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Technical Note

Customized guide for transmucosal pterygomaxillary disjunction: Proof of concept

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ABSTRACT

Potential complications related to pterygomaxillary disjunction have been widely described in the literature, most of them being due to the inaccurate and blind approach involved. The present study used preoperative virtual planning to establish a surgical cutting guide for pterygomaxillary osteotomy. It was placed in the maxillary tuberosity supported by molars, and a flapless vertical osteotomy was performed with a piezoelectric saw. Then, maxillary down-fracture was performed with slight pressure through an anterior approach. The use of the surgical guide added accuracy and predictability to the procedure, with no prolongation of the surgery time. There were no undesired fractures or bleeding. Regarding manipulation of the surgical guide in the posterior area, it was found to be easily manageable and very stable over the posterior teeth, due to its small size and precision, respectively. In conclusion, this technique seems to improve the accuracy of pterygomaxillary disjunction without prolonging the surgery time. Furthermore, it reduces potential complications related to the conventional procedure. Nevertheless, a larger body of patient data is needed to confirm the benefits of the technique.

1. Introduction

The pterygomaxillary disjunction technique ideally consists of a clean vertical fracture beginning laterally in the pterygomaxillary groove and progressing medially through the pterygomaxillary junction between the maxilla and the lateral pterygoid process. The technique was first described by Wassmund and Schuchardt in 1939 [1].

Unfavorable pterygomaxillary separation can cause a number of complications. The most common problem is bleeding arising from the branches of the maxillary artery, which runs into the pterygopalatine fossa. Aberrant blood vessel healing could lead to the appearance of arteriovenous fistulas [2]. Moreover, untoward fractures that extend to the base of the skull and orbit may be related to other potential complications such as loss of function of the lacrimal gland, cranial nerve palsies (especially cranial nerves II, III and VI), stroke, damage to the internal carotid artery, and loss of vision (related to hypotension and hypoperfusion of the optic nerve) [3].

Several techniques have been described for pterygomaxillary separation in the context of LeFort I osteotomy, such as the curved osteotome, or placing the posterior osteotomy through the maxillary tuberosity or third molar socket. In this context, the “twist technique” involves performing the disjunction through an anterior approach that enables immediate and effective separation of the maxilla with adequate visualization of the greater palatine neurovascular bundle, and a substantially smaller soft tissue incision [4].

Regardless of the procedure used, this approach is considered a blind and operator-sensitive technique. Thus, the present study describes the use of preoperative virtual planning to establish a surgical cutting guide that is placed in the maxillary tuberosity and allows for vertical osteotomy with a piezoelectric saw.

The Ethics Committee of Teknon Medical Center approved the study under number ISF. The Declaration of Helsinki guidelines were followed in all treatment phases, and written informed consent was obtained from all subjects.

2. Technical Note

2.1. Digital planning

A cone beam computed tomography (CBCT) image was taken with the IS i-CAT system, version 17–19 (Imaging Sciences International, Pennsylvania, United States of America). With the Blue Sky Plan software, version 4.7.20 (Blue Sky Bio, Illinois, United States of America), bilateral segmentation from the first premolar to the most distal area of the pterygoid process was carried out, transforming the digital

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images and communication on medicine (DICOM) format to stereolithography (STL) files. Additionally, an STL model of the maxilla of the patients was obtained, using an intraoral scanner (3shape TRIOS MOVE, Copenhagen, Denmark).

The STL files of the segmentation and the STL files of the intraoral scanner were fused and exported to the Autodesk Meshmixer (Autodesk Inc, California, United States of America), in which the surgical guide was designed, with occlusal support in the molars. Analyzing the anatomical area in the STL image, the splint contained a slot at the level of the pterygomaxillary suture which allowed for insertion of the piezoelectric inset. To offer better intraoral handling, a connecting bridge between both surgical guides was made, yielding a unitary surgical guide (Fig. 1). At this point, the depth and length of the planned osteotomy were calculated in order to avoid soft tissue damage and preserve the greater palatine canal.

