Frontoorbital advancement by gradual distraction

Technical note

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A substantial number of patients with coronal synostosis who undergo frontoorbital advancement still require additional surgical treatment to correct increased intracranial pressure or unsatisfactory craniofacial structure. However, frontoorbital advancement currently requires elevation of the frontal as well as the orbital bone, which can result in a fragile dura mater and partial resorption of the advanced bone. Thus the dura is easily torn by dissection and the advanced bone is further resorbed and deformed during repeated craniofacial operations. To avoid these drawbacks and to create an easier second surgical treatment via the intracranial approach, a new technique for frontoorbital advancement is presented. In this technique frontoorbital bone is advanced as a single unit, without elevation from the underlying dura, by means of gradual distraction. The details of the technique and an illustrative case are reported.

KEY WORDS • frontoorbital advancement • gradual distraction • coronal synostosis • distraction osteogenesis

For the past two decades, frontoorbital advancement and cranial vault remodeling have been performed at an early age in patients with coronal synostosis in the hope that this type of surgical approach would result not only in improvement in craniofacial function and structure, but in increased satisfactory growth and development of this anatomical region. However, a substantial number of patients who undergo frontoorbital advancement still require secondary surgical treatment for increased intracranial pressure or unsatisfactory craniofacial structure. This is particularly true in patients with syndromic craniosynostosis, more than 20% of whom reportedly have required repeated frontoorbital advancement and/or cranial vault reshaping. Monobloc, facial bipartition or Le Fort III osteotomy is often required later for correction of midface deformities.

The present frontoorbital advancement procedure requires elevation of both frontal and orbital bones. This can result in advanced bone that is partially resorbed and brittle, bony spicules that pierce the dura, and convoluted dura mater that is herniated through the inner table of the skull. In a second operation performed via the intracranial approach, the dura is easily torn during calvarectomy and the bone that is advanced is further resorbed and deformed. If the frontal and orbital bones could be advanced during the initial operation without elevation from the dura, it would be much easier during the second procedure to complete the craniotomies and dissect the dura free from the inner table of the skull and cranial base. A shorter operating time and decreased blood loss could also be anticipated. In the current report we describe a technique in which frontoorbital bone is advanced by gradual distraction without elevation from the dura.

Distraction Osteogenesis

Distraction osteogenesis, first applied to clinical use by Codivilla and popularized by Ilizarov, has become a standard technique for reconstruction of orthopedic limb deformities. In the field of maxillofacial surgery, the technique has been successfully used by McCarthy, et al., for lengthening the mandible. Midface and cranial distractions have also been reported in recent years. The advantages of distraction osteogenesis are: 1) the need for bone grafts is obviated; and 2) there is a concomitant expansion.
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of overlying soft tissues. The current disadvantages of the technique include: 1) an external scar results; 2) another operation is required for device removal; 3) the length of treatment is relatively long; and 4) there is a possibility of infection at the site of device anchoring.

Illustrative Case

This 4-month-old girl presented with brachycephaly, which had been recognized at birth. Physical examination revealed protuberant superior frontal and squamous temporal bones and a retropositioned supraorbital ridge, flattened occiput, and widely open anterior fontanel. Premature closure of the bilateral coronal suture and the harlequin deformity of the sphenoid wings were demonstrated radiographically (Fig. 1). There were no abnormal findings in the patient’s extremities or trunk. We diagnosed the deformity as bilateral coronal synostosis for which frontoorbital advancement was indicated. Because we found no signs of increased intracranial pressure, we postponed the operation until the patient reached 10 months of age.

Surgical Technique

The operation was performed with the patient supine. Through a coronal incision, the anterior scalp flap was elevated in the supraperiosteal–subgaleal plane to the supraorbital ridge, flattened occiput, and widely open anterior fontanel. Premature closure of the bilateral coronal suture and the harlequin deformity of the sphenoid wings were demonstrated radiographically (Fig. 1). There were no abnormal findings in the patient’s extremities or trunk. We diagnosed the deformity as bilateral coronal synostosis for which frontoorbital advancement was indicated. Because we found no signs of increased intracranial pressure, we postponed the operation until the patient reached 10 months of age.

