Floating C-shaped orbital osteotomy for orbital rim advancement in craniosynostosis: preliminary report

JOHN A. PERSING, M.D., JOHN A. JANE, M.D., PH.D., T. S. PARK, M.D., MILTON T. EDGERTON, M.D., AND JOHNNY B. DELASHAW, M.D.

Departments of Plastic and Reconstructive Surgery and of Neurological Surgery, University of Virginia School of Medicine, Charlottesville, Virginia

A method of lateral orbital rim advancement is described for periorbital deformities associated with coronal and metopic synostosis in infants. The technique offers the advantages of a smooth lateral rim contour and improvement in accompanying malar recession. In 13 patients with follow-up periods of up to 2 years following surgery, improved orbital contour has been appreciated. Further observation is warranted to determine whether this improvement will last into adulthood.

KEY WORDS  • craniosynostosis  • orbitoplasty  • metopic synostosis  • coronal synostosis  • zygoma  • orbit

SKULLS deformed by metopic, unilateral, or bilateral coronal synostosis result in diminished projection of the supralateral orbital rim. In addition, individuals with coronal and to a lesser extent metopic synostosis have reduced anteroposterior projection of the zygoma (Fig. 1). Although many methods have been described to correct the orbital rim abnormalities, the lateral canthal advancement technique is presently the most widely practiced. There are two problems with this technique, however. First, with this procedure, the advancement of the supralateral orbital rim ends at the level of the frontozygomatic suture. This method does not, therefore, correct the accompanying malar recession seen in patients with coronal and metopic synostosis. Second, advancement of the supralateral rim at the level of the frontozygomatic suture may create a stepoff deformity in the lateral orbital rim.

To address these problems, we have revised the previously described lateral canthal advancement procedure and orbitoplasty procedure. We have further modified the technique according to the age of the patient and the type of craniosynostosis deformity present. The guiding principle for younger patients (< 3 years of age) is to allow the orbital rim to “float” forward with subsequent brain and globe enlargement. In children older than 3 years, the rim is fixed securely in the desired position. Modifications in the orbitoplasty procedure are made according to suture pathology; these are oriented to address the excess bulging present in the squamous temporal region in patients with coronal synostosis and the temporal “hollowing” in patients with metopic synostosis.

Fig. 1. Three-dimensional computerized tomography scan of a patient with left-sided coronal synostosis showing recession of the zygoma and lateral orbital rim ipsilateral to the fused suture.
Operative Technique

Coronal Synostosis (Early)

In children less than 3 years of age exhibiting coronal synostosis, the C-shaped lateral orbital rim advancement is begun by performing a bifrontal craniotomy. The lateral aspect of the sphenoid wing ipsilateral to the fused suture is characteristically misshapen and displaced anterosuperiorly. It is removed by rongeur to free any remaining basal stenosis of the "coronal ring" or frontosphenoid suture. This approach gives access to the anterior temporal region, where a separate craniotomy is performed to remodel the temporal bone. The abnormal convexity of the temporal bone is reduced, and the remodeled bone is secured to the basal cranial vault and temporal bone.

An osteotomy line is placed approximately 5 mm posterior to the superior orbital rim in the orbital roof (Fig. 2). Care is taken to avoid injury to the globe by prior in-continuity subperiosteal and subperi orbital dissection over the orbital rim. The globe is gently retracted. An osteotomy is performed in the lateral orbital wall, taking a wide segment (7 to 8 mm) through the level of the frontozygomatic suture, so as to maintain structural stability of the rim in this region (Fig. 3). The mid-body portion of the zygoma is cut obliquely and connected with an osteotomy in the floor of the orbit, which extends medially to a point just lateral to the zygomaticomaxillary suture (Fig. 3). The superior and inferolateral orbital rim is "green-stick" fractured forward to the degree desired, where it is held in position by placement of cranial vault bone grafts harvested from the parietal region and wedged in the oblique osteotomy line through the zygoma. The bone grafts are secured only to the posterior aspect of the advanced lateral wall (Figs. 4 and 5). The orbital rim and the zygoma are not bridged with wire so as to allow minimal resistance to further advancement of the rim by the
growing globe and frontal lobe of the brain. The orbital rim is therefore allowed to “float” forward with the frontal bone graft. The temporalis muscle is advanced forward and attached to the lateral aspect of the orbital rim.

Coronal Synostosis (Late)

The approach in older patients (> 3 years) with orbital rim deficiency associated with coronal synostosis is similar to that for the younger patient. The same bifrontal craniotomy-osteotomy line is used except that more secure fixation of the interposition bone grafts at the level of the zygoma is performed. Additional bone grafts in the orbital roof may further add to the security of the advanced orbital rim. Even in older patients, a modification in orbital rim placement is necessary to approximate the normal growth and development in the region. A child aged 3 years will require placement of the orbital rim in a slightly overcorrected, advanced position.

