

## Advancement-onlay: an improved technique of fronto-orbital remodeling in craniosynostosis \*

Steven R. Cohen<sup>1</sup>, Henry K. Kawamoto, Jr.<sup>2</sup>, Fernando Burstein<sup>4</sup>, and Warwick J. Peacock<sup>3</sup>

<sup>1</sup> Section of Plastic and Reconstructive Surgery, University of Michigan, Taubman Center No. 2130, 1500 East Medical Drive, Ann Arbor, MI 48109-0340, USA

<sup>2</sup> Division of Plastic and Reconstructive Surgery and <sup>3</sup> Division of Neurosurgery, UCLA Medical Center, Los Angeles, California, USA

<sup>4</sup> Division of Plastic and Reconstructive Surgery, Scottish Rites Children's Hospital, Atlanta, Georgia, USA

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**Abstract.** Eighteen patients with nonsyndromic craniosynostosis underwent fronto-orbital remodeling with an advancement-onlay technique. The mean age of the infants was 5 months (range=2–11 months) when the procedure was performed for the following indications: unilateral coronal synostosis ( $n=10$ ); bilateral coronal synostosis ( $n=3$ ); metopic synostosis ( $n=2$ ); and multiple craniosynostoses ( $n=3$ ). The technique consists of (1) unilateral or bifrontal craniotomy, (2) superior orbital rim recontouring and advancement, and (3) frontal bone graft rotation and onlay. Posteriorly, the frontal bone graft is left "floating," while anteriorly, rigid fixation with microplates and screws has supplanted wire osteosynthesis. The use of rigid fixation prevents uncontrolled "float" of the forehead and eliminates the need for temporal struts. Follow-up time ranged from 6 to 60 months (mean=2.6 years). There were no serious postoperative complications. Surgical results were good to excellent in 94% of cases and poor to fair in 6%. Only 1 patient with a Kleeblattschädel deformity required major revision, while another patient with trigonocephaly underwent a minor, extracranial recontouring procedure. Supraorbital rim and/or forehead recession suggestive of relapse or initial inadequacy of anterior projection occurred in 3 patients (17%). Residual, mild contour abnormalities of the forehead and/or temporal regions were found in 5 cases. To date, no gross disturbances in craniofacial growth related to our method of rigid fixation have been observed and no clinically detectable resynostosis has occurred.

**Key words:** Advancement-onlay – Fronto-orbital remodeling – Craniosynostosis

Most authors would agree that in the absence of increased intracranial pressure, the goal of treatment of

craniosynostosis is to produce normal calvarial shape and facial dimensions [2, 9, 12]. Longitudinal, three-dimensional computed tomography (CT) studies of nonsyndromal solitary and bicoronal synostosis have shown normalization of endocranial anatomy, confirming the efficacy of cranio-orbital operations [5–8]. Lesser degrees of normalization occur in patients with multiple synostoses [5].

Improvement in exocranial or surface anatomy generally accompanies correction of osseous abnormalities. However, precise data quantifying postoperative changes in surface morphology are not yet available, making it difficult to compare the myriad of results reported by different centers [7]. In a two-center study, Bartlett et al. analyzed late results in 48 patients undergoing either unilateral or bilateral fronto-orbital remodeling for unilateral coronal synostosis [1]. Aesthetic outcome was good to excellent in over 75% of patients, regardless of the type of procedure [1]. However, on detailed inspection, they found residual irregularities of the ipsilateral temporal and/or lateral forehead in the majority of cases [1].

We, too, have observed less than ideal results, consisting of supralateral orbital rim and/or forehead recession in selected patients with nonsyndromic craniosynostosis. Concern about possible early relapse or initial inadequacy of anterior projection of the superior orbital bar led to the development of an improved and simplified technique: advancement-onlay.

The technique consists of a (1) unilateral or bifrontal craniotomy, (2) superior orbital rim recontouring and advancement, and (3) frontal bone graft rotation, remodeling, and onlay (see Figs. 2–8). The frontal bone is left "floating," free of any posterior fixation [3]. Anteriorly, where relapse, segment shifts, or cephalic "floating" may occur with closure of the coronal flap, rigid fixation with microplates and screws has supplanted wire osteosynthesis. Midline resection of the deformed metopic suture and cranial vault reshaping are performed for trigonocephaly and multiple synostoses, respectively.

