. This procedure allows for correcting various types of open bite and transverse discrepancies during the surgical process, eliminating the need for multiple surgical stages and reducing orthodontic treatment time.

Maintaining the final splint fixed to the upper arch for six to seven weeks is recommended. Additionally, intermaxillary elastics (1/8" in size, medium force) should be used, with one placed in the midline and one on each side in a slight Class III configuration to guide occlusion. These elastics should be worn continuously for eight weeks and only during nighttime for an additional week.

Regular clinical and radiographic follow-up of patients is essential to assess bone healing in the osteotomy sites and detect early relapses associated with muscle forces. In some cases, it may be necessary to continue using elastics for an extended period, with increased force and quantity, to address these variables.

3. results

MMST results during orthognathic surgery were illustrated through a clinical case reported as following:

**3.1 Clinical Case**

42 years old male patient, ASA I, presented to consultation in Private Office with aesthetical issues. He started orthodontic treatment, where no compensation was made in his dentition, through changes in the position of the teeth.

**3.2 Clinical characteristics**

Diminished mid facial third, increased lower facial third, hypertonicity of the mental muscles, mild deviation of middle line on the chin to the left, concave profile, closed nose-lip angle, mild antero-posterior excess of the mandible and chin.

**3.3 Occlusal Characteristics**

Right canine in Class III and Left canine in Class I. Right molar in Angle Class I and Left molar in Class III. Posterior crossbite in both sides (Figure 5). Presurgical imaging was obtained, in CBCT (Figure 6).

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**Fig. 5. Pre surgical occlusal characteristics.**

**Interface gráfica do usuário, Aplicativo

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**Fig. 6. Pre surgical CBTC.**

**3.4 Treatment plan**

Informed consent from the patient was obtained and there were not unanticipated events encountered during the surgical procedure. The surgery began with buccal incision in the oral mucosa, approximately five millimeters above the attached gingiva, extending from the premolar region to the other side. The subperiosteal plane exposes the maxillary bone and the piriform opening. Then, a high quadrangular Le Fort I osteotomy was performed, along with the disjunction of the pterygomaxillary and septal sutures. Vertical interdental osteotomies were made according to the orthodontic surgical plan between the lateral incisors and canines. For maxillary advancement, maxilla was anteriorly pulled until entirely tension-free for occlude with the mandibula. Total maxillary advancement required was 4 mm. A Y-shaped or three-piece segmentation was performed, with the segments joining in the septal region and extending along the midline to the posterior nasal spin.

A bilateral parasagittal incision was required before the osteotomy. The incision was approximately 2,0 cm distant from the cervical region of the posterior teeth. Osteotomy of the palatal suture started from the posterior nasal spine and continues until it reaches the two interdental osteotomies in the anterior region. Total expansion of the palate was 14 mm.

A surgical guide (acrylic resin) was made with perforations in the embrasures of all teeth to secure it to the leveling arch of the fixed appliance using a metallic ligature (Aciflex 2-0) and a metallic trans palatal bar. The surgical guide ensured predictable results in achieving a better interocclusal relationship.

Lindorf plates in the anterior region and two "L" plates in the posterior region, anchored on the zygomatic pillar were used. A final splint fixed to the upper arch was maintained for seven weeks (Figure 7). Intermaxillary elastics (1/8" in size, medium force) were used for eight weeks, with one placed in the midline and one on each side in a slight Class III configuration to guide occlusion.

Clinical and radiographic follow-up of patients for three months were made to assess bone healing in the osteotomy sites and detect early relapses associated with muscle forces.

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**Fig. 7a. Post surgical occlusal characteristics.**

Interface gráfica do usuário, Aplicativo

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**Fig. 7b. Post surgical CBCT.**

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**Fig. 7c. Retention appliance.**

4. DISCUSSION

The MMST is indicated for individuals with a transverse deficiency in the anterior, posterior, or both regions, correction of Bolton discrepancy, and alteration of the labio-lingual inclination of the incisors. It offers the advantage of achieving three-dimensional correction of intra-arch asymmetries through manipulating the segments in a single surgical step11. While this method is known and recommended by various orthodontists and surgeons, it requires careful orthodontic-surgical planning to ensure proper coordination of the arches during surgery and meticulous management of the osteotomized segments to maintain soft tissue integrity and adequate local blood supply.

