Technical Strategy Using Piezosurgery to Correct Flattened Supraorbital Rim in Unilateral Coronal Craniosynostosis

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Abstract: The surgical correction of orbital deformities in patients with unilateral coronal craniosynostosis is challenging. Traditional techniques have shown the persistence of orbital flattening. This study presents a new strategy for remodeling the compromised orbit, using the piezosurgery technique, which improves the orbital curvature.

Key Words: Craniosynostosis, operative technique, pediatric neurosurgery, ultrasonic bone cutting

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Unilateral coronal craniosynostosis describes the premature fusion of a single coronal suture, which occurs at a rate of 1 in 10,000 live births. Because growth perpendicular to the suture becomes restricted, patients with unilateral coronal synostosis characteristically demonstrate the ipsilateral flattening of the orbital rim and frontal bone. Vertical orbital dystopia can also occur, and the contralateral forehead may exhibit compensatory frontal bossing. Deviation of the nasal root of the face and the chin is also observed.[1–6]

Several techniques have been described to treat these deformities. Classical techniques include frontal bone overlay, lateral canthal advancement, and tongue-in-grove techniques.[2,7–11] However, long-term evaluation of the postoperative period often reveals recession and flattening of the supraorbital rim, ipsilateral to the fused suture.[6,12–14]

This report describes an adapted and modified technique for correcting a compromised orbital rim in patients with unilateral coronal craniosynostosis, using a piezosurgical technique, which employs ultrasound to section hard tissues without harming the surrounding soft tissues and performs precise and controlled sections in the bone.[15] This technique, which was developed in the last decade, revolutionized osteotomies in the spine and skull base and in maxillofacial surgeries.[15,16] Although studies have demonstrated the effectiveness and safety of this technique for pediatric neurosurgery during osteotomies, where it reduces bone bleeding, none have been published for its application in bone remodeling during craniosynostosis surgery.[15–21]

This study provides a practical surgical strategy for correcting a flattened orbital rim during frontalorbital advancement (FOA) using piezosurgery during the remodeling of the compromised orbit.

METHODS

Bilateral FOA was used to treat unilateral coronal craniosynostosis. Under general anesthesia, the patient was positioned in a dorsal supine position, with the head stabilized on a horseshoe-shaped headrest. A curved hemicoronal incision was made, using a Colorado needle with an electrocautery tip, and a subgaleal dissection was performed, with the pericranium maintained in situ. If the anterior fontanelle remained open, its borders were exposed, and the extradural space was dissected. A bilateral frontal craniotomy was conducted 2 cm posterior to the coronal suture (Figs. 1-2). For orbital bandeau osteotomy, a subperiosteal dissection was performed toward the frontozygomatic suture and orbital rim bilaterally. An osteotomy was initiated just above the nasion, using an ultra sound-activated device. The Mectron Piezosurgery system (Mectron Medical Technology, Carasco, Genova, Italy), also known as the piezosurgery bone scalpel, consists of a platform with a powered piezoelectric handpiece, operating with a functional frequency between 25 and 29 kHz and the tip makes micromovements ranging from 60 to 210 μm with 29,000 micromovements per second.[21] Thereafter, an osteotomy was made in the frontozygomatic suture, on the regular side and contralaterally, extending to the temporal region (Fig. 2). The dura mater was carefully separated to the inner

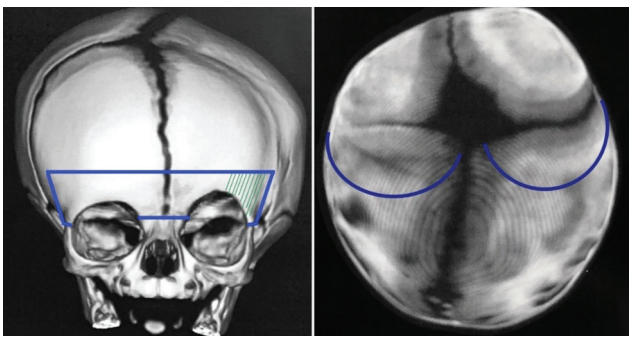

FIGURE 1. Computed tomography scan of a skull with unilateral coronal craniosynostosis, showing the planning of the orbit (blue lines, left) and the positions of the semicuts on the compromised orbit (thin green lines). The posterior limit of the craniotomy is posterior to both coronal sutures.