In essence, our technique combines contemporary fronto-orbital remodeling with a "throw-back" to the

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Offprint requests to: S. R. Cohen

original onlay technique utilized by Rougerie [4]. Herein, we describe its application in 18 patients treated from 1985 to 1990 at the UCLA Medical Center.

## Materials and methods

Patients with craniosynostosis are seen in joint consultation by a plastic surgeon and pediatric neurosurgeon. Plain films of the skull and face are routinely ordered. CT scans are obtained to rule out underlying neurologic abnormality.

Like others, we prefer to intervene within the first 6 months of life and capitalize on early, rapid brain growth to promote calvarial expansion and remodeling [10]. Midface retrusion is treated secondarily at 4 to 6 years of age, at which time either a LeFort III or monoblock advancement is performed, depending on the morphology of the residual deformity.

## Types of deformities and operative techniques

### *Unilateral coronal synostosis (plagiocephaly)*

Our surgical approach consists of extended frontal craniotomy and superior orbital bar advancement (Figs. 2–4). Thus, rather than arbitrarily selecting either unilateral or bilateral orbital advancement and forehead reshaping, a frontal craniotomy is designed to encompass the ipsilateral flattened area, extending contralaterally to where the forehead appears normal (Fig. 4).

A superior orbital osteotomy is made approximately 1 cm above the orbital roof and carried across the midline to include the portion of the contralateral superior orbital rim that is recessed or otherwise deformed. Recently, we have angled the osteotomy superiorly in the vicinity of the future frontal sinus (sinus sparing osteotomy) to avoid compromise of its subsequent development (Fig. 2).

In milder cases of plagiocephaly, where contralateral bossing is limited and orbital deformation is negligible, the frontal craniotomy and orbital osteotomy are confined to the affected side. Thus, the bony cuts are tailored to the topography of the deformity (Fig. 3).

The use of rigid microplate and screw fixation has obviated the need for creating tongue-in-groove extensions into the temporal fossa. Temporal osteotomies are now electively performed to correct bony depressions and are not considered a necessity for stabilization of the superior orbital bony fragment.

Recontouring of the superior orbital rim is achieved by standard techniques. Incomplete vertical cuts and/or effacement of the bone on its posterior surface facilitate bending of the superior orbital bar. The recontoured rim is then symmetrically repositioned and secured with microplates and screws at the vertical limb of the superior orbital osteotomy and at the lateral orbital osteotomy (Fig. 2).

The detached frontal bone is remodeled and rotated to provide the best contour and then onlayed over the advanced superior orbital bar. Cutouts are made to correspond to the curvature of the superior orbital rim (Fig. 2). Microscrews sunk in a tandem (position) fashion secure the frontal onlay in place, adapting the underlying superior orbital bar to the onlay's shape. Posteriorly, the frontal bone graft is left "floating."

Prior to wound closure, the ipsilateral superior orbital roof is bone grafted, obliterating the "harlequin" configuration. The lateral canthus is resuspended if it had been detached during the procedure. The contralateral brow is lifted to equalize the level of the eyebrows.

### *Bilateral coronal synostosis (brachycephaly)*

Our operative approach to patients with bilateral coronal synostosis consists of bifrontal craniotomy with bilateral recontouring and

advancement of the superior orbital bar (Fig. 5). Temporal extensions are made not so much for purposes of fixation, but rather to improve the contour of the temporal region. The advanced superior orbital rims are fixed with microplates and screws at the frontonasal junction and at the lateral orbital osteotomies of the rims. The frontal bone graft is either recontoured or rotated and trimmed to establish the most normal-appearing forehead. Cutouts for the superior orbital margins are then performed and the frontal bone graft is onlayed over the advanced superior orbital bar. Microscrews secure the onlayed graft to the underlying rim. Residual temporal prominences can be resected and repositioned or "barrel staved" [11] and infrafractured. Posteriorly, the recontoured frontal bone is left floating.

