Le Fort I Maxillary Advancement Using Distraction Osteogenesis

Patrick D. Combs, MD Raymond J. Harshbarger III, MD, FACS, FAAP

¹ Department of Craniofacial & Pediatric Plastic Surgery, Dell Children's Medical Center, Austin, Texas

Semin Plast Surg 2014;28:193–198.

Address for correspondence Raymond J. Harshbarger III, MD, FACS, FAAP, Department of Craniofacial and Pediatric Plastic Surgery, Dell Children's Medical Center, University Medical Center Brackenridge, Austin, TX 78723 (e-mail: RJHarshbarger@seton.org).

Abstract

Keywords

- Le Fort I distraction osteogenesis
- cleft lip/palate
- Le Fort I osteotomy
- maxillary hypoplasia
- midface advancement

Treatment of maxillary hypoplasia has traditionally involved conventional Le Fort I osteotomies and advancement. Advancements of greater than 10 mm risk significant relapse. This risk is greater in the cleft lip and palate population, whose anatomy and soft tissue scarring from prior procedures contributes to instability of conventional maxillary advancement. Le Fort I advancement with distraction osteogenesis has emerged as viable, stable treatment modality correction of severe maxillary hypoplasia in cleft, syndromic, and noncleft patients. In this article, the authors provide a review of current data and recommendations concerning Le Fort I advancement with distraction osteogenesis. In addition, they outline their technique for treating severe maxillary hypoplasia with distraction osteogenesis using internal devices.

Le Fort I advancement has been a reliable procedure for correction of maxillary retrusion and class III occlusal relationships for over 50 years.¹ However, conventional orthognathic surgery carries the risk of relapse and complications with extreme movements, and in certain patient populations.² Maxillary hypoplasia in the cleft lip and palate patient population can be particularly difficult to address with traditional orthognathic surgery. The presence of soft tissue scarring and risk of velopharyngeal incompetence in cleft patients, as well as the significant potential for relapse limit the efficacy of conventional orthognathic surgery in this patient population.^{3,4} The problem is expounded by the estimation that the incidence of maxillary hypoplasia significant enough to warrant orthognathic surgery is 25%.⁵

Distraction osteogenesis (DO) of the craniofacial skeleton was first introduced by McCarthy in 1992.⁶ Molina and Ortiz Monasterio first advanced the maxilla in human patients using an orthodontic face mask and elastics.⁷ Polley and Figueroa introduced distraction of a monobloc segment using an external fixator in 1995.⁸ They subsequently developed the rigid external distraction system for maxillary advancement in cleft patients with severe maxillary hypoplasia.^{2,9} Since then, several internal and external distraction devices have been developed for maxillary advancement.^{10–14} Le Fort

I DO has become a valuable tool, if not workhorse technique, for the management of severe maxillary hypoplasia in the syndromic and cleft lip and palate population, and in growing patients.

Indications for Le Fort I Distraction Osteogenesis

The often discussed limit for conventional Le Fort I maxillary advancement is 10 mm. Greater movement risks instability and eventual relapse.¹³ Soft tissue scarring, potentially poor bone quality, and aberrant dentition make maxillary advancement in the cleft lip and palate patient population a particular challenge.⁹ The degree of relapse after conventional Le Fort I advancement in cleft patients ranges from 22 to 40% in the horizontal plane, and 19 to 70% in the vertical plane.^{4,15} Although somewhat variable in the literature, the maximum recommended advancement in cleft patients is around 6 mm.^{2,12,16} Combining maxillary advancement with mandibular setback has been a treatment option used for severe maxillary hypoplasia. Because cleft patients have been shown to have normal to slightly small mandibles,^{9,17,18} this strategy may lead to facial disharmony depending on the starting mandibular position. Maxillary advancement using

DO carries the potential for relative long-term stability even in groups that have responded poorly to traditional advancement.

In addition to limitations in cleft and syndromic patients, maxillary advancement using conventional Le Fort I osteotomies is generally confined to patients approaching skeletal maturity. Distraction osteogenesis allows for high osteotomies and a lack of rigid fixation techniques, which avoids injury to tooth follicles and allows for advancement in the growing patient.^{9,19–21} The majority of patients treated with maxillary DO reported in the literature have been aged 6 to 15 years.³ Distraction osteogenesis provides a treatment modality for growing patients with severe maxillary hypoplasia.

