**Evaluation of Outcome of Fronto-Orbital Advancement in Patients of Craniosynostosis**

**Abstract**

**Background:** Craniosynostosis (CS) is the premature fusion of one or more cranial sutures, leads to abnormal craniofacial form and function. **This study aimed to** evaluate the cosmotic and functional outcome of fronto-orbital advancement in patients of craniosynostosis. **Methods:** This prospective study of 11 patients diagnosed with metopic and coronal cs. All studied cases were subjected to the following: Detailed history (age, gender and time of presentation), general evaluation (deformity of face) , ophthalmological evaluation by fundus examination and visual field and Degree of Exophthalmos Patients with intracranial pathologies were excluded from the study and neurological evaluation (manifestation of increased intracranial pressure) with suitable radiological investigations by CT brain including estimation of orbital volume (AP, horizontal and vertical) orbital rim.. **Results**: There was significant increase in vertical, horizontal, anteroposterior and orbital dimensions and volume 6 months postoperative when compared to preoperative & immediately postoperative. **Conclusion:**The primary indications for cranial remodeling with fronto-orbital advancement in cases of anterior calvarial (metopic and coronal) synostosis are twofold: the prevention of potential neurologic impairment and the enhancement of aesthetic improvements in skull shape. For many patients, the latter represents the primary motivation for seeking treatment. Deformities arising from craniosynostosis are best addressed through cranial vault reshaping, ideally at an early age, before calvarial bones have fully ossified. The measurement of orbital volume serves as an intuitive assessment of surgical improvement, making it a valuable indicator in the evaluation of fronto-orbital advancement outcomes.

**Keywords:** Fronto-Orbital Advancement; Craniosynostosis; Fascial deformity; Plagiocephaly.

**Introduction**

Craniosynostosis (CS) is the premature fusion of one or more cranial sutures, leads to abnormal craniofacial form and function. It is often associated with increased intracranial pressure leading to abnormal neurocognitive development (1).

The most affected infants require extensive reconstructive surgery. It affects approximately 5 per 10,000 births and incurs substantial emotional and financial costs (2).

For about half of CS cases, the sagittal suture is affected for 15%. the metopic suture for 20 %, the coronal suture for 3 %, the lambdoid suture and for 7%, multiple sutures.

Based on reports of prenatal diagnoses and autopsies, it is thought that CS occurs as early as the second trimester, although most CS cases have a prenatal onset and are diagnosed at or soon after birth, postnatal craniosynostosis can occur and in most cases are less severe (3).

Normally, suture closure does not begin until 3 to 9 months of age for the metopic suture and not until the third decade of life for the other sutures (4).

The etiology of CS is presumed to be multifactorial, with multiple contributing genetic and environmental factors. Studies suggest various risk factors for CS, such as smoking, advanced maternal age, in utero constraint, male sex, and Caucasian race-ethnicity, but its actual causes remain largely unknown (5).

This is particularly true of non-syndromic CS, i.e., cases for which no genetic cause has been identified, which comprise about 90% of all cases. Some cases of craniosynostosis need surgical intervention to reshape the skull and decrease intracranial pressure and also fronto- orbital advancement (FOA) is commonly used to treat coronal and metopic synostosis (6).

FOA is commonly used to treat coronal and metopic CS, because these forms of CS all cause changes in the shape of for head and upper portion of eye socket that result in abnormal appearance (7).

The purpose of this study was to evaluate the cosmotic and functional outcome of fronto-orbital edvancement in patients of craniosynostosis.

**Patients and Methods**

This prospective study of 11 patients diagnosed with metopic and coronal cs, and operated in Benha University from January 2020 to December 2021 by fronto-orbital advancement.

An informed written consent was obtained from the parents . They received an explanation of the purpose of the study and had a secret code number. The study was done after being approved by the Research Ethics Committee, Faculty of Medicine, Benha University.