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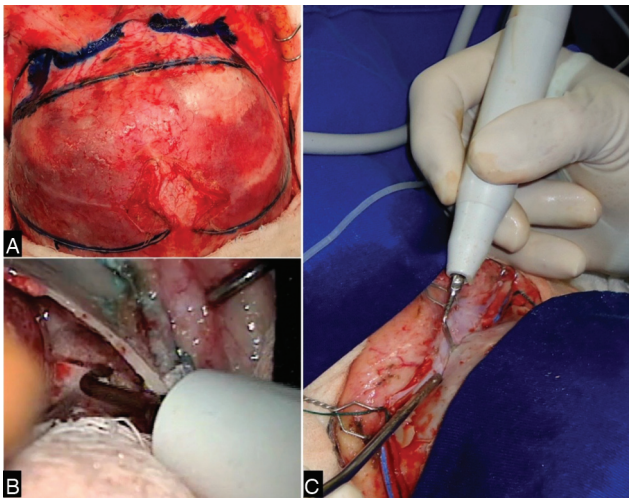

FIGURE 2. Bifrontal craniotomy and orbitectomy planning, using methylene blue dye (A). Osteotomy of the right orbit roof using piezosurgery (B). Osteotomy in the frontonasion region (C).

part of the median line, using bipolar forceps for cauterization, and osteotomies on the orbital roof were performed. Thus, the orbital bandeau was removed en bloc. The pediatric neurosurgeon performed several linear and parallel semi-incisions in the inner part of the flattened orbit, which is novel in bone remodeling, using the piezosurger bone scalpel device (Fig. 3). A bow was created by bending the supraorbital rim, using the fingers. The "greenstick" effect was observed and a new shape was created, similar to that of the regular side. To achieve FOA, the bandeau was first fixed using a small absorbable plate on the inner part of the midline. Two additional long plates were also used to fix the orbital bandeau to the temporal region. The frontal flap was fixed to the orbital bandeau using 2 absorbable plates that were positioned in an "X" shape (Fig. 4). No fixation was used for the posterior frontal bone. This technique is, therefore, practical and helps in the creation of a desirable shape during FOA (Figs. 5-7).

FIGURE 3. After orbitectomy, several semicuts were made behind the flattened orbit and the mini groove, shown by black arrows on the posteroanterior (above) and superior views (below).

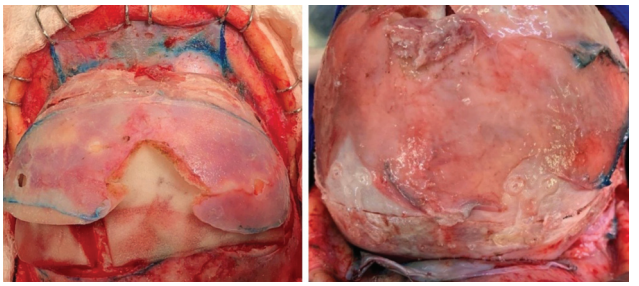

FIGURE 4. Frontalorbital advancement (FOA) and fixation by plates and absorbable screws. Front floatant and gel foam under the frontal flap in the superior view (left). Fixation of the orbital bandeau in the frontal bone by plates positioned in an "X" shape (right).

DISCUSSION

Orbital flattening correction to treat unilateral anterior craniosynostosis can be difficult and the deformity often persists due to the difficulty in creating orbital curvature. The present technique is similar to the technique described by Knoll et al, for bowstring canthal advancement, where a bifrontal parietal cranioplasty is performed with unilateral orbital rim advancement and the orbital curvature is created using intracranial kerfs.[12] Despite excellent cosmetic findings, the risks associated with this procedure include broken orbital bones during kerf generation, which can produce gaps in the inner part of the orbit. At this point, en bloc FOA and piezosurgery bone scalpel can facilitate this technique. The

FIGURE 5. A girl presented with the classical findings of left early coronal suture closure, with right nasal deviation, slight upper left eye displacement, and right frontal bossing (A, frontal view; C, left oblique view). Six months postoperatively, she displayed symmetry of the eyes and the recovery of nasal displacement, in the front view (B), and left frontal expansion, observed in the top view (D).

FIGURE 6. Evolution of the upper eyebrow in a girl treated with the piezosurgery variant technique, showing complete recovery 6 months postoperatively (right).

piezosurgery bone scalpel can provide selective and micrometric cuts, due to microvibrations at the surgical tip, which helps perform thin osteotomies with minimal bone loss.[17] We observed that the thin semicuttings made on the back side of the compromised orbit facilitate the remodeling of this bone. The recommendation is to provide approximately 10 parallel semicuttings in the inner part of the bandeau to allow the remodeling of the orbital rim (Figs. 1 and 3).