At our institution, we perform Le Fort I DO on patients with severe maxillary retrusion who require advancement of more than 10 mm in noncleft patients, or more than 5 to 6 mm in cleft lip and palate patients. We perform the procedure at one of two time points, depending on the degree of retrusion and disability. The first is in growing patients with established severe negative overjet near the time of maxillary growth completion, at around age 11 to 12. The second is in patients with severe maxillary retrusion who have reached skeletal maturity.

Conventional Maxillary Advancement versus Distraction Osteogenesis

Nearly two decades of maxillary advancement using DO has spawned comparisons between this technique and conventional osteotomies, both in retrospective and prospective studies. In a study of 25 cleft patients, Baek et al found no significant difference in relapse between the conventional osteotomy (CO) group and the DO group despite a significantly larger advancement in the DO group.²² In a randomized trial of 29 cleft lip and palate patients, Cheung et al found a statistically significant increase in relapse in the CO group at 12 weeks.²³ Kumar et al found a 48% greater relapse for cleft lip and palate patients treated for severe maxillary deficiency (>10 mm) by CO compared with DO.²⁴ In a comparison of cleft patients treated with CO versus DO for advancements ranging from 4 to 10 mm, Chua et al found a significantly decreased relapse mean at 5 years in the DO group.²⁵ Interestingly, the gradual advancement produced by DO may result in greater facial soft tissue changes and nasal projection than similar advancements using conventional osteotomies.²⁶

Long Term Outcomes of Le Fort I Distraction Osteogenesis

Due to the recentness of the technique's inception as well as the relative rarity of the procedure per institution, data on long-term results of maxillary advancement using DO are limited to small case series. In addition, performing the procedure in growing patients makes outcomes data such as relapse difficult to interpret. Figeroa and Polley showed horizontal stability after 2 years.²⁷ Other authors, in follow-up periods ranging from 2 to 6 years, have found horizontal

relapse of 5.5% to 23%.^{19,28–30} The majority of relapse occurred in the first 6 months following consolidation. In growing patients, two groups have found a decrease in the ANB angle over time. It is postulated that this is the result of the differential growth rate of the mandible to the distracted maxilla.^{19,27} Both groups of patients maintained class I occlusal relationships after distraction. This has led some groups to recommend overcorrection in growing patients.^{19,31,32}

Le Fort I Distraction Osteogenesis and Velopharyngeal Function

It has been hypothesized that the potential negative effect on velopharyngeal competence risked by advancing the maxilla with a conventional LeFort I osteotomy may be mitigated by gradual advancement. Prospective comparisons between patients undergoing moderate (4 to 10 mm) maxillary advancement by conventional osteotomy versus DO found no difference on velopharyngeal function between the groups.^{33,34} Both Polley and Figeroa's group and Rachmiel et al found 3 of 18 patients with worsened hypernasality after DO, similar to reported rates after conventional Le Fort I advancement. Deterioration in velopharyngeal function appeared to be associated with larger advancement.^{35,36}

Device Selection

Multiple internal and external devices have been developed and utilized for maxillary DO. Whether distraction is better accomplished using internal or external devices has been the subject of debate. Proponents of external distraction systems argue the following advantages:

1. When distracting using an external device, the vector can be adjusted any time during distraction.
2. The device can be removed without the need for sedation or general anesthetic.
3. Distracting using an external device potentially allows for a higher Le Fort I osteotomy, as there is no need to consider a zygomatic area for the footplate of an internal distractor.^{16,37}

However, Le Fort I advancement using internal devices offers several advantages:

1. External devices can be intimidating and cumbersome to patients and clinicians.
2. Internal devices are largely buried under soft tissues, and may be better tolerated during the distraction/consolidation process than external devices.^{4,37}
3. It has been postulated that the "pushing" forces of internal distraction may impart a stability advantage over external DO.²⁵

Authors' Preferred Technique

At our institution, patients are prepared for Le Fort I DO with presurgical orthodontics in a manner similar to preparation for conventional orthognathic surgery for an Angle class III occlusal relationship. This includes coordination of the arches

Fig. 1 Virtual surgical plan for Le Fort I distraction osteogenesis using internal distractors. The osteotomies and vectors of distraction have been anticipated (Medical Modeling, Golden, CO).