**Inclusion Criteria:** Metopic CS **,** Coronal CS (Unilateral, Bilateral) **,** Combined Metopic and Coronal CS\ **,** Without prevelange of age and gender

**Exclusion Criteria:** Saggital CS, Lambdoid CS **,** Intracranial Pathology **,**Unfit for surgery

**All studied cases were subjected to the following**: **Detailed history** (age, gender and time of presentation), **general evaluation** (deformity of face) , **ophthalmological evaluation** by fundus examination and visual field and Degree of Exophthalmos Patients with intracranial pathologies were excluded from the study and **neurological evaluation** (manifestation of increased intracranial pressure) with suitable **radiological investigations** by CT brain including estimation of orbital dimension (AP, horizontal and vertical and volum) orbital rim. and CT scans with 3D reconstruction to ensure the diagnosis of the affected sutures and MRI Brain to exclude cerebral malformations or any other intracranial pathologies plan for surgery.

Patients were admitted 2 days before surgery for laboratory evaluation and cross matching of blood whenever needed for transfusion after surgery. Surgery was done under general anesthesia. Hypothermia was avoided by using sheets of cotton and plastic to wrap the limbs and trunk when warmer wasn’t available.

Removal of the synostosed suture with reshap ing of the forehead and orbital advancement were done for all patients with some modifications depending on the sutures involved. The aim of surgery was to give the brain enough space for normal growth and to correct the deformity in the shape of the skull.

**Surgical Technique:**

Before starting the surgery informed written ethical consents were taken taken from parents of all case with approval of scientific ethical comitte.

protection of the cornea should be done by eye ointment and preoperative antibiotic was given to the patient.

Utilizing a bicoronal incision in a wavy or zigzag fashion was important to provide adequate exposure of the frontoorbital region and it has good cosmetic results with less postoperative scar, the shaving in older child was limited to area of incision.



**Figure 1** Shows wavy or zigzag fashion

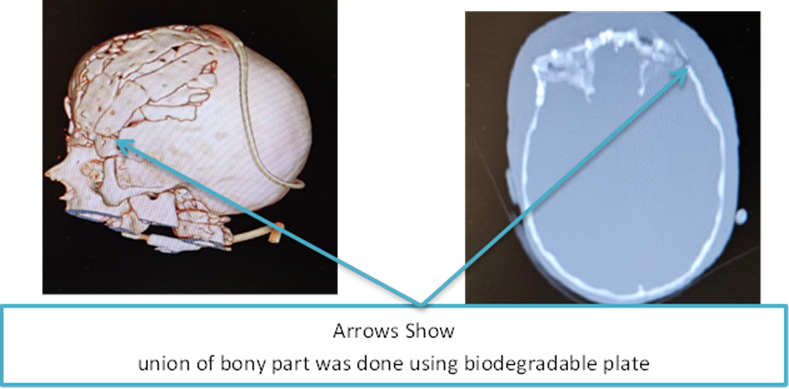
The incision was infiltrated with diluted adren- aline saline 1/200000 to minimize scalp bleeding. Then the scalp was dissected anteriorly in the frontal and temporal region in subgalial plan. The dissection stopped 1 finger breadth above the supra orbital rim and dissection plane advanced to be subperiosteal . until we reached the supraorbital rim, where the supra orbital nerves and vessels were freed and dissected to preserve them the posterior scalp flap was then dissected posteriorly. (**Figure 1)**

The subperiosteal dissection was then extended to the periorbita where it was carefully dissected from superior and lateral wall of the orbit. Care was taken to avoid marked compression on the globe. Any tears to the periorbita were sutured immediately to prevent herniation of the orbital fat. Temporalis muscle was then dissected and reflected postero-inferiorly in subperiosteal plan using sharp dissection from below upwards to preserve its blood and nerve supply.

Key burhole was then made on each side just below the anterior end of the superior temporal line, exposing the frontal lobe dura above, periorbita below with the orbital roof in between.

Using the craniotome, osteotomy was done passing through the frontal compartment of the key holes and the midline burr holes, Frontal craniotomy was then completed by doing posterior osteotomy starting from midline at the coronal suture (if only the metopic suture was involved) and behind the coronal suture (if coronal suture was involved) and extend on each side of the greater sphenoid wing. The greater sphenoid wing was then drilled out all the way to the anterior clinoid. This step was very important to allow for growth at the mid face and orbit, then 2 lateral osteotomies was done to complete the removal of the frontal bone flap, leaving the supra orbital bar in plac .