The piezoelectric technique has been applied to pediatric neurosurgery in the past decade and several successful applications have been described, such as craniotomies, spinal osteotomies, orbital decompression, endoscopic-assisted craniosynostosis surgery, and bone harvesting and splitting, owing to the safety, precision, and ease of manipulation.[15–17,19–21] Here, this technique was used for precise and controlled cutting in anterior coronal craniosynostosis. This is the first report of the use of the piezosurgery bone scalpel for creating several controlled fractures to facilitate bone remodeling. Nonetheless, care should be taken by surgeons to avoid overcutting and control of the device is needed to achieve molding. A learning curve is required for achieving the skills to perform these procedures within an adequate time.[17]

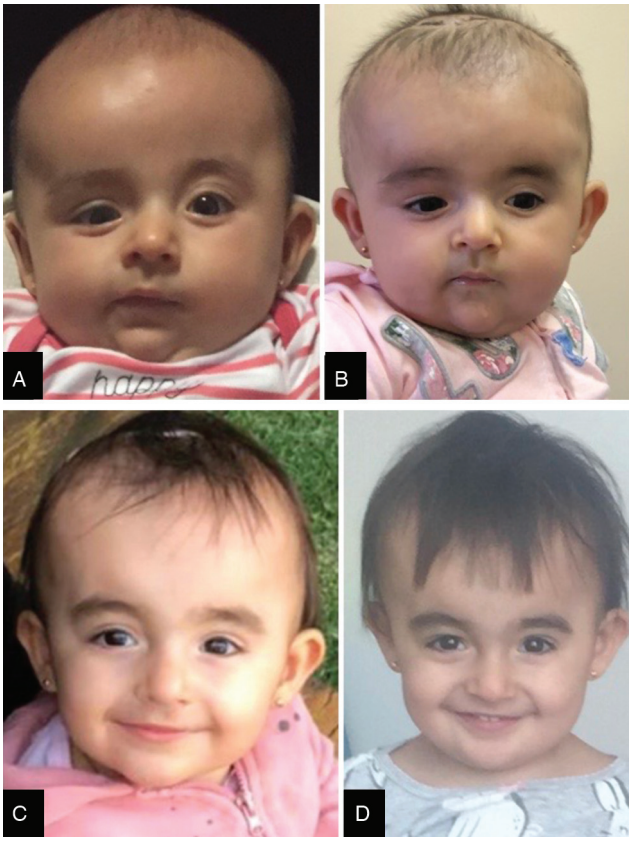

FIGURE 7. Severe eye and face asymmetry associated with the left coronal closure in a girl treated at 3 months of age. The preoperative period showing a pronounced upper position of the left eye and nasal dislocation (A). Postoperative evolution depicting the complete recovery of the eye position after 1 month (B) and facial symmetry after 6 months (C) and 1 year (D).

The necessity for unilateral or bilateral deformity correction when advancement is performed to treat unilateral coronal synostosis is debatable.[8–10,22] A meta-analysis reported that these techniques have similar outcomes and complications, although a trend toward better cosmetic outcomes, as distraction procedures, is observed.[7] However, the advantage of bilateral correction is that all deformities can be corrected and intracranial expansion is possible. For the present technique, better orbital remodeling can be achieved by combining bilateral correction with piezosurgery orbital remodeling (Figs. 5-7).

Endoscopic strip craniectomy and postoperative helmet therapies are limited to infants younger than 4 months but show results comparable to bilateral FOA in terms of supraorbital symmetry and improved facial symmetry and midline deviation, as demonstrated by the comparative morphometric research conducted by Tan et al.[23] The persistence of face asymmetry, following the performance of open surgical approach, is demonstrated by Gabrick et al, who performed an analysis of the asymmetrical face, orbit, and nasal root features, using 3-dimensional photographs, and found significant persistent asymmetry in the middle third facial region, the orbit, and the nasal root among school-aged patients who have undergone surgical corrections for unilateral coronal synostosis.[24] The endoscopic approach is minimally invasive technique, with reduced blood loss, shorter length of stay, and shorter procedure duration.[23,25,26] However, in our experience, bilateral FOA can also be combined with measures, such as using an electrocautery tip to open the skin, controlling all blood sources in the scalp, and the nondetachment of the pericranium, to minimize bone bleeding. Additionally, piezosurgery during orbitectomy and orbit remodeling can be used in infants older than 3 months of age, to achieve facial symmetry, with the early recovery of the orbital position and nasal deviation (Figs. 5-7).

The absence of a long outcome is the limitation of this study. Follow-up was done for no more than 1 year so it was not possible to evaluate if the flat orbital relapsed. Nevertheless, this study describes a piezosurgery technique for correcting unilateral coronal craniosynostosis to achieve desirable cosmetic results in a short follow-up.

In conclusion, the use of piezosurgery in remodeling the supraorbital rim improves FOA during unilateral coronal craniosynostosis treatment.

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