Fig. 2 Location of the zygomatic footplates has been determined by the location of the planned osteotomy as well as the robustness of the bone for holding fixation. Note the drill guides for the distractor fixation, contoured to the shape of the zygoma.

and decompensation of the anterior dentition. After completion of orthodontic preparation, the patient is imaged with a low-dose craniofacial computed tomography scan, and virtual surgical planning is conducted with the craniofacial surgery and orthodontic teams. This allows for accurate

design of the osteotomies, localization of the zygomatic footplate based on robustness of the malar bone, and definition of the appropriate vector of distraction (► **Figs. 1 and 2**). Guides are included with the virtual surgical plan that allow for precise angulation of the internal distractors and

Fig. 3 Virtual plan and guide for angulation of the internal distractor, based on the planned vector of distraction (Medical Modeling, Golden, CO).

Fig. 4 Prior to surgery, the distractors are mounted to a model of the patient's facial skeleton. This confirms the accuracy of the surgical plan and guides, and allows for adjustments to be made prior to implantation.

placement of the zygomatic footplates (►Fig. 3). Prior to surgery, the guides and distractors are tested and modified using a patient-specific stereolithographic skull model (►Fig. 4). This allows for customization of the internal distractors, saving time during the surgical procedure.

In the operating room, the patient may be intubated orally when there is no need for maxillomandibular fixation. After upper gingivobuccal incisions and subperiosteal exposure of the midface, the zygomatic footplate guides are positioned and screw holes are predrilled. Design of the osteotomy, location of the footplate guides, and vector are based on the virtual surgical planning. After completion of the nasal septal and pterygomaxillary osteotomies, the mobility of the Le Fort I segment is tested. The internal distractors are then affixed to the zygomas using the guides and predrilled screw holes. The distal footplates are wired to the patient's dentition and orthodontia. The internal distraction devices are tested prior to gingivobuccal closure.

In appropriate patients with a significant yaw deformity, nasotracheal intubation is performed. The yaw deformity is corrected after the osteotomies with a prefabricated splint prior to placement of the internal distractors.

After a latency period of 5 to 7 days, distraction is initiated at a rate of 0.5 mm twice a day for a total of 1 mm per day. Distraction is done as an outpatient after the patient and his or her family are instructed on proper technique. The patients are followed closely during the distraction period by the combined craniofacial and orthodontic teams. Distraction is continued until an Angle class II occlusal relationship is achieved, with possible overcorrection depending on patient age. During the consolidation phase, the patient is treated with elastics for maintenance of desired occlusion and molding of the generate if necessary (►Fig. 5). The distraction phase may result in an open bite, which is corrected with the elastics. The consolidation phase continues for 8 weeks, after which the internal distractors are removed through limited gingivobuccal incisions. The patient continues regular orthodontic appointments for postprocedural adjustments with elastics if necessary (►Fig. 6).

Conclusions

Conventional Le Fort I advancement with rigid fixation remains the treatment option of choice for patients with Angle class III occlusal relationships who have reached skeletal maturity and require mild to moderate advancement. Advancement using Le Fort I DO has been shown to be a stable, reliable treatment modality for patients with moderate to severe deformities, especially in the cleft lip and palate population, as well as in growing patients. Treatment requires extensive coordination within the craniofacial team, including the surgical and orthodontic members. The use of virtual surgical planning allows for a streamlined and potentially more predictable operation, distraction, and end result.

Future Directions

Although the technique has been used for almost two decades, Le Fort I DO is really still in its infancy as a treatment modality. Advancements continue to be made in the devices and distraction protocols. One area where further study is warranted is in the analysis of the principles of distraction osteogenesis in the setting of Le Fort I movement. Should traditional principles be followed? What flexibility is present given postoperative manipulation of the distracted segment

Fig. 5 Presurgical occlusion (A) and consolidation phase (B) Note the orthodontic treatment with elastics during the consolidation phase.

Fig. 6 Lateral cephalogram illustrating predistraction (A) and postdistraction (B) occlusion.

with orthodontics? Where does the bone actually form in Le Fort I DO, and where are the key areas for stability? With the accumulation of more long-term data, improved and informed distraction protocols will result in more effective, long-lasting patient outcomes. Le Fort I DO will likely be an important component in the treatment of multiple craniofacial anomalies.