If the metopic suture was involved certain steps were done to facilitate reconstruction of the triangular shaped supra orbital bar. At first, midline drilling of the synostosed metopic suture, from the inner side down to the anterior cranial fossa was done, leaving only thin outer cortex of bone. Then additional partial thickness bony cuts were made at the lateral edge of the supra orbital bar on both sides perpendicular to the roof of the orbit to facilitate remodeling and correction of the hypo- telorism. Another bony cut was then made on both sides at the frontozygomatic suture passing through the lateral orbital wall utilizing the orbital compo nent of the previously made key holes. Using a small osteotome, the orbital roof was cut 1.5cm behind the supra orbital rim. Now the supraorbital bar could be easily displaced anteriorly and spread- ed out laterally on each side. This reconfiguration. was maintained using an intervening bone graft, designed to fit just between the lateral edge of supra orbital baranteriorly and the sphenoid poste- riorly. The frontal bone flap was then reconstructed with removal of the coronal synostosed suture if it was involved. This was done by reversing the position of the frontal bone flap (posterior part in anterior position) or could be divided into 2 parts then placed again in a reverse pattern.



**Figure 2 Arrows Show union of bony part was done using biodegradable plate**

Radially oriented bony cuts were then made in the parictal bone to allow growth of the newly reshaped skull as one unit. Tiny holes were made in all bony parts and then the bony parts were secured in place together with absorbable sutures, leaving one cm width between edges, except at the advanced orbital bar in which we approximate the frontal bone to it and was secured with sutures without gap.only one case re-union of bony part was done using biodegradable plate (**Figure 2)**

Patient with bilateral coronal craniosynostosis presented with widened biparietal diameter and frontal towering. Their surgical correction involved advancement of the orbital and frontal bone bilaterally. In unilateral coronal craniosynostosis, surgical correction was done bilaterally with mild recession of the unaffected part and advancement of the affected one with bilateral removal of the synostosed coronal suture. The periostium was then replaced over the reshaped bone. Temporalis muscle was replaced adequately to prevent hollow- ing of the sphenoid area. The wound was then closed in 2 layers in sub cuticular fashion over a drain in most cases .

After surgery, the patients were placed in pediatric ICU usually for 48 hours, drain was usually removed by the 2nd day or according to output, parents were informed about the swelling that it should subside after a few days. Patients were usually discharged at the 5th day form surgery. they came for suture removal at the 12 day post- operatively.

**Table 1: Whitaker classification was applied in our study which**



**(Table 1)** Shows thatWhitaker classification **Class I:** No refinements or surgical revisions considered advisable or necessary **Class II:** Soft-tissue or lesser bone-contouring revisions advisable apt to be performed on an outpatient basis or requiring a maximum of 2-day hospitalization **Class III:** Major alternative osteotomies or bone grafting procedure advisable **Class IV:** Major craniofacial procedure advisable, duplicating or exceeding the original operation

**Statistical analysis**

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp). Qualitative data were described using number and regardscent. The Shapiro-Wilk test was used to verify the normality of distribution. Quantitative data were described using range (minimum and maximum), mean, standard deviation, median and interquartile range (IQR). Significance of the obtained results was judged at the 5% level.

**Results**

**Table 2** shows the studied patients as regards demographic data and clinical data, surgical procedure done.

There was a significant increase in vertical, horizontal, anteroposterior and orbital dimensions and volume immediately postoperative in both right and left orbits when compared to preoperative results. Whereas there was significant increase in vertical, horizontal, anteroposterior and orbital dimensions and volume 6 months postoperative when compared to preoperative & immediately postoperative. There was no significant differences in preoperative fundus examination compared to postoperative results (p>0.05). **Table 3**

In terms of postoperative results according to Whitaker classification, all cases 100% had class I. Preoperative & post-operative Eye Globe Protrusion Grades among the studied patients and Distribution of the studied patients as regards post-operative results according to Whitaker classification and post-operative complications were illustrated in **Table 4.**

**Discussion**

The term craniosynostosis indicates the premature, pathologic, partial or complete, fusion of one or more of the cranial vault sutures (8).

It is not clear what is the appropriate age to perform the surgery, the mean age at the time of surgery in this study was between (10.95 to 21.27 months). in Wójcicki and Prudel study the average age was 24 months (9).