Metopic Synostosis (Early)

The initial approach to patients with lateral orbital rim recession and metopic synostosis accompanied by bone depression in the temporal region is much the same as for patients with coronal synostosis. A bifrontal craniotomy is performed, and the temporalis muscle is elevated from the temporal fossa. The orbital roof osteotomy is placed, as in coronal synostosis, 5 mm posterior to the orbital rim. Thereafter, the approach differs from that in coronal synostosis; the lateral portion of the greater wing of the sphenoid bone is split vertically, and, together with the squamous portion of the temporal bone, it is elevated as a flange attachment to the lateral orbital rim. This flange attachment is reshaped with the Tessier rib-bender to a more convex form, thereby correcting the narrowing in the temporal region (Fig. 6). No attempt is made to secure the orbital rim and its lateral border; rather, parietal calvarial bone grafts are wedged in the oblique zygoma osteotomy line. The bone grafts are secured anteriorly to the orbital rim (not posteriorly to the posterior zygoma and arch).

Metopic Synostosis (Late)

Patients older than 3 years of age exhibiting metopic synostosis are treated similar to younger patients, as described above, except that the bone grafts are placed both in the orbital roof and the lateral zygoma, with fixation encompassing both borders of the split zygoma (Fig. 7). Slight overadvancement may be necessary to adjust for remaining regional growth, as in patients with coronal synostosis.

Discussion

The frontal bone (superior orbital rim) and orbital roof are derived from paraxial mesoderm, which also forms part of the capsule covering the forebrain; the lateral wall and the floor of the orbit develop from the visceral mesoderm of the maxillary process. The growth of the orbit, like the brain, is accelerated early in life. In normal development, the orbit which initially closely encircles the globe increases rapidly in size from 18 x 21 mm at birth to 28 x 32 mm (height x width), or 80% to 85% of adult dimensions, by 3 years of age.15
Orbital rim advancement in craniosynostosis

In coronal and metopic synostosis, however, the development of the orbit including its rim is deficient. The etiology of this growth restriction is unclear, but the amount of bone deposition from the multiple frontal bone and the three zygomatic ossification centers appears to be reduced. In an effort to correct the periorbital abnormalities, we have adapted the floating-forehead concept, as described by Marchac and Renier for cranial vault abnormalities, and the lateral canthal advancement technique described by Hoffman and Mohr. In young infants with significant brain and cranial growth potential remaining, the C-shaped orbital rim osteoplasty without fixation to the cranial base restores the normal orbital rim projection and offers reduced resistance, at least initially, to further orbital rim advancement as the brain and globe grow. The smooth lateral contour of the rim provides for a more accurate approximation of the normal orbital rim anatomy. In 13 patients this improved rim contour has persisted for up to 2 years following surgery; however, further follow-up monitoring will be necessary to determine whether this improved effect will last through childhood into adulthood.

In children with craniosynostosis who are treated initially at an advanced age (> 3 years of age), the free-floating concept of Marchac and Renier may not be applicable. As more than 80% of brain/globe enlargement has already occurred by this age, the impetus for further supralateral rim advancement is slight. In such cases, the concerns about rim fixation may outweigh those related to growth as long as the rim is placed in an overcorrected, advanced position.

Modification of the orbital rim advancement technique is desirable as well, according to the type of sutural pathology and skull deformity present. Patients with coronal synostosis frequently have a protuberant squamous temporal bone ipsilateral to the fused suture, associated with malformations of the cranial base. We believe, as others do, that we should remove the possible basal stenosis of the "coronal ring" to achieve the overall optimum skull shape in coronal synostosis. However, there is no apparent reason to do this for patients with metopic synostosis, as basolateral synostosis is not a prominent feature of this type of sutural pathology. Therefore, individualization of technique is warranted.

In order to "prop" forward the bone profile in patients with metopic synostosis, a posterolateral flange of sphenoid and squamous temporal bone is allowed to remain attached to the orbital rim. Increased lateral temporal projection is further aided as the orbital rim is advanced anteriorly, because the rim rotates outward about the anterior rim attachment and pivot points.

This orbital rim osteotomy technique, with modifications, has proved successful in the initial management of orbital rim deformities associated with metopic and coronal synostosis. The ultimate effect on increased periosteal dissection and more extensive osteotomy on growth of the region is not yet determined. Early results do not show a reduced potential for periorbital growth or impairment of early tooth eruption; rather, they show an improvement in symmetry and normalization of appearance. To date, no additional discernible intraorbital injury to the globe or extraocular muscles has been appreciated.

Aside from the possibility of greater risk to vision, the disadvantages of this operative procedure are the extra time required for the additional dissections and the increased blood loss related to osteotomy into the body of the zygoma. Neither of these problems has been troublesome to this point.

Acknowledgments

The authors wish to thank Craig Luce for his drawings and Lucille Staiger for preparation of the manuscript.

References


Manuscript received April 21, 1989.
Accepted in final form August 31, 1989.
Address reprint requests to: John A. Persing, M.D., Department of Plastic and Reconstructive Surgery, Box 376, University of Virginia Health Sciences Center, Charlottesville, Virginia 22908.