Additionally, creating spaces between the roots is necessary to perform interdental osteotomies, diverging them and avoiding root injuries during surgery. Researchers report a minimum safety distance of 3mm between adjacent teeth, emphasizing the importance of proper blood supply through well-planned incisions and minimal periosteal detachment of the osteotomized segments11-2. Performing interdental osteotomies in regions with restricted interradicular space is a significant risk factor for marginal bone loss13.

Studies have reported complications associated with the technique, including necrosis of the repositioned maxillary segment, widening of the alar base, mobility, dental injury or loss, oronasal communication, bone loss, and gingival recession in the interdental osteotomy region10, 14-6.

In our clinical experience, even in cases where the minimum 3mm space is absent, osteotomy can be performed cautiously to avoid deepening the osteotomy with a rotatory instrument or Piezosurgery blade. After drawing or marking the osteotomy line on the cortical bone, segment separation is initiated and completed using a spatula chisel, as described previously.

The postoperative stability of the MMST is controversial. There is a lack of criteria to evaluate the influence of segmentation on skeletal and orthodontic relapse post-surgery and compare it with a control group undergoing single-block Le Fort I osteotomy. Another critical factor that may introduce bias in evaluating the results is the inclusion of monomaxillary and bimaxillary surgeries in the same sample, considering the influence of mandibular surgery on maxillary stability7.

The diversity of surgical techniques, fixation systems, and imaging methods represents potential sources of failure in multicenter studies. Therefore, few studies meet these criteria and can be considered for evaluating the MMST14.

The stability of surgically assisted palatal expansion was compared with the segmented maxillary osteotomy over a two-year postoperative period. Their results showed that maxillary expansion using the segmentation technique produced greater stability17.

A retrospective study evaluated the stability of maxillary advancement by comparing single-block Le Fort I osteotomy with the segmentation technique, using cephalometric analyses in the preoperative, immediate postoperative, and late postoperative periods (at least one year). The results showed a higher tendency for relapse in patients undergoing single-block Le Fort I osteotomy compared to segmented cases16.

A comparative study on the stability between one-segment and three-segment Le Fort I osteotomy techniques resulted in no statistically significant difference in bone relapse in one-segment or multiplanar movements. They emphasized that the choice of maxillary segmentation should consider the individual indications of each patient and the occlusal benefits obtained14.

In our experience, we utilized the Y-shaped osteotomy technique, a unilateral relaxing incision, detachment of the palatal mucosa passing through the palatal suture to the opposite side, complemented by mucoperiosteal detachment through osteotomy (on the side opposite to the relaxing incision). We employed a surgical guide with occlusal coverage and reinforced it with a trans palatal bar for 40 to 50 days. Intermittent intermaxillary blockage was achieved using 1/8" medium-force elastics. A palatal retention plate with clasps was used for three months after removing the surgical guide, and the segmented upper arch was replaced with an open continuous archwire.

5. Conclusion

Our results can be considered highly stable in both the postoperative and long-term periods compared to adult patients undergoing surgically assisted maxillary expansion with tooth-borne expanders. We do not have clinical findings regarding SAME using an expander supported by the palatal bone.

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Competing interests

“Authors have declared that no competing interests exist.”

Authors’ Contributions

Igor Thiago Bragatto de Mendonça: conceived the original idea, designed the study, wrote the surgery technique protocol,

Marília de Oliveira Coelho Dutra Leal: took the lead in writing the manuscript

Renato Assis Machado and Andréa Juliana Luz Perdigão: managed the literature searches.

Roberto Macoto Suguimoto: wrote the surgery technique protocol

Rubens Gonçalves Teixeira and Claudio Roberto Pacheco Jodas: investigate surgical aspects and supervised the findings of this work.

All authors discussed the results and contributed to the final manuscript.

All authors read and approved the final manuscript

Consent

"All authors declare that ‘written informed consent was obtained from the patient (or other approved parties) for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editorial office/Chief Editor/Editorial Board members of this journal."

Ethical approval

“All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee (Ethical issues under number CAAE 76678823.2.0000.5374) and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.”

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