Median age was 16 months, in our study. Median age was 16 months, in our study. in Keshavarzi study the median age was 16.6 months (10), and in other study the median age are 11.5 months.in Cohen and in Persing study median age is 8.2 months (11).

There was no significant correlation between the appearance and age at the time of surgery within the giving range15). In the postoperative Whitaker classification, all patient 100% in our study had a class I outcome,. It was founded that 43 patients (79.6%) had a class I outcome, 10 patients were class II, none of their patients were class III, and only one patient was class IV and frontorbital advancement was the standardized operation (11). Glener et al. showed front orbital advancement provides immediate and adequate correction in supraorbital bar (12).

Our patients underwent cranial remodeling with frontoorbital advancement anterior type in metopic synostosis and antro latral type in Coronal synostosis and oxycephaly .

This correction involved lateral extension of the coronal sutures all the way done to the greater wing of the sphenoid ridge at the skull base. We found this technique facilitates global fashioning and allow large cor- rection of the orbital rim and forehead.

Wide strip suturectomy was advocated by some other authors, relying only on brain growth for skull expansion only, without correction of the deformed skeleton . Although possible and simple but it carried higher incidence of resynostosis with little effect on face and forehead development this is preferred in younger group but in our study group most cases were presented in older age

Every effort should be made to minimize blood loss during this surgery. We used high speed drills and craniotome to fasten process of bone cutting and minimize blood loss.

We reported estimated blood loss was 145 mL ± 8.26 ml in OT. Operative time was 1.58 ± 0.38 hours) reported shorter operative time 2.2 hours in OT. 190 mL blood loss in OT. Hospital stay in our study was 2.49 ± 1.32 day in OT as reported by (11)also.

Preoperative fundus examination revealed papilledema in 3 patients (27.27%) that resolve in follow up in line with that reported in (11) study.

Eye Globe Protrusion Examination was done routinely for all patients by measurement of line extended from the lateral orbital rim to the front surface of the cornea .Preoperative examination revealed that two cases (18.18%) had Grade II, nine cases (81.81%) had grade III while postoperative examination showed that two cases (18.18%) had normal while five cases (45.45%) grade I and four cases (36.36%) had grade II.

Other study reported signs of high intracranial tension in CT and MRI as BCC appearance which presented in 7 cases (63.6%) in our study.

Orbital measurements by CT anteroposterior, Vertical, Horizontal lines and Volume were done Preoperative and Postoperative (Immediate and after 6 Month) showing improvement of this measurement, Orbital volume measurement can be an intuitive assessment of the improvement of the surgery. as The improvement of orbital volume can also be used as one of the indicators for evaluation in FOA (13).

We Reported there was a significant decrease in orbital dimensions and volume in left orbit compared to right orbit in cases with left cononal craniosynostosis , In 100% of the UCS cases, the orbital volume on the affected side was smaller than on the unaffected side.

We reported dural tear in Three cases (27.27%) in the patients operated by OT similar to study that reported six patients developed dural tear (11.11%) and a higher percentage (22%) that presented by other study24). One patient (9.09%) was developed temporal hallowing in OT compared to other studies that stated (18%) of temporal hallowing 24%). And One patient (9.09%) was developed periorbital tear intra operatively which was repaired immediately (11).

Our study is limited by small sample size, with only 11 cases included in the analysis. We recommend larger studies to address these issues with a larger sample size.

**Conclusion**

The primary indications for cranial remodeling with fronto-orbital advancement in cases of anterior calvarial (metopic and coronal) synostosis are twofold: the prevention of potential neurologic impairment and the enhancement of aesthetic improvements in skull shape. For many patients, the latter represents the primary motivation for seeking treatment.

Deformities arising from craniosynostosis are best addressed through cranial vault reshaping, ideally at an early age, before calvarial bones have fully ossified.

The measurement of orbital volume serves as an intuitive assessment of surgical improvement, making it a valuable indicator in the evaluation of fronto-orbital advancement outcomes.

