Le Fort II Distraction With Zygomatic Repositioning: A Technique for Differential Correction of Midface Hypoplasia

Richard A. Hopper, MD, MS,*
Hitesh Kapadia, DDS, PhD,† and Srinivas M. Susarla, DMD, MD, MPH‡

Severe midface hypoplasia is frequently addressed with subcranial midface advancement at the Le Fort II or Le Fort III level. Le Fort II advancement has a predominant affect on the vertical and sagittal positioning of the nasomaxillary complex; in contrast, the Le Fort III advancement allows for correction of zygomatic position and exorbitism. In this report, the authors described a technique for correction of exorbitism which concomitantly addresses central midface vertical and sagittal deficiency. The technique involves a combination of a Le Fort III osteotomy with a Le Fort II distraction. The Le Fort III osteotomy allows repositioning and fixation of the zygomas to correct lateral hypoplasia and exorbitism, maintaining the globes in a more functional position. The Le Fort II distraction allows for movement of the central midface independent of the lateral orbits and zygomas, correcting the sagittal and vertical position without orbital distortion. With the medial canthal apparatus attached to the Le Fort II segment and the lateral canthus attached to the stabilized lateral orbits, the differential movement achieved can also have a favorable effect on palpebral fissure orientation.

© 2018 American Association of Oral and Maxillofacial Surgeons

Treatment of syndromic midface hypoplasia has long been a challenging problem for craniomaxillofacial surgeons. The rationale for subcranial midface advancement was borne of expanding knowledge of midface fractures after Le Fort’s1 seminal description of classic midface fracture patterns in 1901.1 Subsequently, Gillies and Harrison2 described midface advancement for treatment of craniofacial dysostosis but were dissatisfied with the technique and abandoned it. In the latter half of the 20th century, the revolutionary work of Tessier3-5 made elective osteotomies for management of total midface deficiency a practical solution. The Le Fort III osteotomy, as initially described by Tessier and refined by others, allowed for correction of exorbitism in a single-stage procedure.3-9 Tessier’s early indications for the procedure were for correction of midface hypoplasia, such as that seen in Apert and Crouzon syndromes, and post-traumatic deformities. The technique subsequently gained widespread acceptance, with numerous modifications to improve results.3-12 With the advent of distraction osteogenesis in the early 1990s, subcranial Le Fort III advancement by distraction became an appealing option in the treatment of syndromic midface hypoplasia.13-23

Received from the Craniofacial Center, Seattle Children’s Hospital, Seattle, WA.
*Professor, Division of Craniofacial and Plastic Surgery.
†Assistant Professor, Division of Craniofacial Orthodontics.
‡Assistant Professor, Divisions of Craniofacial and Plastic Surgery and Oral and Maxillofacial Surgery.

Conflict of Interest Disclosures: Dr Hopper shares patent royalties with KLS Martin. Dr Susarla owns stock in Polarity TE, Inc. Dr Kapadia has no relevant financial relationship(s) with a commercial interest.

Address correspondence and reprint requests to Dr Susarla: Craniofacial Center, Seattle Children’s Hospital, 4800 Sand Point Way NE, Seattle, WA 98105; e-mail: srinivas.susarla@seattlechildrens.org
Received March 30 2018
Accepted April 20 2018
© 2018 American Association of Oral and Maxillofacial Surgeons
0278-2391/18/30388-4
https://doi.org/10.1016/j.joms.2018.04.023

2002.e1
In contrast, the Le Fort II osteotomy is a described option for management of central midface deficiency. The Le Fort II procedure has been suggested by some for treatment of sagittal deficiencies involving nasomaxillary position, such as that seen in Binder syndrome and in cleft midface hypoplasia. In 1986, Tulasne and Tessier described the use of the Le Fort II osteotomy with simultaneous mandibular

**FIGURE 1.** Surgical stages of the Le Fort II distraction with zygomatic repositioning procedure. **A, B,** A Le Fort III craniofacial separation with step osteotomies at the lateral orbital walls. **C,** Repositioning and fixation of the right orbito-zygomatic complex by transposition of the step osteotomy. This movement typically shifts the lateral inferior orbital rim and malar prominence 3 to 4 mm superiorly and 5 to 7 mm anteriorly. **D,** Release of the repositioned right orbito-zygomatic complex through an intraoral osteotomy lateral to the infraorbital nerve. (Fig 1 continued on next page.)

osteotomy for correction of the clockwise rotation deformity in Treacher Collins syndrome. Variations of the technique, including modifications to the shape of the central midface segment (pyramidal vs quadrangular) and location of incisions (coronal, cutaneous, and intraoral), have been described in the craniomaxillofacial surgery literature. When performing a Le Fort II osteotomy, distraction osteogenesis as an alternative to traditional osteotomies followed by immediate repositioning and stabilization can be considered.

