Orbital rim and malar advancement for unilateral coronal synostosis in the older pediatric age group

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The authors describe a technique for lateral orbital rim and malar advancement in patients in the older pediatric age group. The technique makes use of a strip craniotomy containing the supraorbital margin, greater sphenoid wing, and temporal bone, with en bloc inclusion of the lateral orbital rim, zygoma, and malar prominence. The method allows a contoured yet stable construction secured in a tongue-in-groove fashion with plate-and-screw fixation. It creates a symmetrical reconstruction of both frontal and lateral orbital aspects in the untreated or inadequately treated older plagiocephalic child with orbital dystopia. The accompanying malar recession is likewise corrected.

KEY WORDS • coronal synostosis • malar prominence • orbit • craniosynostosis • zygoma

OLDER children with untreated or inadequately corrected unilateral coronal synostosis commonly display a flattened or recessed superolateral orbital contour and an underdeveloped malar prominence ipsilaterally. In the past, the traditional strip craniectomy along the course of the coronal suture, sometimes combined with morcellation in the frontal bone, succeeded in symmetrically realigning the craniofacial skeleton in only 62% of cases; these results were usually only achieved when the procedure was performed within the first 3 months of age. The horizontal advancement techniques of Tessier, later refined and altered by numerous authors, provided consistently better cosmetic results. In the midst of these operative refinements, however, problems persisted in the older pediatric population; these included lateral orbital wall step-off, malar hypoplasia, resorption of interposed osseous struts with collapse, inadequate fixation, and palpable fixation hardware.

We have applied a means of advancing the orbital rim and zygoma in cases of unilateral coronal synostosis which is similar to a method described by Persing, et al., for the treatment of metopic synostosis, and have found the results to be excellent in the older child and adolescent. The planning and evaluation of more recent operations have improved with the advent of three-dimensional surface reconstruction of the craniofacial skeleton using computerized tomography (CT). The three-dimensional perspective overcomes the visual shortcomings of two-dimensional radiographic imaging and facial photography in which asymmetries of the skeleton are not readily appreciated.

Our experience with untreated or inadequately treated unilateral coronal synostosis and orbital dystopia in 18 patients aged 3 years or over and their follow-up monitoring from 18 to 36 months have resulted in certain modifications of reported techniques. The modified procedure produces a stable reconstruction of the recessed fronto-orbital contour and advancement of the hypoplastic malar prominence. This report outlines our surgical method, providing examples of pre- and postoperative three-dimensional CT surface reconstructions of the craniofacial skeleton.

Clinical Material and Methods

Case Material

In a 2-year period, 18 patients, aged 3 to 23 years, underwent surgical correction of a unilateral fronto-orbital skeletal recession and orbital dystopia due to coronal synostosis. The female: male ratio in this group was 7:11. The deformity appeared on the right in 11 cases and on the left in seven. Eight patients had been operated on previously at or before 7 months of age for coronal synostosis. Of these patients, six had undergone...
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**FIG. 1.** Three-dimensional computerized tomography surface reconstructions of the craniofacial skeleton of a 7-year-old boy who had undergone a left frontal morcellation for unilateral coronal synostosis at 4 months of age: frontal view (left), 45° right rotation (center), and 45° left rotation (right). The left lateral fronto-orbital region is recessed with elevation of the greater sphenoid wing. The left lateral and inferior orbital rim is thinner with less prominence of maxillary structures.

Bilateral coronal strip craniectomies to the level of the pterion with insertion of silicone U-channel implants, in one unilateral frontal morcellation and contralateral coronal craniectomy had been performed (Fig. 1), and in another the right frontal bone had been released by craniotomy but not the supraorbital bar (Fig. 2). Two patients had Crouzon's disorder and had undergone bilateral coronal craniectomies with U-channel implants but still presented with unilateral fronto-orbital reces-
sions and dystopia.

**FIG. 2.** Left: Preoperative three-dimensional computerized tomography surface reconstructions, lateral view, of the craniofacial skeleton of a 9-year-old boy with right unilateral coronal synostosis. Right: Same study and view, 2 years following reconstruction. The zygoma and maxillary structures are seen to be advanced with the lateral and superior orbital rims.

