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Case Report

Occipitofrontal switch for correction of anterior plagiocephaly planned through virtual mock surgery

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ABSTRACT

Background: Unilateral coronal synostosis causing anterior plagiocephaly can result in restricted brain development and severe facial deformities. Various surgical procedures have been described for the correction of this deformity. Cranial vault remodeling, however, is associated with several complications. Occipitofrontal switching is a novel technique which utilizes a part of the contralateral occipital bone to reconstruct the frontal area. This is the first such case reported from India and first report where virtual mock surgery has been utilized for precision and improving outcome in this elegant procedure.

Case Description: A 5-year-old girl presented with left anterior plagiocephaly. 3D image of her skull was reconstructed using Geomagic Freeform software (3D Systems, Rock Hill, SC). Measurements were accurately drawn and the procedure was practised virtually before performing the occipitofrontal switch on the patient. There were minimal blood loss and postoperative morbidity. One year follow-up of the patient showed optimal correction of the defect in the forehead region, symmetrical shape of the frontal and occipital region and symmetrical brows.

Conclusion: The technique of occipitofrontal switch for correction of anterior plagiocephaly is an elegant procedure with good functional and aesthetic outcome.

Keywords: 3D model, Occipitofrontal switch, Plagiocephaly

INTRODUCTION

Craniosynostosis occurs due to premature fusion of one or more sutures of the cranial vault.[1] Unilateral coronal synostosis can result in frontal and occipital plagiocephaly.[8] Of these, anterior plagiocephaly, if uncorrected may result in restricted brain development and severe facial deformities.[9] Various surgical procedures have been described for the correction of this deformity including barrel stave osteotomy, frontoparietal suturectomy, and fronto-orbital advancement.[4] Cranial vault remodeling, however, is associated with several complications.[11] Occipitofrontal switching is a novel technique which utilizes a part of the contralateral occipital bone to reconstruct the frontal area.[5] Because one of the problems of anterior plagiocephaly is the inherent deficiency of the affected frontal bone, this technique is beneficial as it brings a new bone into the area and thus helps combat the growth deficiency. Our patient had anterior plagiocephaly. Using virtual planning and virtual mock surgery, we planned the exact area of the occipital bone to be switched into the frontal area.

This is the first such case reported from India and first report where virtual mock surgery has been utilized for precision and improving outcome with this elegant procedure.

CASE PRESENTATION

A 5-years-old female child presented to our outpatient department with facial asymmetry. On examination, she had flattening of the forehead and elevation of the eyebrow on the left side [Figure 1]. Clinical diagnosis of left-sided unilateral coronal synostosis was made. 3D computer tomography scan confirmed the diagnosis and revealed a bulged region over the diagonally opposite occipital bone. There were no features suggestive of raised intracranial tension. The child had no associated deformities.

Preoperative planning

Based on the 3D computer tomography picture a virtual 3D model of the skull was made using the software INVIVO 5 and the model was imported to a virtual clay modeling design software in a haptic based environment, Freeform Geomagic. (3D Systems, Rock Hill, SC) [Figure 2].

Virtual planning and mock surgery was done by the following steps

First, the left fronto-orbital bar was measured preserving the supraorbital and supratrochlear nerve [Figure 3a]. Second, the deformed hemifrontal triangle was marked enclosed by point 3, 4, 5 making angle of 43.6 degrees with median plane [Figure 3b]. Third, a contralateral hemioccipital triangle was reconstructed enclosed by point 6, 7, 8 making an angle of 40 degrees with the coronal plane [Figure 3c]. This triangle was then transferred to the frontal region. Minor adjustments were made till there was optimal matching between the occipital triangle and frontal area. The occipital triangle was measured from fixed bony points and the measurements noted.

Surgery

After obtaining clearance from the anaesthesia team and written informed consent from the parents, patient was taken for occipitofrontal switch under general anaesthesia. Patient was placed in the supine position. Bicoronal incision was made which provided adequate exposure to the defective left frontal bone and the planned donor area on the right side occiput. Scalp flaps were raised. The markings obtained from the virtual 3D model were applied to the skull in the defective frontal area and the donor occiput region. Occipital triangle was harvested first followed by the frontal triangle. Curved bone obtained from the hemioccipital triangle was placed over the defective frontal region and secured with biodegradable plates and screws. The flat bone obtained from the defective frontal region was placed over the occipital region and similarly secured [Figure 4a]. Symmetrical correction was obtained in both frontal and occipital regions. The left fronto orbital bar was reconstructed by a biodegradable reconstruction plate using the template from the opposite side [Figure 4b]. Scalp flaps were sutured back. The surgery was completed in 150 min. Patient did not need blood transfusion or postoperative ICU care. There were no complications in the postoperative period. Patient was discharged on the 5th postoperative day.