The surgical guide was printed (Formlabs 2, Formlabs, Inc., Massachusetts, United States of America), with biocompatible photopolymer resin (Surgical guide, Formlabs, Inc., Massachusetts, United States of America). After printing, were washed with 99,5% of isopropyl alcohol for 5 mins using the Wash and Cure Machine of ANYCUBIC (ANYCUBIC Technology Co, Shenzhen, China), light cured in the same equipment for 10 min, and sterilized at 121 °C during 15 min (Autoclave Line B from W&H, Bürmoos, Austria).

2.2. Surgical technique

The study technique was applied in 12 patients, undergoing LeFort I osteotomy in the context of orthognathic surgery (11 cases), and one patient underwent surgically assisted rapid palatal expansion (SARPE). All surgeries were performed by the first author (FHA) (Table 1).

Orthognathic surgery procedures were carried out under general anesthesia, while the SARPE case was performed under sedation and local anesthesia, as described in detail elsewhere. In brief, through a minimally invasive incision running between the superior lateral incisors, subperiosteal elevation was performed to the pterygomaxillary junction [5]. Then, through a sub-spinal osteotomy, subperiosteal dissection of the nasal floor and disinsertion of the septal cartilage was carried out with a narrow periosteal elevator. A reciprocating saw with a 4-cm blade was used to perform bilateral horizontal osteotomies.

Then, the customized cutting guide was placed on the maxillary tuberosity, supported by the posterior molars (Fig. 2). The pterygomaxillary junction osteotomy was performed through a flapless approach using a piezoelectric saw (W&H Piezomed unit, W&H, Bürmoos, Austria) with the B1 fine-toothed saw to cut the bone in a coronal-apical direction, through the slot of the surgical guide until the suture resistance was felt. Then, the vertical osteotomy was enlarged as many millimeters as previously planned on a virtual basis. The same procedure was repeated on the other side. When required, vertical osteotomies were performed with the piezoelectric saw between the central incisors (SARPE) and between the lateral incisors-canines (segmented LeFort I osteotomies).

Finally, a crossed alar cinch and V-Y mucosal closure were carried out through the anterior approach. Both posterior approaches for guided pterygomaxillary osteotomy were also stitched with 4–0 polyglactin suture [6].

There were no complications during the operative and postoperative periods. A postoperative CBCT was performed in order to evaluate pterygomaxillary disjunction pattern (Table 1).

3. Discussion

Pterygomaxillary disjunction may lead to a number of complications, and the blind and operator-sensitive approach makes the technique even more difficult. For this reason, the use of a surgical guide constitutes a new technique that appears to allow the procedure, to be carried out with greater predictability, thereby avoiding potential complications [7].

For virtual planning purposes, it is mandatory to review the anatomical aspects of the pterygomaxillary junction, which have been described by Dadwal et al. [8]. The authors reported that the average width of the pterygomaxillary junction was 7.8 ± 1.5 mm, the distance of the greater palatine canal from the pterygomaxillary junction was 7.4 ± 1.6 mm, and the length of fusion of the pterygomaxillary junction was 8.0 ± 1.9 mm. In the context of the presented technique, the upper and inner limits of the pterygomaxillary osteotomy can be previously planned in the preoperative CBCT study: the greater palatine neurovascular bundle is located in the CBCT scan, and the length of the osteotomy therefore can be transferred intraoperatively, as reported in Table 1.