The operation was performed with the patient supine. Through a coronal incision, the anterior scalp flap was elevated in the supraperiosteal–subgaleal plane to the supraorbital ridge. At approximately 1 cm above the supraorbital rims, a transverse incision was made in the periosteum and dissection continued along the subperiosteal–subperiosteal plane down to the infraorbital rims. The temporal muscles were separated from the squamous portion of the temporal bones bilaterally.

The osteotomy lines were almost identical to those of conventional frontoorbital advancement except for the lack of supraorbital osteotomy and tongue-in-groove osteotomy. Burr holes were placed at the pterion just behind the sphenoid wing and at the lateral side of the anterior fontanel bilaterally. Another burr hole was placed on the glabella 1 cm above the nasion.

Osteotomy was performed using a motor-driven saw and rongeurs to connect the burr holes, taking care not to dissect bone and dura. At the lateral portion of the orbital roof, where the osteotomy was most difficult, we performed a 7- to 10-mm-wide strip craniectomy by using rongeurs at the pterion to ease access to the greater wings of the sphenoid bone (arrow). Right: Custom-made internal distraction devices are placed in the bregma and bilateral temporal regions. After 5 days, distraction is initiated.

Distraction Protocol

After 5 days, the distraction was initiated. The distraction devices were activated two times daily, approximately 0.5 mm per activation. In this manner, the desired advancement was achieved in 13 days. The devices were left in place for 3 additional weeks. The distraction devices were removed after general anesthesia had been induced in the patient. Surgical access was made through the initial incision.

Postoperative Course. The patient’s postoperative course was uneventful and good cosmetic results were achieved (Figs. 3 and 4).

Discussion

The main purpose for development of the present procedure is to avoid convolution of the dura mater and resorption of the advanced frontoorbital bone. The present technique has the added merit of obviating the need for bone grafts and skin grafts, which are sometimes required in extremely advanced cases. Furthermore, gradual distraction expands not only the frontoorbital bone, but also the attached dura, without leaving extradural dead space (Fig. 5). Moore, et al.,10 reported that frontoorbital

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advancement in infants with Apert’s syndrome is associated with persistence of an extradural dead space for up to 4 weeks, potentially leading to persistent deformity, relapse, and repeated surgery. It can be speculated that gradual distraction would minimize these problems.

On the other hand, drawbacks of the technique include: 1) the inability to reshape the frontoorbital bone; 2) the necessity of an additional operation to remove the distraction devices; and 3) the possibility of extradural hematoma formation during distraction. Close observation using computerized tomography scanning would be necessary to guard against the latter risk.

The present schedule for distraction was based on the protocol of McCarthy, et al., for mandibular distraction, in which bone regeneration occurs from the cut edges of the mandible. However, there are two possible modes of bone regeneration in patients in whom frontoorbital bone distraction is performed. Bone regeneration may occur from the cut edges of the calvaria (distraction osteogenesis) or from islands within the dura mater. In the latter situation, no latency period is needed before distraction and a higher rate of distraction can be expected. Further investigation into the distraction schedule is needed, including examination of the latent phase between completion of the distraction and removal of the devices.

It is a subject of discussion whether this technique should be used in all patients requiring frontoorbital advancement. Although it is well documented that a significant percentage of patients with syndromic craniosynostosis require repeated frontoorbital advancement, a much
smaller percentage of patients with nonsyndromic craniosynostosis require reoperation. The drawbacks of this technique may outweigh its benefits in patients with nonsyndromic craniosynostosis. Taking into consideration the difficulty of distinguishing between syndromic and nonsyndromic craniosynostosis in very young patients, further studies will be needed to determine the applicability of this technique.

Conclusions

Frontoorbital advancement by gradual distraction has a potential advantage over the current standard procedure because: 1) resorption of the advanced bone and deterioration of the dura are minimal; 2) distraction expands not only the frontoorbital bone, but also the attached dura, thus minimizing relapse; 3) distraction also expands the overlying scalp, thereby obviating the necessity of skin grafts, which are sometimes required in extremely advanced cases; and 4) distraction eliminates the need for a bone graft.

Although elucidation of the mechanism of bone regeneration and development of a three-dimensional remodeling distraction device are mandatory, frontoorbital advancement by gradual distraction could become a new treatment for patients with coronal synostosis, particularly those with syndromic craniosynostosis.

References

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![Figure 5. Axial computerized tomography scan obtained during distraction showing almost no extradural dead space between the frontal bone and the dura mater.](image-url)