RESULTS

The virtual 3D model helped in accurately predicting the curvature of the diseased site and thus helped in the markings at the defective frontal and the occipital region. This reduced the margin of error. The occipital bone fragment obtained was a perfect fit for the defect in the frontal area. This also helped in reducing the operative time. Since bioabsorbable plates were used for the fixing the bony triangles there would

Figure 1: Five years female with left unilateral anterior plagiocephaly

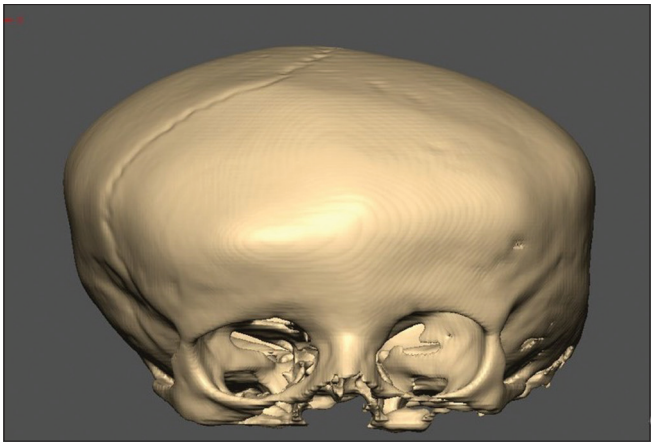

Figure 2: Virtual model of the skull

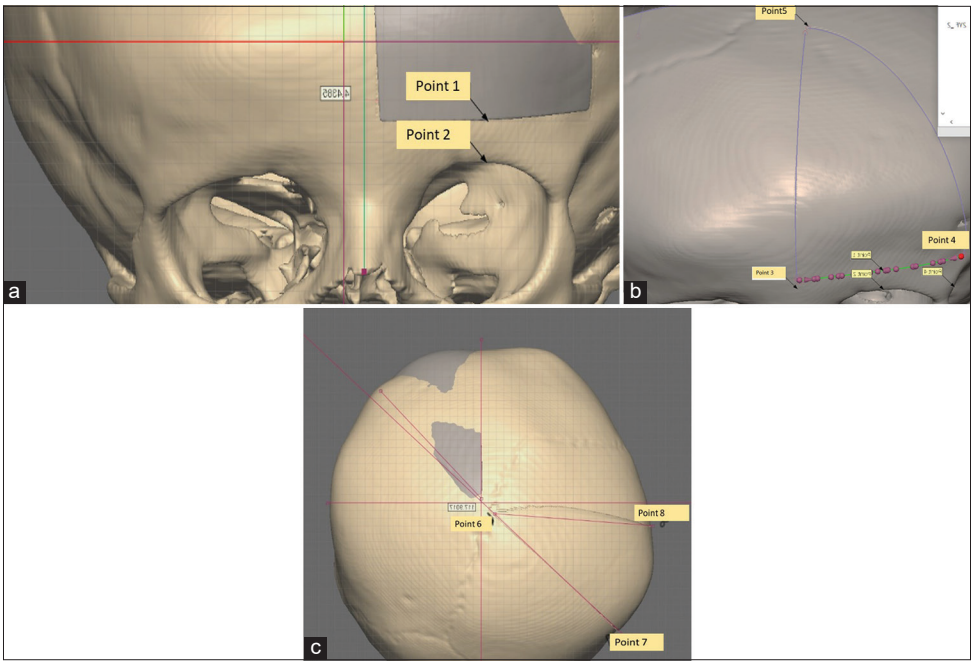

Figure 3: (a) Measurement of the left fronto orbital bar. (b) Marking of deformed hemifrontal triangle. (c) Reconstruction of contralateral hemioccipital triangle.

