

Treatment of Maxillary Hypoplasia in Cleft Lip and Palate: Segmental Distraction Osteogenesis With Hyrax Device

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Abstract: The objective of this work is to describe a segmental maxillary distraction osteogenesis (SDO) with segmental Lefort I with an inexpensive device.

Four patients who presented severe class III and maxillary hypoplasia due to cleft lip and palate sequel were treated. A SDO was performed using a dental-anchored Hyrax device, achieving enlargement of the upper jaw without altering speech, with adequate and stable occlusion. Dental implants in a new formed bone were installed.

The authors can conclude that SDO is a good treatment alternative for patients with maxillary hypoplasia. It preserves velopharyngeal function and is a stable treatment, maintaining the overjet achieved with distraction osteogenesis, without changes in posterior occlusion. The open bite generated with tooth-borne devices can be solved with temporary anchorage devices and intermaxillary elastics during consolidation phase. Modified Hyrax device allows expanding and moving forward the maxillary arch, with a low cost.

Key Words: Cleft lip, cleft palate, dentofacial deformity, distraction osteogenesis, maxillary hypoplasia, maxillary retrusion, midfacial retrusion, segmental distraction, velopharyngeal insufficiency

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Cleft lip and/or palate (CLP) are congenital malformations with several alterations in growth and development of upper jaw. Speech and hearing impairments, malocclusions, transverse maxillary collapse, dental anomalies, and agenesis are frequent. The severity of the cleft and some surgical procedures (lip repair, palatoplasty) cause the contraction of the upper dental arch, meaning that maxillary expansion is necessary in such patients.¹ Multiple types of procedures have been described over the years which improve maxillary hypoplasia in patients with cleft lip and palate. It is difficult to treat them with traditional orthognathic surgery due to the risk of velopharyngeal insufficiency and the risk of relapse (25%–40%), when an advancement of over 10 mm is needed.²

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Distraction osteogenesis allows making stable movements, with less risk of velopharyngeal insufficiency.³ Although some reports⁴ have described deterioration in speech following distraction osteogenesis associated with a classical Lefort I osteotomy, that is why Liou et al³ describe a segmental technique to prevent the risk of velopharyngeal insufficiency appearing through the use of customized intraoral devices. Based on the Liou technique, this work describes a low cost system using a Hyrax device.

METHODS

This study was approved by the Hospital del Salvador Ethics Board.

A prospective study was conducted with 4 sequential patients with sequel of cleft lip and palate, attended in Maxillofacial Department of Hospital del Salvador and Hospital San Borja Arriarán, in Santiago, Chile between 2013 and 2015.

The inclusion criteria was: class III malocclusion due to severe hypoplasia of upper jaw (more than 10 mm of maxillary advanced needed), with small maxillary arch (due to hypodontia and agenesis), adequate velopharyngeal function (scores 0 and 1, and they do not want to have any risk of deterioration of their velopharyngeal function [VPF]), and complete closure of the palate and alveolar clefts with bone grafting before segmental distraction osteogenesis. All the patients received presurgical orthodontic treatment. No patients with those inclusions criteria underwent conventional Lefort I osteotomy.⁴

The Pittsburgh weighted speech scale⁵ was used for the evaluation of the velopharyngeal function pre and postsegmental distraction. This scale uses a standardized scoring system to evaluate a patient based on nasal air emission, facial grimace, resonance, voice quality, and articulation. The individual scores are summed and the total scores are used to classify patients into 1 of 4 categories of velopharyngeal function (in increasing order of dysfunction): competence, borderline competence, borderline incompetence, and incompetence. The speech parameters evaluated were hypernasality, nasal emission, and nasal turbulence before and 1 year after surgery (Table 1).⁵