An advantage of the Le Fort III osteotomy is the ability to improve the sagittal projection of the lateral orbit and zygomatic body, thereby correcting exorbitism and zygomatic hypoplasia. The disadvantage of this approach is the limitation in downward and forward movement.
movement owing to the potential for creating enophthalmos or hypoglobus secondary to the associated changes to the orbit. As such, the technique is limited to management of sagittal and vertical central midface deficiency. Lengthening the central midface can be accomplished with the Le Fort II osteotomy, but at the cost of uncorrected zygomatic hypoplasia and exorbitism.

In this technical note, the authors describe a detailed technique for correction of exorbitism with simultaneous correction of central midface vertical and sagittal deficiency.35,36 The technique involves a combination of a Le Fort III osteotomy with a Le Fort II distraction and has not been previously described in detail elsewhere. The Le Fort III osteotomy allows for repositioning and fixation of the zygomas to correct lateral hypoplasia and exorbitism and maintains the globes in this more functional position. The Le Fort II distraction allows for movement of the central midface independent of the lateral orbits and zygomas, allowing sagittal and vertical correction without orbital distortion. With the medial canthus of the eyelids attached to the Le Fort II segment and the lateral canthus attached to the stable lateral orbits, the differential movement of this technique can have a favorable effect on palpebral fissure orientation.

All guidelines in the Declaration of Helsinki were followed during this study. Institutional review board approval was obtained for this work. Written consents were obtained for the use of patients’ photographs.

Description of Technique

LE FORT III OSTEOTOMY AND DOWNFRACTURE

A Le Fort III osteotomy is performed first (Fig 1A). An orotracheal intubation or existing tracheostomy is used to establish a secure airway for the procedure. The procedure begins with exposure of the upper midface through a coronal incision. The dissection is subperiosteal, with elevation of the anterior half of the temporalis muscles bilaterally as part of the composite scalp flap down to the inferior orbital rims and anterior aspect of the zygomatic arch. With reflection of the temporalis muscle, the zygomatic arch is cut with a reciprocating saw just behind the zygomatic body. Then, stepped bilateral osteotomies are made through the lateral orbit using a piezoelectric saw, from the frontozygomatic suture into the inferior orbital fissure. A small osteotome is used intraorbitally to cut from the inferior orbital fissure and along the orbital floor to the uncinate process posterior to the lacrimal fossa. Next, a piezoelectric saw is used to cut across the nasofrontal junction and continued along the medial orbital walls behind the lacrimal fossa to join the orbital floor cuts. Then, an osteotome is placed from the temporal fossa underneath the orbit into the anterior edge of the inferior orbital fissure. The osteotomy continues inferiorly just underneath the skull base along the posterior wall of the maxillary sinus to the pterygomaxillary junctions to create a pterygomaxillary separation in continuity with the orbital cuts. Then, a septal osteotome is used to separate the midface from the nasofrontal junction to the posterior nasal spine. Downfracture of the facial skeleton is performed carefully from the skull base with manual pressure and then fully mobilized with Rowe-Kiley forceps (Fig 1B).

ZYGOMATIC REPOSITIONING

Using the Rowe-Kiley forceps, the right lateral orbital step osteotomy is transposed and fixated with 1.5-mm titanium plates to advance the zygomatic body and inferior orbital rim 5 to 7 mm anteriorly and 3 to 4 mm superiorly for optimal enophthalmos correction (Fig 1C). Then, an upper gingival labial sulcus incision is used to provide subperiosteal exposure of the maxillary buttress lateral to the infraorbital nerve and foramen but with care taken not to release the zygomatic retaining ligament (MacGregor patch) to avoid compromising vascularity to the zygoma. The repositioned orbito-zygomatic complex is released from the remainder of the Le Fort III segment using a piezoelectric saw intraorally, with the osteotomy located lateral to the infraorbital nerve, and continued into the orbital floor to join the transverse orbital floor cut. In this manner, the right zygoma is
separated from the central midface (Fig 1D). Then, the Rowe-Kiley forceps are used to reposition, fixate, and release the left orbito-zygomatic complex in a similar fashion (Fig 1E). This staged repositioning is important to avoid strain across the weak zygomaticomaxillary suture, which can occur if simultaneous repositioning is attempted.