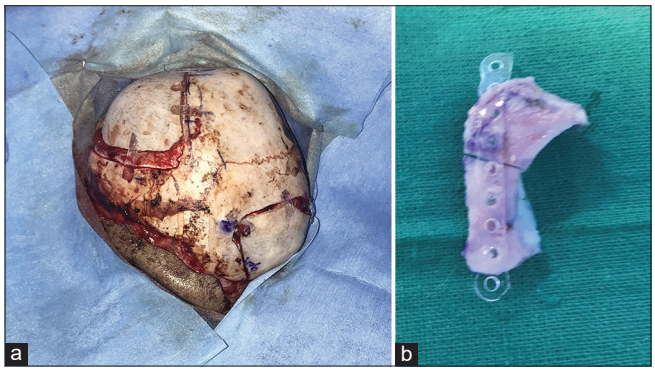

Figure 4: (a) Occipital triangle placed in the frontal region and frontal triangle to the occipital region. (b) The fronto orbital bar reconstructed with biodegradable reconstruction plate.

Figure 5: Follow-up after 1 year.

be no growth disturbance. The patient's parents were pleased with the outcome and cosmetic appearance. 1 year follow-up of the patient showed optimal correction of the defect in the forehead region, symmetrical shape of the frontal and occipital region and symmetrical brows [Figure 5].

DISCUSSION

The term plagiocephaly was coined by Virchow in 1851 based on the Greek term Plagio(slanted/oblique) to define individuals with unipartite flattening of orbit and frontal bone associated with scoliosis of face and skull. In anterior plagiocephaly, there is premature unilateral fusion of the coronal suture. The anterior cranial fossa is underdeveloped in these patients along with altered development of facial and cranial bones. This clinically manifests as flattening of orbit and frontal bone in the affected side. Skull and facial bone anomalies include homolateral advancement of the petrous bone toward the affected side, contralateral deviation of nasal pyramid and vomer, and compensatory growth of temporal bone and forehead of the opposite side.[3]

The goal of craniosynostosis surgery is to achieve a mesocephalic skull shape with adequate space for brain expansion.[10] This can be achieved by dynamic or static techniques. In older children, various static remodeling techniques are used.[4] Lannelongue and Lane defined the

first technique for correction of plagiocephaly in the later part of the 18th century in the form of strip craniectomy.[6,7] These techniques allowed cranial decompression but they did not correct the cosmetic deformity. In 1967 Tessier presented his landmark paper regarding cranial vault remodeling which is still the gold standard.[12] At present, there are various techniques such as supraorbital rim advancement, monobloc frontal bone advancement, and distraction osteogenesis .[11] Cranial vault remodeling, however, is associated with several complications including dural tear, significant blood loss and infections.[13]

In unilateral plagiocephaly, the unique technique of occipitofrontal switch allows the abnormal hemifrontal bone to be replaced by contralateral hemioccipital bone.[10] This has two advantage. First, it has been observed that there is a compensatory overgrowth in sutures that are adjacent to the fused suture.[8] Thus, there is an occipital bulge in case of anterior plagiocephaly which is conveniently utilized in this technique to compensate for the deformed and depressed hemifrontal bone. Second, there is decreased growth potential in the fused bony plate.[2] However much that bone is remodeled, it may never grow normally which is the reason for requirement of secondary corrections later on. By bringing a new bone into the area allows for the normal growth of the frontal region when the child grows up. Using biodegradable screw plate also helps in this matter as they do not hamper the bone growth.[8]

This unique technique has been described in only one published article.[10] Kim *et al*. had utilized clay model in planning the occipitofrontal switch. In our case, we did not 3D print the model but simply utilized a virtual modelling software to predict the markings. This helped in eliminating the significant cost of printing. We performed the mock surgery several times before attempting the actual procedure, thus improving the precision and ease of operability and resulted in less operating time with no requirement of transfusion. Thus, ours is the second published case of occipitofrontal switching, and first publication from India. This is also the first case where 3D virtual mock surgery has been used.

CT scan done 6 months postoperatively showed stable osteosynthesis. There were no complications in the postoperative period. At 1 year follow-up, the patient's parents were very much satisfied with the cosmetic outcome. The forehead, brow, and occiput were symmetrical. Long term follow-up of the patient is to be done to look for further aesthetic changes and graft resorption.

CONCLUSION

The technique of occipitofrontal switch for correction of anterior plagiocephaly is an elegant procedure with good functional and aesthetic outcome.

Acknowledgment

None.

Statement of ethics

Written informed consent was obtained from the patient's parents (father and mother) for publication of this case report and any accompanying images.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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