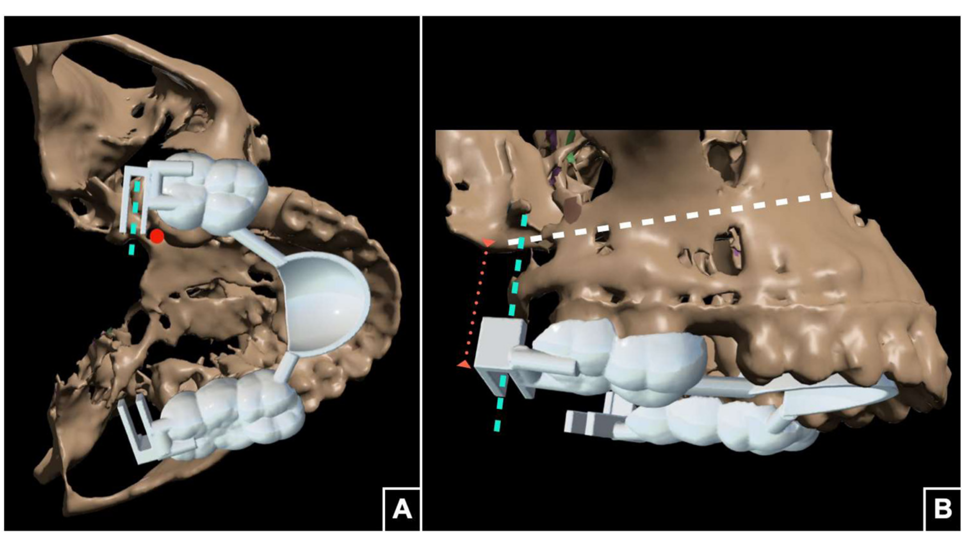

Fig. 1. Digital planification with Meshmixer (Autodesk Inc, California, United States of America), of the surgical guide. *Picture A:* can be detailed from the occlusal view, the area of interest of the surgical guide illustrating with the green dash line, the access of the osteotomy for the pterygomaxillary disjunction. The red spot mark, indicate the greater palatine neurovascular bundle location. *Picture B:* can be detailed from the lateral view with the green dash line in a coronal-apical direction, the vertical pterygoid osteotomy, with the white dash line in a mesio-distal direction, the horizontal Lefort osteotomy, and the red dash line is the distance measured from the entrance of the splint to the junction of the horizontal osteotomy, that it was 24 mm in length.

Table 1
Number of patients operated upon, gender, age, type of surgery performed (mainly LeFort I surgery), and distances measured from entrance of the surgical splint to the junction of the horizontal osteotomy.

PATIENT	GENDER	AGE	SURGERY	VERTICAL OSTEOTOMY LENGHT	PLACEMENT OF THE PTERYGOMAXILLARY DOWNFRACTURE
1	F	22 Y	SARPE	24 mm	Just in the junction
2	M	38 Y	Lefort I	25 mm	Just in the junction
3	M	26 Y	Lefort I	30 mm	Just in the junction
4	F	35 Y	Lefort I	28 mm	Just in the junction
5	M	30 Y	Lefort I	23 mm	Just in the junction
6	F	29 Y	Lefort I	25 mm	Just in the junction
7	F	36 Y	Lefort I	24 mm	Just in the junction
8	M	34 Y	Lefort I	22 mm	Just in the junction
9	F	42 Y	Lefort I	25 mm	Just in the junction
10	M	41 Y	Lefort I	27 mm	Just in the junction
11	M	25 Y	Lefort I	29 mm	Just in the junction
12	F	28 Y	Lefort I	27 mm	Just in the junction

On the other hand, the piezoelectric saw has been widely recommended in the literature for pterygomaxillary disjunction, since it reduces the risk of uncontrolled fracture, avoids undesired bleeding, and shortens the overall surgery time. Therefore, the authors also recommend its use in this guided but blind approach [8].