**FIGURE 3.** Le Fort II distraction with zygomatic repositioning treatment of Apert syndrome facial dysmorphology. A, Preoperatively, the patient exhibited relative vertical impaction of the central face with upward medial canthal slant, short nasal length, and deep nasolabial creases. There also was a central forehead concavity after remodeling of fronto-orbital advancement in infancy. There was a dual concavity in the B, sagittal and C, coronal planes. *(Fig 3 continued on next page.)*


LE FORT II DISTRACTION AND CUSTOM COMPUTER-ASSISTED DESIGNED/COMPUTER-ASSISTED MANUFACTURED FOREHEAD IMPLANT PLACEMENT

After completion of the zygomatic repositioning (ZR) and Le Fort II osteotomy, a custom onlay forehead implant can be placed, if needed, for contour irregularities, such as in many cases of Apert...
syndrome (Fig 1F). It is important to anticipate bony step deformities that can occur along the Le Fort II osteotomies after a large-magnitude movement. Small triangles of bone can be removed at the inferior orbital rim and the nasofrontal root to smooth the contour in anticipation of the future distraction movement (Fig 1F).

A lateral canthopexy is performed to re-secure the ligament to the posterolateral orbit. A microblade is used to cut through the lateral retinaculum percutaneously and then 2 Keith needles are placed on the superior and inferior aspects of the retinaculum, passed through the periosteum, grasped with 3-0 polydioxanone (PDS; Ethicon Inc, Bridgewater, NJ) suture, and passed through the periosteum. Then, these sutures are passed through 2 separate drill holes in the non-repositioned portion of the lateral orbit at the level of the frontozygomatic suture and tightened. The medial canthus should remain attached to the upper portion of the mobile Le Fort

---

**FIGURE 3 (cont’d).** D-F, One year after Le Fort II distraction with zygomatic repositioning with simultaneous placement of a forehead onlay implant, the previous stigmata were lessened through differential movement of the central and lateral face. Reprinted with permission from Hopper et al. 36

II segment. In this way, the downward movement of the central midface during distraction will lower the medial palpebral fissure relative to the secured lateral canthopexy, improving the reverse canthal tilt frequently observed in syndromic patients (Fig 2A, B). The exposed skull is irrigated thoroughly with antibiotic irrigation, the deep temporal fascia and muscle are reattached to drill holes in the lateral
and superior orbital rims, and the coronal incision is closed with interrupted 3-0 polyglactin sutures (Vicryl; Ethicon Inc) in the galea and a continuous 5-0 chromic gut suture for the skin.

Once the coronal incision is closed, the distraction splint is secured to the maxilla. The custom acrylic splint contains an embedded portion of a facebow with 2 arm loop extensions for halo traction. The
splint is fixated to the maxillary arch with 2 pairs of 26-gauge suspension wires (Fig 1G). The lateral wires are passed through drill holes through the lateral maxillary buttress inferior to the Le Fort II osteotomy. The medial wires can be passed through holes drilled in the lateral piriform rim in older patients or circum-maxillary wires can be passed with an awl through the piriform, underneath the nasal mucosa, and down through the palatal midline. Then, the intraoral wounds are irrigated thoroughly and closed with 4-0 chromic gut suture.

Orthodontic bone anchors are placed in the midline between the interdental spaces in the mandible with a vertical mucosal incision. The maxillary bone anchor is placed below the anterior nasal spline (Fig 1H) or can be placed on the splint itself. These bone anchors are used to allow for inferior vector control with elastics during distraction. A rigid external fixation traction device is applied with cranial pins, a vertical midface post, and a transverse activation arm with multivector control at the occlusal plane level. A 45° downward vector is established and the activation arms are secured to the oral traction splint using 24-gauge hand-tied wires (Fig 1H). The device is deactivated to initially compress the midface during the acute swelling phase.

FIGURE 5 (cont’d). D-F, The 4-year postoperative result shows improved midface and position after Le Fort II with zygomatic repositioning. (Fig 5 continued on next page.)

POSTOPERATIVE CARE AND DISTRACTION PROTOCOL

Patients are maintained sedated and intubated for 2 to 3 days in the intensive care unit. Once an air leak is confirmed around the endotracheal tube, extubation is initiated. Distraction is started after a latency period of 3 days and proceeds at a rate of 2 mm per day. The distraction vector is chosen to achieve a balance of desired nasal dorsal length, anterior vertical maxillary length, and maxillary occlusal plane angle. The endpoint of distraction is achieved when the desired overjet (usually an overcorrection of 3 to 5 mm) exists and the medial canthal position is neutral relative to the lateral canthal position. Once end activation is achieved, patients are kept in consolidation for 6 weeks before device removal.