### *Metopic synostosis (trigonocephaly)*

Correction of trigonocephaly involves a modification of conventional techniques (Fig. 6). A frontal craniotomy is performed, the metopic suture is resected, and the superior orbital rim is removed. Extensive recontouring of the midline portion of the rim is necessary to correct its wedge shape. Also, during its recontouring, the superior orbital bar is often fractured in half. Therefore, we prefer to resect the deformed metopic suture in its entirety, down to and including the midline of the superior orbital rim.

The superior portion of the orbital rim is then translocated laterally (Fig. 6). An appropriately contoured portion of the frontal bone graft is selected to reconstruct the forehead and onlayed over the supraorbital rim, spanning both halves (Fig. 6). Microplates and screws are used to fix in position, thereby reconstituting the superior orbital bar, while maintaining the new interorbital distance. If only a greenstick fracture of the superior orbital bar is required to correct the lateral recession, the fixation technique mentioned above may be all that is necessary. However, if extensive advancement of the lateral portion of the superior orbital bar is required, fixation with microplates and screws is added at the osteotomies of the lateral orbital rims (Fig. 6).

As in the other repairs, the frontal bone graft is left free of posterior fixation. Great lengths are taken, however, to rectify the bitemporal depressions associated with this deformity.

### *Multiple synostoses*

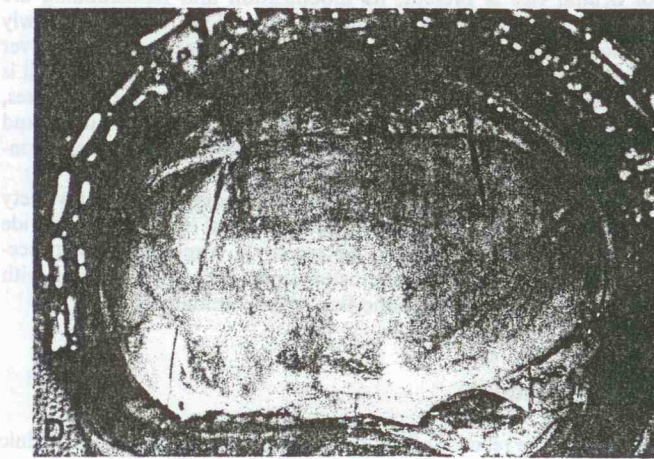
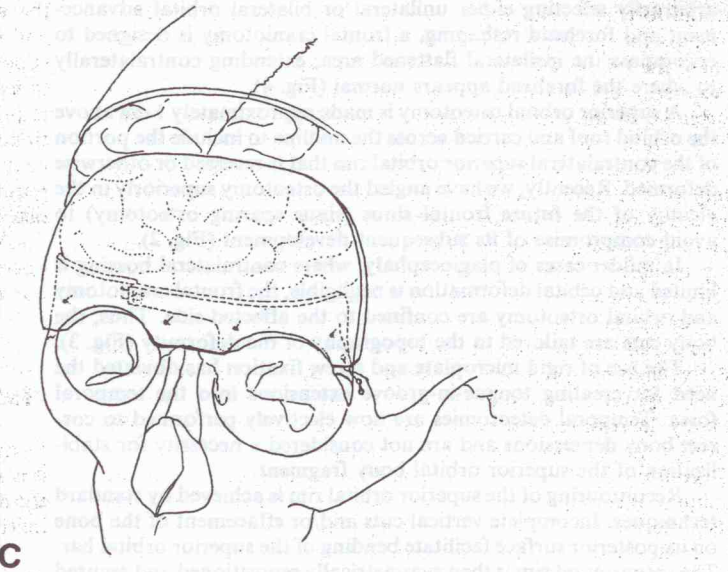
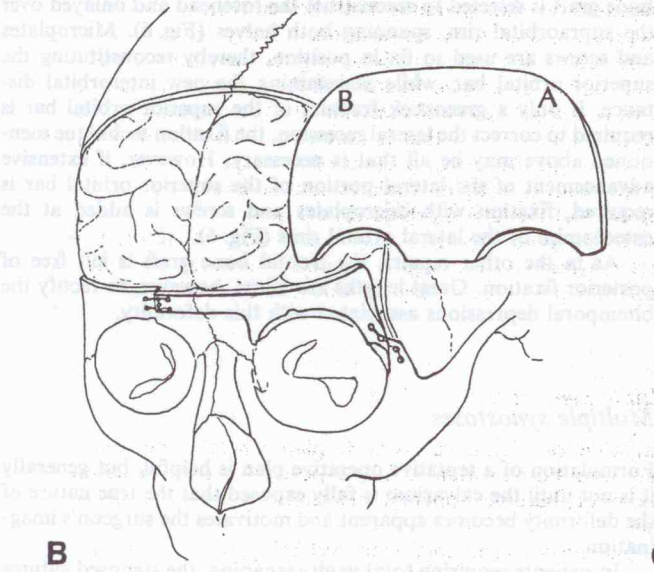
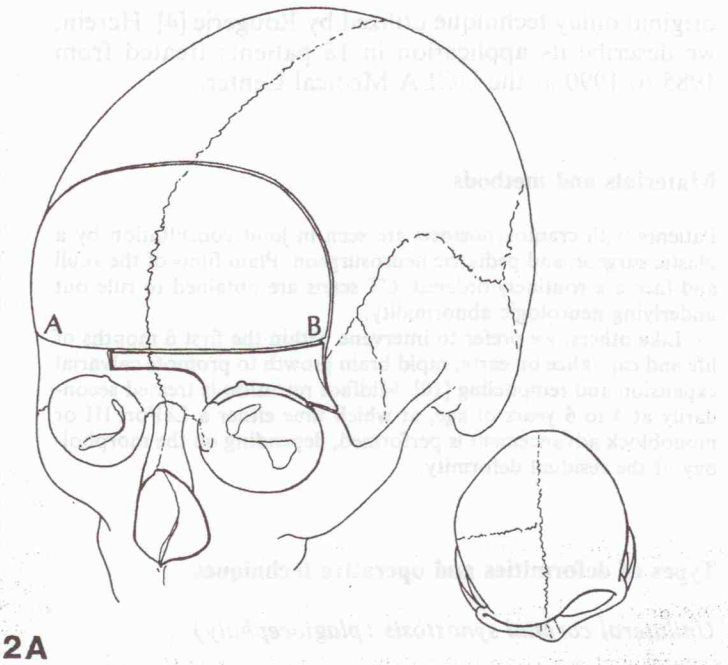
Formulation of a tentative operative plan is helpful, but generally it is not until the calvarium is fully exposed that the true nature of the deformity becomes apparent and motivates the surgeon's imagination.