A Hyrax device was installed in a way so as to allow the screw to open in a sagittal direction (not in a transverse direction as is commonly used). It was teeth anchored and cemented 2 days prior to surgery. An osteotomy was performed on the level of the piriform recess (identically to Lefort I) up to the level of first molar, on each side. In this point a vertical osteotomy, between bicuspid and the first molar (1.5 and 1.6 and between 2.5 and 2.6) was done (Fig. 1A and B). No previous space was created for osteotomy between molar and premolar. With a small saw or piezo surgery, used carefully there are no problems with roots. There were no dental injuries. Temporary anchorage devices were placed at the same surgical time. Three microscrews (1.6 mm) were placed in the distracted segment (between tooth 1.2–1.3, 1.1–2.1, 2.2–2.3) and sometimes 2 microscrews in the lower jaw (between 3.1–3.2, 4.1–4.2), when the orthodontic arch is smaller than stainless steel 17 × 25 (Fig. 1C). Activation of the Hyrax device began on the fifth day postsurgery, as a standard protocol⁶ (0.5 mm every 12 hours), until the separation was as long as desired.

TABLE 1. Patient Distribution According to Age, Type of Cleft, Dental Aggenesis, Presence of Pharyngeal Flap, Velopharyngeal Function Before and After Surgery, Amount of Distraction in Hyrax and in Alveolar Area, and Complications

Patient	Age	Type of Cleft	Dental Aggenesis	Previous Pharyngeal Flap	Velopharyngeal Function Before Surgery (Pittsburgh Weighted Speech Scale)	Amount of Distraction mm in Hyrax Device	Amount of Distraction mm in Alveolar Area	Velopharyngeal Function 1 Year After Surgery (Pittsburgh Weighted Speech Scale)	Complications
1	25	Bilateral cleft lip, alveolar and palate	1.3–2.2–2.3	Yes	0	14	10	0	Change de hyrax device for another one with longer screw
2	20	Bilateral cleft lip, alveolar and palate	1.3–1.2–2.2–2.3	Yes	0	14	9	0	No
3	18	Left cleft lip and palate	2.2–2.3	No	0	12	8	0	No
4	21	Left cleft lip and palate	2.2–2.3	Yes	1	15	10	1	No
Average	21				0.25	13.75	9.25	0.25	

Informed consent was obtained to begin treatment, and to ensure their collaboration.

RESULT

Patients with an average age of 21 years (18–25), with severe maxillary hypoplasia were included in this study, the amount of

distraction was an average of 13.75 mm^{2,7–9} in the screw of the Hyrax device, and 9.25 mm in the alveolar zone,^{10–12} because the alveolar space gained does not have a 1:1 relationship with the Hyrax screw. Three patients had previous pharyngeal flap (2 patients with 0 in VPF score, and 1 with 1), the other one without pharyngeal flap was a score 0 in VPF (complete competent) before. No changes in VPF were observed after SDO. Three patients showed competent VPF, and 1 borderline competent before surgery (Pittsburgh weighted speech scale),⁵ and their conditions stayed equal after surgery.

One hyrax device had to be changed after 11 days of activation, due to the need of a longer screw than the first one (Table 1).

The average of overjet before surgery was –12 mm. The overjet after distraction was an average of 2.5 mm.^{2,3} After a year of surgery only 1 patient decreased 1 mm, the others remained intact, with a high occlusal stability (Table 2).

On a tooth-borne device, an open bite is expected and was observed after the procedure was completed (due to the fact that the force is applied below the center of resistance of the segment). To solve it, the Hyrax device was removed after 8 weeks of consolidation phase, and elastic traction was applied, using intermaxillary elastics (1/4 Heavy) located on micro screws (placed during osteotomy surgery) to avoid causing a dental extrusion. The elastics were worn 24 hours a day during 4 weeks.

The overbite before surgery was an average of –0.25 mm. At the end of distraction the average of overbite was –4.25 mm, and the average of open bite after 4 weeks of intermaxillary elastics was 1 mm. Finally after dental rehabilitation the average of overbite was 2.375 mm.

The total follow-up was an average of 2.75 years (Table 2).