References

- Obwegeser HL. Surgical correction of small or retrodisplaced maxillae. The "dish-face" deformity. *Plast Reconstr Surg* 1969; 43(4):351–365
- Polley JW, Figueroa AA. Management of severe maxillary deficiency in childhood and adolescence through distraction osteogenesis with an external, adjustable, rigid distraction device. *J Craniofac Surg* 1997;8(3):181–185, discussion 186
- Cheung LK, Chua HD. A meta-analysis of cleft maxillary osteotomy and distraction osteogenesis. *Int J Oral Maxillofac Surg* 2006; 35(1):14–24
- Rachmiel A. Treatment of maxillary cleft palate: distraction osteogenesis versus orthognathic surgery—part one: maxillary distraction. *J Oral Maxillofac Surg* 2007;65(4):753–757
- Ross RB. Treatment variables affecting facial growth in complete unilateral cleft lip and palate. *Cleft Palate J* 1987;24(1):5–77
- McCarthy JG, Schreiber J, Karp N, Thorne CH, Grayson BH. Lengthening the human mandible by gradual distraction. *Plast Reconstr Surg* 1992;89(1):1–8, discussion 9–10
- Molina F, Ortiz Monasterio F, de la Paz Aguilar M, Barrera J. Maxillary distraction: aesthetic and functional benefits in cleft lip-palate and prognathic patients during mixed dentition. *Plast Reconstr Surg* 1998;101(4):951–963
- Polley JW, Figueroa AA, Charbel FT, Berkowitz R, Reisberg D, Cohen M. Monobloc craniomaxillofacial distraction osteogenesis in a newborn with severe craniofacial synostosis: a preliminary report. *J Craniofac Surg* 1995;6(5):421–423
- Polley JW, Figueroa AA. Rigid external distraction: its application in cleft maxillary deformities. *Plast Reconstr Surg* 1998;102(5): 1360–1372, discussion 1373–1374
- Malagon HH, Romo GW, Quintero Mosqueda FR, Magaña FG. Multivectorial, external halo-assisted midface distraction in patients with severe hypoplasia. *J Craniofac Surg* 2008;19(6): 1663–1669
- Kahn DM, Broujerdi J, Schendel SA. Internal maxillary distraction with a new bimalar device. *J Oral Maxillofac Surg* 2008;66(4): 675–683
- Yamaji KE, Gateno J, Xia JJ, Teichgraber JF. New internal Le Fort I distractor for the treatment of midface hypoplasia. *J Craniofac Surg* 2004;15(1):124–127
- Wang XX, Wang X, Yi B, Li ZL, Liang C, Lin Y. Internal midface distraction in correction of severe maxillary hypoplasia secondary to cleft lip and palate. *Plast Reconstr Surg* 2005;116(1):51–60
- Picard A, Diner PA, Galliani E, Tomat C, Vazquez Mr, Carls FP. Five years experience with a new intraoral maxillary distraction device (RID). *Br J Oral Maxillofac Surg* 2011;49(7):546–551
- Posnick JC, Dagys AP. Skeletal stability and relapse patterns after Le Fort I maxillary osteotomy fixed with miniplates: the unilateral cleft lip and palate deformity. *Plast Reconstr Surg* 1994;94(7): 924–932
- Scolozzi P. Distraction osteogenesis in the management of severe maxillary hypoplasia in cleft lip and palate patients. *J Craniofac Surg* 2008;19(5):1199–1214
- Semb G. A study of facial growth in patients with unilateral cleft lip and palate treated by the Oslo CLP Team. *Cleft Palate Craniofac J* 1991;28(1):1–21, discussion 46–48
- da Silva Filho OG, Normando AD, Capelozza Filho L. Mandibular growth in patients with cleft lip and/or cleft palate—the influence of cleft type. *Am J Orthod Dentofacial Orthop* 1993;104(3): 269–275
- Cho BC, Kyung HM. Distraction osteogenesis of the hypoplastic midface using a rigid external distraction system: the results of a one- to six-year follow-up. *Plast Reconstr Surg* 2006;118(5): 1201–1212
- Gürsoy S, Hukki J, Hurmerinta K. Five-year follow-up of maxillary distraction osteogenesis on the dentofacial structures of children with cleft lip and palate. *J Oral Maxillofac Surg* 2010;68(4): 744–750
- Rachmiel A, Aizenbud D, Peled M. Long-term results in maxillary deficiency using intraoral devices. *Int J Oral Maxillofac Surg* 2005; 34(5):473–479
- Baek SH, Lee JK, Lee JH, Kim MJ, Kim JR. Comparison of treatment outcome and stability between distraction osteogenesis and Le-Fort I osteotomy in cleft patients with maxillary hypoplasia. *J Craniofac Surg* 2007;18(5):1209–1215
- Cheung LK, Chua HD, Hägg MB. Cleft maxillary distraction versus orthognathic surgery: clinical morbidities and surgical relapse. *Plast Reconstr Surg* 2006;118(4):996–1008, discussion 1009