In patients requiring total vault reshaping, the stenosed sutures are first resected. If abnormal angulation or recession of the superior orbital rim is present, its mobilization and repositioning are indicated in addition to vault reshaping (Figs. 7–9). The newly contoured frontal bone graft can then be cut out and onlayed over the advanced rim. If recession or angulation of the rim is mild, it is a wasted exercise to mobilize the superior orbital bar. In these cases, the abnormal angulation of the rim can be bevelled or burred and a new superior orbital rim can be fashioned from the onlayed frontal graft.

Total cranial vault reshaping can be accomplished by a variety of techniques, but ultimately relies on surgical ingenuity to provide the best contour. Currently, we employ a combination of procedures, including barrel stave osteotomies [11], bone bending with wedge osteotomies, and bone-flap switch techniques.

## Study population

Review of the records of the UCLA Craniofacial Anomalies Clinic from January 1985 to January 1990 disclosed 65 patients with syn-



**Fig. 1.** Five-month-old patient with multiple synostosis following conventional fronto-orbital advancement. Note the uncontrolled vertical "float" of the forehead with recession of the superior orbital rim.

**Fig. 2A-D.** Operative approach to unilateral coronal synostosis. **A** Frontal sinus sparing osteotomy. Note vertex view showing plagiocephalic deformity of the calvarium. **B** Superior orbital rim advanced, frontal bone graft recontoured with orbital rims cutout. **C** Frontal bone graft onlayed and secured with microplates. **D** Intraoperative photograph showing advancement of the superior orbital rim and onlay of the frontal bone graft. Note placement of microplates and screws.