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FIG. 3. Stages in the craniofacial reconstruction for unilateral coronal synostosis in the older child and adolescent. A frontal craniotomy allows definition of the supraorbital margin, which is raised en bloc with a posterior flange of sphenoid and temporal bone along with the lateral and inferior orbital rims and zygoma. After this segment is remodeled, it is advanced and rotated in a tongue-in-groove fashion into a slightly overcorrected position and the frontal bone is replaced.

Pre- and Postoperative Imaging

A preoperative three-dimensional surface reconstruction of the craniofacial skeleton is obtained routinely from high-resolution axial CT scans and accompanying software. The extent of previous surgery is readily seen and asymmetries of the facial skeleton in the region of the lateral canthus and malar prominence are assessed (Fig. 1). Intercanthal distance (nasion to lateral canthus), orbital position, orientation and volume, zygoma length, and bone mass of the malar prominence can be ascertained on rotated views of the skeleton. Although postoperative CT reconstructions are not routine, they may be used to verify the extent of advancement (Fig. 2).

Operative Technique

A bicoronal skin incision is made with extension to the level of the zygomatic arch on the involved side. The frontal scalp and pericranial tissue are reflected anteriorly in separate layers and secured while the temporalis fascia and muscle are split in the direction of the muscle fibers and reflected anteroinferiorly and posteriorly as separate flaps. The lateral and inferior orbital bone margins are defined. Along the superior orbital ridge, the periorbita which is continuous with the stripped pericranium is separated from the orbital roof. The supraorbital nerve and artery are often easily preserved by freeing them from their bone canal or groove; a minor osteotomy may facilitate this. A midline burr hole 1 cm above the plane of the supraorbital ridge is made and united with a second burr hole made beneath the superior temporal line behind the orbital process of the frontal bone. A small frontotemporal craniotomy is performed with its lateral margin extending directly posteriorly from the second burr hole a distance of 4 to 5 cm. The frontopolar, orbital, and temporal dura is stripped from the inner cranial surface and the periorbita and orbital contents are depressed, allowing visualization of the entire supraorbital margin which may be released from the midline laterally with the aid of a sagittal saw and osteotomes. The lateral aspect of this craniotomy is extended into the sphenoid and temporal bones creating a lengthy strip of bone which is finally released in an en bloc fashion with inclusion of the lateral and inferior orbital margins and a segment of the zygoma (Fig. 3). The pericranial flap may be used to cover the opening in the frontal sinus if one exists; it is sutured to the dura mater, closing over the sinus. The bone is now contoured by partial osteotomies of its surface so that its frontal and lateral canthal shape corresponds to the opposite side. When replaced, the posterior extent of the segment is advanced and rotated along its groove to bring the lateral canthal portion of the involved orbit forward, and is secured at its most ideal location in a slightly overcorrected position with plate-and-screw fixation (Fig. 4). The frontotemporal bone flap is similarly reshaped and positioned over the contoured supraorbital margin. In the event of resorption of interposed bone, the new construct will hold its position with its plate-and-screw fixation. With this osseous advancement, a defect is created at its posterior margin. This is filled by one or more split-thickness bone grafts harvested from the bone flap or obtained further posteriorly from the parietal bone. The temporalis muscle and fascia are closed separately in the usual manner with the superior fascial edge sutured to the bone.

Operative Results

The follow-up period for these 18 patients ranged from 18 to 36 months. A stable and very satisfactory symmetrical realignment of the craniofacial skeleton was achieved in all patients, irrespective of prior surgery or the age at presentation to the craniofacial unit. Despite a rather disfiguring unilateral fronto-orbital recession, the patients presented here did not demon-
FIG. 4. Operative photograph showing lateral orbital rim (closed arrow) secured in an advanced position with plate-and-screw fixation (open arrow) of the posterior osseous flange. The frontal craniotomy (asterisk) has been repositioned and secured with wire, leaving a posterior defect which is filled with split-thickness cranial bone graft.

strate a significant contralateral frontal and parietal bulge of the cranial vault to warrant contralateral reconstruction. Forward displacement of the lateral orbital rim varied individually to achieve Pronto-orbital symmetry and ranged from 8 to 12 mm, with slight overcorrections of 2 to 3 mm reserved for the youngest children to achieve symmetry at a later age with further contralateral skeletal expansion.