- 24 Kumar A, Gabbay JS, Nikjoo R, et al. Improved outcomes in cleft patients with severe maxillary deficiency after Le Fort I internal distraction. *Plast Reconstr Surg* 2006;117(5):1499–1509
- 25 Chua HD, Hägg MB, Cheung LK. Cleft maxillary distraction versus orthognathic surgery—which one is more stable in 5 years? *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2010;109(6):803–814
- 26 Chua HD, Cheung LK. Soft tissue changes from maxillary distraction osteogenesis versus orthognathic surgery in patients with cleft lip and palate—a randomized controlled clinical trial. *J Oral Maxillofac Surg* 2012;70(7):1648–1658
- 27 Figueroa AA, Polley JW, Friede H, Ko EW. Long-term skeletal stability after maxillary advancement with distraction osteogenesis using a rigid external distraction device in cleft maxillary deformities. *Plast Reconstr Surg* 2004;114(6):1382–1392, discussion 1393–1394
- 28 Kanno T, Mitsugi M, Hosoe M, Sukegawa S, Yamauchi K, Furuki Y. Long-term skeletal stability after maxillary advancement with distraction osteogenesis in nongrowing patients. *J Oral Maxillofac Surg* 2008;66(9):1833–1846
- 29 Wiltfang J, Hirschfelder U, Neukam FW, Kessler P. Long-term results of distraction osteogenesis of the maxilla and midface. *Br J Oral Maxillofac Surg* 2002;40(6):473–479
- 30 Aksu M, Saglam-Aydinatay B, Akcan CA, et al. Skeletal and dental stability after maxillary distraction with a rigid external device in adult cleft lip and palate patients. *J Oral Maxillofac Surg* 2010;68(2):254–259
- 31 Doucet JC, Herlin C, Bigorre M, Bäumlér C, Subsol G, Captier G. Effects of growth on maxillary distraction osteogenesis in cleft lip and palate. *J Craniomaxillofac Surg* 2013;41(8):836–841
- 32 Harada K, Sato M, Omura K. Long-term maxillomandibular skeletal and dental changes in children with cleft lip and palate after maxillary distraction. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2006;102(3):292–299
- 33 Chua HD, Whitehill TL, Samman N, Cheung LK. Maxillary distraction versus orthognathic surgery in cleft lip and palate patients: effects on speech and velopharyngeal function. *Int J Oral Maxillofac Surg* 2010;39(7):633–640
- 34 Chanchareonsook N, Whitehill TL, Samman N. Speech outcome and velopharyngeal function in cleft palate: comparison of Le Fort I maxillary osteotomy and distraction osteogenesis—early results. *Cleft Palate Craniofac J* 2007;44(1):23–32
- 35 Guyette TW, Polley JW, Figueroa A, Smith BE. Changes in speech following maxillary distraction osteogenesis. *Cleft Palate Craniofac J* 2001;38(3):199–205
- 36 Rachmiel A, Aizenbud D, Peled M. Distraction osteogenesis in maxillary deficiency using a rigid external distraction device. *Plast Reconstr Surg* 2006;117(7):2399–2406
- 37 Figueroa AA, Polley JW. Clinical controversies in oral and maxillofacial surgery: Part two. External versus internal distraction osteogenesis for the management of severe maxillary hypoplasia: external distraction. *J Oral Maxillofac Surg* 2008;66(12):2598–2604