Dental implants were installed in each distracted segment (right and left) where new bone was formed (4 months after consolidation phase). No bone graft was necessary in any patient. Good quality of bone was founded (types 3 and 4 in Lekholm and Zarb classification with adequate primary stability in dental implants)¹³ (Figs. 2–5).

DISCUSSION

The literature describes multiple techniques to allow maxillary advancement in patients with maxillary hypoplasia: traditional Lefort I for maxillary advancement; Lefort I maxillary distraction with external or internal distraction devices; anterior segmented distraction osteogenesis.

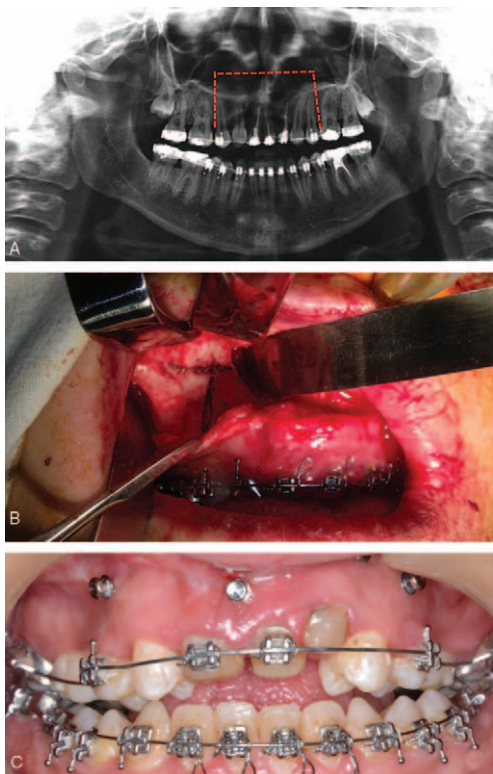


FIGURE 1. (A) Panoramic x ray showing the place of the vertical osteotomy. Note that the upper second molar has proper occlusion with the inferior second molar. (B) Intra operative view of the vertical left osteotomy (between tooth 2.5 and 2.6). Note the small distance from piriform notch and first molar. (C) temporary anchorage devices location for vertical management of open bite.

TABLE 2. Overbite and Overjet Before and After Distraction, and Total Follow-Up

Patient	Overbite Before Surgery	Overbite at the End of Distraction	Overbite After TAD and Intermaxillary Elastics	Overbite a Year After Dental Rehabilitation	Overjet Before Surgery	Overjet at the End of Distraction	Overjet a Year After Surgery	Follow-Up Years
1	-2	-7	0	2.5	-13	+3	+3	3
2	0	-3	1	2	-12	+2	+2	4
3	2	-2	2	3	-10	+3	+2	2
4	-1	-5	1	2	-13	+2	+2	2
Average	-0.25	-4.25	1	2.375	-12	+2.5	2.25	2.75

TAD, temporary anchorage device.

The conventional Lefort I osteotomy with advancement over 10mm is an unstable procedure, with high risk of producing velopharyngeal insufficiency.¹⁰ In contrast, distraction osteogenesis offers some advantages, allowing great maxillary advances, it is more stable, and speech problems from velopharyngeal insufficiency are less.^{2,11,12,14} However, patients of hypernasal speech have been found after distraction osteogenesis (DOG), similar to those reported following a conventional Lefort I.^{7,12} Despite DOG with total osteotomies performs gradual traction, pharyngeal flaps become thinner. Segmental DOG does not move the posterior area of upper jaw (specifically the velopharyngeal zone), that is why their VPF does not change. No patients underwent a pharyngeal surgery after segmental DOG. In some patients the forward movement with Lefort I osteotomy (conventional or with DOG), would leave the last inferior second molar without occlusion with the upper molar.