Antibiotic coverage in the perioperative period was routine and no infections occurred. No intracranial or intraorbital complications arose; specifically, a mechanically induced diplopia secondary to clot formation or ocular malalignment did not occur. Forehead and scalp sensation was preserved in all cases with successful sparing of both supraorbital and supratrochlear nerves. One case of weakness of the frontalis muscle was noted postoperatively and ascribed to retraction injury of the facial nerve branch during exposure of the lateral orbital rim.

Reoperation presented technical difficulties in some patients because of dural adhesions to both scalp and bone. In one such case, a potentially serious complication arose when blood loss during a rather tedious reopening was sufficient to reverse a left-to-right intracardiac shunt. This resulted in abrupt arterial oxygen desaturation with cardiac arrhythmia and transitory loss of vital signs. The operation was aborted but was successfully completed in a second stage 1 week later without complication.

Discussion

The stimulus for development of the craniofacial skeleton in the region of the orbit in early postnatal life arises from accelerated growth of both the cerebral hemisphere and globe with its attendant surrounding soft tissues. By the age of 3 years, as much as 85% of the adult size of the orbit has been achieved while 80% of cerebral growth has occurred. In severe unilateral coronal synostosis, osseous restraints overcome this natural pattern of craniofacial development mediated by soft tissue growth and result in flattening of the ipsilateral frontal bone, elevation of the greater sphenoid wing, foreshortening of the orbit, and hypoplasia of the infraorbital maxillary structures. Using three-dimensional axial CT reconstructions, Marsh, et al., have shown that the roof and floor of the orbit and the anteroposterior dimension of the maxilla ipsilateral to the coronal synostosis are shorter than the same contralateral structures. Similarly, serial axial surface areas of the orbit ipsilateral to the synostosis were smaller than those contralaterally. The width of the lateral orbital wall overlying the commonly expanded middle cranial fossa (greater wing of the sphenoid) was decreased compared to the contralateral bone. The spectrum of impending skeletal abnormalities can often be corrected readily in the neonate with coronal synostosis by release and flotation of the forehead and orbital margins, allowing for subsequent soft-tissue mediated skeletal development in a manner approximating the normal state.

The C-shaped orbital rim osteoplasty without fixation to the cranial base described by Persing, et al., offers considerable promise for full facial skeletal development with maturity.

Previous attempts at correction of unilateral coronal synostosis have concentrated largely upon forehead and lateral canthal advancement techniques, with little attention given to the inferior orbital margin and midfacial skeleton. In some cases, this has resulted in a deficiency in facial skeletal growth and an asymmetry in orbital development. When combined with a suboptimal surgical result in the forehead, this may lead to considerable cosmetic deformity with craniofacial asymmetries and orbital dystopia.

Few significant unilateral coronal synostoses in early neonatal life go untreated in the present day. There is, however, a relatively larger population of children and adolescents who, during the past 3 to 10 years, have been operated on for this condition and in whom the cosmetic results have not been ideal. In this older age group osseous fixation becomes necessary because of the relative lack of further expansion from soft-tissue enlargement. For this reason a slight overcorrection in advancement of the orbital rim is desirable to attain eventual symmetry with the maturation of skeletal growth.

The use of three-dimensional axial CT surface reconstructions allows accurate preoperative assessment and measurement of canthal asymmetries, orbital volumes...
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and orientations, and osseous underdevelopment. Similar studies are rarely done postoperatively as the cosmetic results to date, after a 3-year follow-up period, have been excellent and well maintained. Injury to the globe or its surrounding neuromuscular apparatus has not occurred and, despite previous surgery, no cerebral injuries have resulted from reoperation.

Acknowledgments

The authors thank Ms. Ruth Cooper for the computer-assisted drawings and Mrs. Wendy Ryan for preparation of the manuscript.

References


Manuscript received April 11, 1990. Accepted in final form July 16, 1990.

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