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Long-term follow-up of one-piece fronto-orbital advancement with distraction but without a bandeau for coronal craniosynostosis: Review of 26 consecutive cases

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ABSTRACT

To adopt the traditional fronto-orbital advancement technique designed by Tessier in the application of a distraction technique, the frontal bone flap should be detached before the distraction. In order to maximize the merit and potency of the distraction, we have applied the "one-piece cranioplasty" technique without bandeau for coronal craniosynostosis. Our new surgical technique was used to treat 10 unilateral and 16 bilateral craniosynosis patients between February 2005 and August 2014. Satisfactory results were achieved in all patients. An average distraction of 25.2 mm was possible without detachment from the dura mater. The average cephalic index (width/length × 100) decreased from 98.3 to 89.9 after 3 months postoperatively and was maintained at 88.6 until 6.4 years on average after the operation. In 10 unilateral coronal synostotic patients, the endocranial angulation of the anteroposterior axis was improved from 165.3° to 174.8° after 3 months postoperatively and was maintained at 174.5° until 5.8 years on average after the operation. Our present findings indicate that the novel one-piece fronto-orbital advancement with distraction approach appears to be less invasive and is suitable for correcting single-suture coronal craniosynostoses, except for the complex form of this condition, even at longer follow-up intervals.

1. Introduction

The gold standard for surgical correction of both unilateral and bilateral coronal craniosynostosis remains the standard bilateral fronto-orbital advancement and reshaping based on the "Bandeau" technique developed by Tessier. This procedure consists of a bilateral frontal craniotomy for suture release and decompression, combined with the creation of a "supraorbital bar" as a bilateral orbital complex by bilaterally osteotomizing the orbital roof (anterior cranial base), supraorbital ridge, and upper lateral orbital rim (Cohen et al., 1991; Fearon, 2008; Marchac and Renier, 1987; Posnick, 1996). This technique is followed by a bilateral advancement and remodeling of the frontal region as well as the orbital region bilaterally, which is then rigidly fixed in position with the supraorbital bar to the face (at the fronto-zygomatic region and the fronto-nasal region) and the reconstructed forehead to the supraorbital bar.

Meanwhile, distraction methods in craniomaxillofacial surgery can be applied successfully in the correction of craniosynostosis (Bartlett et al., 1990; Bradely et al., 2006; Cohen et al., 2000; Hirabayashi et al., 1998; Kobayashi et al., 1999). However, the distraction technique with a supraorbital bar or bandeau has some pitfalls. The adoption of the traditional fronto-orbital advancement technique in the application of the distraction technique requires that the frontal bone flap be detached before distraction. This action might diminish the advantages and potencies of the distraction in terms of maintenance of the blood supply and the remodeling capacity of the frontal bone flap (Gosain et al., 2003). Therefore, to maximize the merit and potency of the distraction, we developed the one-piece fronto-orbital advancement technique without a

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supraorbital bar and published several articles detailing this approach and its effects on endocranial morophology (Choi et al., 2009, 2010). Since 2005, we have successfully applied the "one-piece cranioplasty technique" for 26 cases of coronal craniosynostosis. We herein present our long-term follow-up findings for these 26 consecutive cases of one-piece fronto-orbital advancement without bandeau for the treatment of the non-complex form of coronal craniosynostosis. We also describe our currently evolving techniques, including outcomes and complications.

2. Material and methods

Our new surgical technique was used to treat 10 unilateral and 16 bilateral craniosynosis patients between February 2005 and August 2014. Multiple-suture synostotic patients were excluded. The patients were of Asian background and had a mean age of 1.9 years (range 0.3–7.3 years). Surgery involved a zigzag bicoronal incision followed by subgaleal dissections. Subperiosteal dissections were made 2 cm above the supraorbital rim. A mark was made for a burr hole of approximately 1.0–1.5 cm at the merging point of the sphenofrontal, zygomatico-frontal, and temporal sutures, corresponding to the pterion (Figs. 1 and 2) (Hirabayashi et al., 2002). The size of the burr hole varied slightly between cases. A coronal osteotomy line was marked on the imaginary coronal suture fusion line. A coronal osteotomy was then performed, and a burr hole was created. Next, a one-piece osteotomy along the designed nasofrontal, orbital roof, zygomatico-frontal, and sphenofrontal sutures was performed using a 5 mm guarded osteotome, taking great care not to injure the dura mater. The greater and lesser wings of the sphenoid bone were clearly visible through the burr hole on the pterion, which is considered the most difficult feature of the one-piece osteotomy (Fig. 1). Although the heights of the greater and lesser wings differed according to each patient, we found that using a preoperatively prepared rapid prototype (RP) skull model to estimate the approximate heights and locations was very helpful (Choi and Kim, 2015). A small malleable retractor was used to guard the dura from the osteotome. No osteotomy was undertaken in the supraorbital area. The completeness of the osteotomy was verified by ensuring there was movement of the fronto-orbital one-piece segment. After the osteotomy procedures, distraction devices (Leibinger Co. & Martin, Co., Tuttlingen, Germany) were applied to the temporal or parietal area to advance the fronto-orbital bone according to the specifics of each deformity. Detachment from the dura was confined to within 1 cm of the osteotomy line. The surgical site was inspected for any dural injury or bleeding focus, after which the scalp was repaired using typical techniques. A typical distraction protocol was used, which first involved a 7-day postoperative latent period followed by a period of 1 mm of distraction per day. The consolidation period ranged from 8 to 12 weeks, after which the devices were removed and the osteogenesis and contour were assessed. We analyzed the serial change of the cephalic index and skull base axis at long-term follow-up, as well as the operation time, the amount of transfusion required, complications, bony defects, and final outcomes with retrospective chart review.