Gunaseelan reported the use of a palate distractor in an anteroposterior direction for maxillary advancement after an alveolar osteotomy.⁸ The study evaluates the amount and direction of movement in a distraction osteogenesis with a Hyrax type interdental distractor to produce 1 mm distraction per day and a 4-month

consolidation period. They obtained positive results in all the patients, expanding the maxillary arch and changing the profile from concave to convex.⁸ Other authors¹¹ propose using internal intraoral distractors after a high Lefort I osteotomy, achieving 8 mm of advance.

Liou et al³ described interdental distraction osteogenesis to create a new segment of alveolar bone and gums attached in the



FIGURE 2. (A) Frontal view before surgery. (B) Profile view before surgery. (C) Frontal view a year after surgery. (D) Profile view a year after surgery (Patient 1).



FIGURE 3. Intraoral view of short maxillary arch before surgery. Between 1.3 and 2.3 there are only 3 teeth and with very small size (A), at the end of distraction (B), after dental implants (C), with dental prosthesis (D).



FIGURE 4. (A) Occlusal view before surgery. (B) Occlusal view at the end of distraction. (C) Occlusal view after elastic therapy with temporary anchorage devices. (D) Final occlusal view a year after surgery.

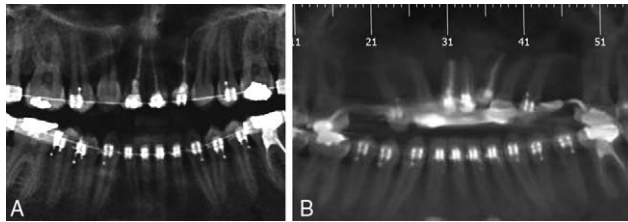


FIGURE 5. (A) Panoramic x-ray before surgery. (B) Panoramic x-Ray after 14 mm of distraction.

reconstruction of maxillary defects. The procedure that he describes includes the preoperative use of a modified Quadhelix; interdental and horizontal maxillary osteotomies, distraction, and subsequently quick orthodontic movement, producing 12 mm advancement, without alterations in the velopharyngeal function.³ The same author has proposed the combined use of Alt-RAMEC (maxillary expansion and construction) to produce suture stimulation over a long period, together with a modified Hyrax device applying traction to mini-implants and an extraoral mask in young patients with class III malocclusions.^{9,15}

Another study used a Hyrax expansion device following an anterior segmental maxillary osteotomy, transmitting the force to the teeth, to then produce a swift orthodontic movement.¹⁶ They achieved 7 mm advancement in 14 days but stress that the biggest consequence of quick palate expansion is that it produces an open bite. They concluded that it is possible to use interdental distractors to correct slight-moderate maxillary hypoplasia and narrow dental arches.

Dental arch needs to be expanded and aligned in presurgical orthodontic treatment¹⁷ and accelerated orthodontic movements are recommended after surgery.¹⁸

Most of the patients with cleft lip and/or palate have agenesis and hypodontia. The authors showed a 71.9% of agenesis and 59.6% approximately have maxillary hypoplasia.¹⁹ Some authors recommend placing the canine in the lateral position or keeping the space to install a dental implant coordinated with Lefort I osteotomy.²⁰

In these series of patients the average amount of distraction was 13.75 mm, maintaining adequate velopharyngeal function, enlargement of the maxillary arch, and with good occlusal stability. The advantages of the Hyrax device (over internal distraction devices) is that it is not necessary a secondary surgery to remove it, and the cost of the internal device is around 500 US dollars, versus the cost of a Hyrax device which is around 30 US dollars.

CONCLUSIONS

We can conclude that segmental maxillary distraction osteogenesis is a good alternative of treatment for patients with severe maxillary hypoplasia and small maxillary arch (due to multiple agenesis and hypodontia). It preserves velopharyngeal function and is a stable treatment, maintaining the overjet achieved, without changes in molar occlusion. The open bite generated with tooth-borne devices can be solved with temporary anchorage devices and intermaxillary elastics during consolidation phase. Modified Hyrax device allows expanding and moving forward the maxillary arch, with a low cost.

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