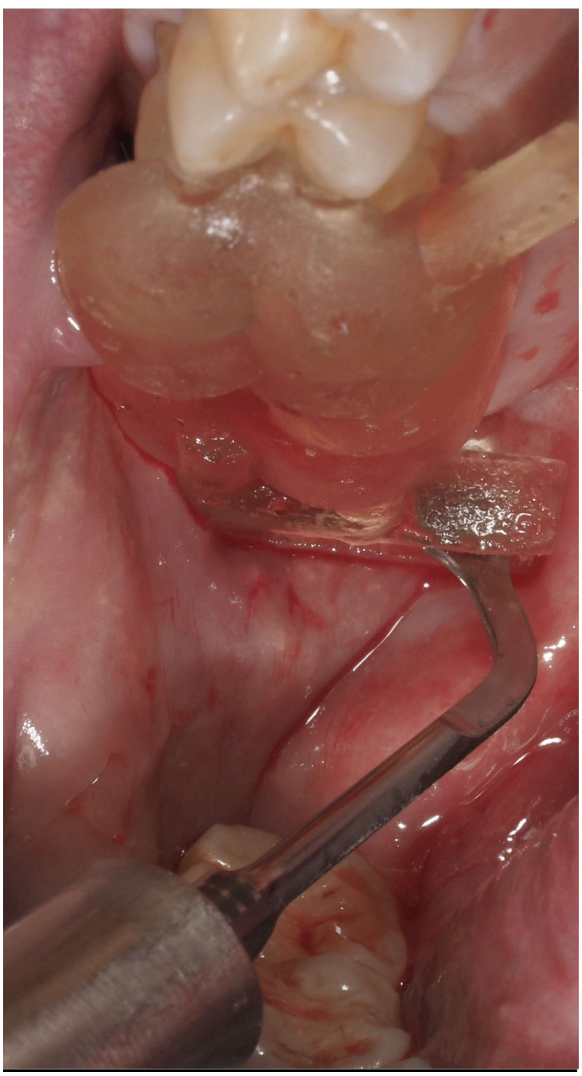

Fig. 2. Pterygomaxillary osteotomy through a flapless approach, using the biocompatible photopolymer resin surgical guide (Formlabs, Inc., Massachusetts, United States of America), with an occlusal support on molars, and a posterior slot which guides the B1 fine-toothed saw of the piezoelectric saw inset (W&H Piezomed unit, W&H, Bürmoos, Austria), into the pterygomaxillary suture, allowing precise osteotomy between the two bones, until the suture resistance is felt.

This guided transmucosal pterygomaxillary osteotomy allows us to use the minimally invasive approach of the "twist technique" while simplifying the maxillary down-fracture procedure: it allows a definitive osteotomy through the pterygomaxillary suture with a decreased strength during the maxillary down-fracture maneuver, and consequently a clean down-fracture just in the junction. Thus, after maxillary down-fracture, no extra time was spent in performing additional osteotomies or bony reshaping to correct eventual inadequate maxillary down-fracture site. Hence, we can conclude that the reported technique did not add extra surgery time, since the minimal spent time in additional osteotomies was more than outweighed by the fact that bone reshaping after maxillary down-fracture was not required in the described cases.

It has been widely described that regardless of the type of the pterygomaxillary disjunction method used, separation of the pterygomaxillary junction may occur in the posterior wall of the maxillary sinus, within the junction, or after suture. All the postoperative CBCT scans in our series showed a clean osteotomy through the pterygomaxillary suture (Table 1, Fig. 3). Thus, it adds precision to the suture osteotomy placement, avoiding deviations into the tuberosity or pterygoid bone.

Regarding the indications of the technique, it is indicated in conventional LeFort I procedures in the context of orthognathic surgery, where the maxillary down-fracture process can be easily achieved with slight pressure during the twist maneuver. This technique could be even more useful in cleft patients, as they present thinner pterygoid junctions, resulting in a higher incidence of unfavorable fractures of the pterygoid plate, and therefore a greater number of complications related to conventional pterygomaxillary disjunction [9]. Moreover, it is recommended for SARPE procedures that require complete down-fracture of the maxilla with pterygomaxillary disjunction, which is only performed when a significant posterior maxillary expansion is needed.

Therefore, this additional surgical guide for transmucosal pterygomaxillary osteotomy, improves the maxillary down-fracture technique, although the authors believe that after an adequate learning curve, the osteotomy could be carried out without the surgical guide as long as pterygomaxillary osteotomy length is previously determined virtually.