FIGURE 5 (cont’d). G-I, Facial balance was subsequently achieved with a Le Fort I osteotomy and bilateral sagittal split osteotomies. His preoperative Apnea-Hypopnea Index was 154 and decreased to 58 postoperatively (decrease, 72.4%).

Indications for Le Fort II Distraction With ZR

APERT AND PFIEFFER SYNDROMES

Le Fort III advancement has been the long-held standard for treatment of midface deficiency in Apert, Pfeiffer, and Crouzon syndromes (Figs 2-4). However, the morphologic features of these conditions differ with regard to midface deficiency and orbital dysmorphology. Although Apert and Crouzon syndromes share the characteristic concave facial profile, the Apert deformity also is characterized by a sagittal nasomaxillary deficiency that is more pronounced than the lateral orbital deficiency, with concomitant vertical deficiency. The result is a midface morphology consisting of a short nasal dorsum, a retruded maxilla that is vertically deficient, with counterclockwise rotation of the occlusal plane, and unfavorable ratio of midface to orbital height. As such, treatment with Le Fort III advancement, which allows for appropriate positioning of the lateral orbit and infraorbital rim to the anterior cornea, will not completely correct the stigmata of the central midface deficiency. The Le Fort II distraction with ZR (LF2ZR) allows for correction of the deficiency in toto. The exorbitism can be corrected with anterior and superior positioning of the zygomas. Central midface distraction allows for sagittal correction (which is greater than that required for correction of exorbitism) and vertical lengthening (Fig 3). This differential movement of the central midface also has a beneficial effect on the medial canthus position, which is typically vertically compacted toward the nasofrontal junction in these conditions (Fig 2). The LF2ZR can be combined with simultaneous mandibular advancement in cases of severe mandibular advancement (Fig 4).

ACHONDROPLASIA

Similar to Apert syndrome, midface hypoplasia in achondroplasia is predominately characterized by central midface deficiency that is more profound than lateral deficiency. Many of these patients have sleep-disordered breathing related to airway obstruction. As such, midface advancement at the Le Fort III level, which might be adequate to correct malar hypoplasia, does not allow sufficient central midface expansion to expand the airway without creating severe exophthalmos. In these patients, independent movement of the zygomas relative to the central midface allows for appropriate malar positioning for facial balance and allows maximum airway expansion. A Le Fort I osteotomy and bilateral sagittal split osteotomies are often still required at maturity for further airway improvement and a stable occlusion (Figs 5, 6). Compared with isolated Le Fort III distraction, this strategy appears to be more effective for management of obstructive sleep apnea in achondroplasia.

CENTRAL MIDFACE RETRUSION FROM POSITIVE PRESSURE THERAPY

In some patients undergoing positive pressure therapy for treatment of obstructive sleep apnea, pressure phenomena from appliances can result in midface retrusion. The design of most masks results in maximum pressure exerted over the central midface, with retrusion that affects the nasomaxillary complex to a much greater extent than the zygomas. In these patients, the authors have found that independent central midface lengthening with simultaneous ZR (as needed for correction of zygomatic hypoplasia and facial balance) results in improved airway anatomy and correction of nasomaxillary deficiency (Fig 7). Although many of these patients might remain dependent on positive pressure therapy secondary to distal airway disease, the improved midface position decreases the pressure required and allows for better mask fit.
In patients with differential midface deficiency, segmental movements of the upper midface by LF2ZR can be used to address several morphologic problems. ZR allows for correction of exorbitism and improved facial balance. Le Fort II distraction allows for elongation of the nasal dorsum, effacement of deep nasolabial creases, inferior movement of the medial canthus, correction of maxillary vertical and
sagittal hypoplasia, airway expansion in patients with obstructive sleep apnea, and alteration of the maxillary occlusal plane. The ability to address these varied deficiencies in a comprehensive fashion makes the LF2ZR procedure a useful tool for correction of severe functional midface hypoplasia in which there are discrepancies in magnitude between the central and lateral components.
References

5. Tessier P: Total osteotomy of the middle third of the face for facio-stenosis or for sequelae of the Le Fort 3 fractures. Plast Reconstr Surg 48:533, 1971