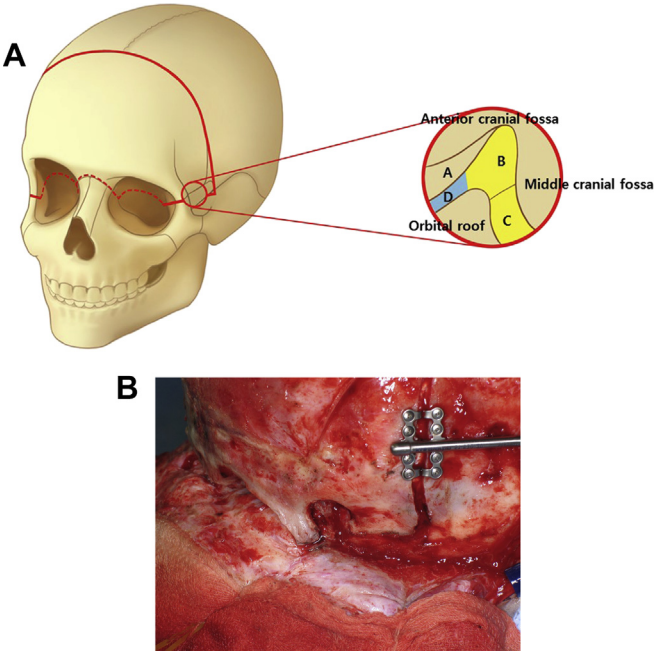

Fig. 1. (A) Illustrations of the pterion. A: Lesser wing of sphenoid. B: Greater wing of sphenoid. C: Temporal bone. D: Frontal bone. (B) The greater and lesser wing of the sphenoid bone were visible through the burr hole on the pterion, the drilling of which is considered the most difficult feature of a one-piece osteotomy without detachment from the dura. Although the heights of the greater and lesser wing differed in each patient, we found it very helpful to use a preoperatively prepared rapid prototype (RP) skull model to estimate the approximate heights and locations.

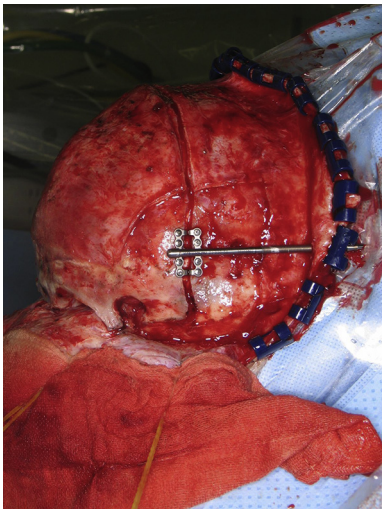

Fig. 2. One-piece fronto-orbital osteotomy. One-piece cranioplasty without supraorbital bar osteotomy using a small temporal burr hole. A <1 cm burr hole on the pterion. The greater wing of the sphenoid is visible through the burr hole.

3. Results

Satisfactory results were achieved in all 26 unilateral and bilateral coronal suture craniosynostotic patients in our current study who were treated by one-piece cranioplasty without bandeau (Figs. 3–5). None of these cases required a transverse osteotomy to make a supraorbital bar. Furthermore, an average distraction of 25.2 mm (range: 18–41 mm) was possible without detachment from the dura mater (Tables 1–3). The average cephalic index (width/length × 100) decreased from 98.3 (range: 86–119.5) to 89.9 (range: 77.9–103.7) after 3 months postoperatively and was maintained as 88.6 (range: 78.5–102.5) until 6.4 years on average after the operation (Fig. 6). Normal values for the cephalic index range from 0.75 to 0.84 (Dvoracek et al., 2015). Our treatment approach resulted in less bleeding and a shorter surgery time (plastic surgery = 114.7 min; total = 358.2 min) compared to traditional methods (plastic surgery = 190 min; total = 430 min). Transfusions were unnecessary in nine patients, and an average of