In conclusion, the described approach seems to improve the accuracy of pterygomaxillary disjunction location, without prolonging the surgery time. Furthermore, it reduces potential complications related to the conventional procedure. Nevertheless, a larger body of patient data is needed to confirm the benefits of the technique.

4. Authors contibution

Federico Hernández-Alfaro: Primary idea for the development of the new approach. Perform the surgical act and obtain documents

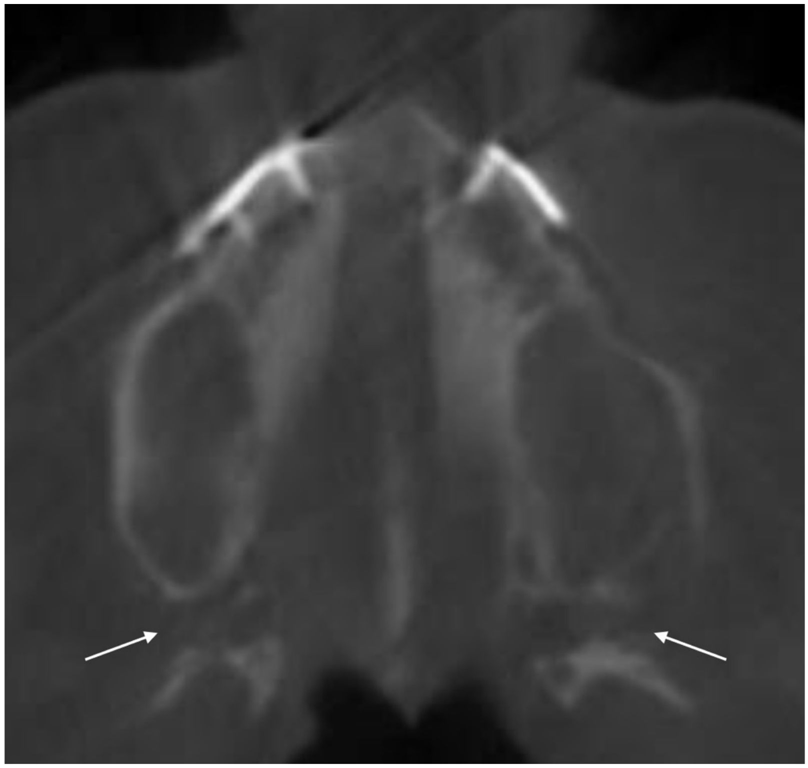

Fig. 3. Axial view of the CBCT scan, exhibiting with white arrows a clean and precise osteotomy through the bilateral pterygomaxillary suture, performed through the surgical splint.

and picture of the case. Contribution in the elaboration of the article. Evaluated the article according with the information that was described advising in the introduction of references and technical approaches. Approve the final manuscript.

Daniel Paternostrro Betancourt: Design the surgical guide. Use the cbct and stl for the design of the new surgical guide approach. Perform the elaboration of the article. Contribution in corrections of the article. Approve the final manuscript.

Orion Luiz Haas-Junior: Be part in the design of the study. Evaluated the pre-analysis of the information. Contribution in the elaboration of the article. Contribution in corrections of the article. Approve the final manuscript.

Adaia Valls-Ontañón: Help in the design of the surgical guide. Obtained information for the manufacture of the splint. Contribution in the elaboration of the article. Contribution in corrections of the article. Approve the final manuscript.

5. Financial disclosure statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Competing Interest

The Authors declare that there are no conflicts of interest.

Ethical approval

The Ethics Committee of Teknon Medical Center approved the study under number ISF. The Declaration of Helsinki guidelines were followed in all treatment phases, and written informed consent was obtained from the patients.

Patient consent

Written patient consent was obtained to publish the surgical photographs.

Acknowledgements

The Authors declare that they have no conflicts of interest in relation to the present study.

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