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**Author contribution**

Authors contributed equally in the study**.**

**Conflicts of interest**

No conflicts of interest

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**Table 2: Distribution of the studied patients as regards demographic data and clinical data,** **surgical procedure done, operative data.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Description | | Studied patients (n=11) | | |
| N | | % |
| Gender | Male | 4 | | 36.4% |
| Female | 7 | | 63.6% |
| Age (months) | Mean± SD | 21.27± 10.95 | | |
| Median | 16.0 | | |
| Range | 10.0 – 36.0 | | |
| Age groups | <24 months | 7 | | 63.6% |
| ≥24 months | 4 | | 36.4% |
| Clinical data | | | | |
| Comorbidities | No | 8 | | 72.7% |
| Yes (Cardiac, Dwarfism) | 3 | | 27.3% |
| Deformity | | 11 | | 100.0% |
| Type of Suture affected | Right Coronal | 5 | | 45.5% |
| Left Coronal | 3 | | 27.3% |
| Metopic | 2 | | 18.2% |
| Metopic & bilateral coronal | 1 | | 9.1% |
| Surgical procedure | FOA ( antero Lateral) | 9 | | 81.8% |
| FOA (anterior) | 2 | | 18.2% |
| Operative data | | | | |
| Hospital stay | Mean± SD | | 2.49± 1.32 | |
| Estimated blood loss (mL) | Mean± SD | | 145.35± 8.26 | |
| Operative time (hours) | Mean± SD | | 1.58± 0.38 | |

**Table 3: Preoperative & post-operative orbital dimensions among the studied patients.**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Orbital Dimensions | | | | Studied patients(n=11) | | | | | | P value |
| Mean | ±SD | | | Range | |
| Vertical | Right orbit | | Preoperative | 27.74 | ±3.64 | | | 22.80 | 32.20 | <0.001\* |
| Immediately postoperative | 30.08 | ±3.23 | | | 23.50 | 34.60 |
| 6m postoperative | 34.00 | ±3.44 | | | 25.60 | 37.10 |
| Left orbit | | Preoperative | 29.39 | ±3.10 | | | 21.60 | 31.90 | <0.001\* |
| Immediately postoperative | 30.89 | ±3.10 | | | 23.30 | 34.50 |
| 6m postoperative | 33.20 | ±3.45 | | | 25.30 | 37.80 |
| Horizontal | Right orbit | | Preoperative | 23.03 | ±4.65 | | | 19.20 | 34.40 | 0.004\* |
| Immediately postoperative | 24.35 | ±4.34 | | | 19.60 | 32.60 |
| 6m postoperative | 26.28 | ±3.29 | | | 21.40 | 30.70 |
| Left orbit | | Preoperative | 24.00 | ±4.86 | | | 18.70 | 32.60 | <0.001\* |
| Immediately postoperative | 24.87 | ±4.94 | | | 19.90 | 33.10 |
| 6m postoperative | 27.16 | ±4.39 | | | 21.50 | 34.20 |
| AP | Right orbit | | Preoperative | 30.20 | ±3.37 | | | 23.30 | 37.30 | 0.009\* |
| Immediately postoperative | 31.89 | ±1.35 | | | 29.30 | 34.10 |
| 6m postoperative | 33.81 | ±1.62 | | | 31.50 | 36.40 |
| Left orbit | | Preoperative | 30.70 | ±1.72 | | | 27.20 | 33.30 | <0.001\* |
| Immediately postoperative | 31.76 | ±1.50 | | | 28.90 | 34.20 |
| 6m postoperative | 33.98 | ±1.94 | | | 29.30 | 36.50 |
| Volume | Right orbit | | Preoperative | 458.13 | ±68.76 | | | 332.20 | 586.42 | <0.001\* |
| Immediately postoperative | 555.30 | ±126.41 | | | 354.32 | 792.22 |
| 6m postoperative | 678.79 | ±90.68 | | | 502.82 | 805.42 |
| Left orbit | | Preoperative | 481.48 | ±73.16 | | | 300.72 | 592.62 | <0.001\* |
| Immediately postoperative | 568.86 | ±112.84 | | | 350.12 | 793.62 |
| 6m postoperative | 717.93 | ±88.67 | | | 507.82 | 805.52 |
|  | |  | | Preoperative | | | Postoperative | | |  |
|  | |  | | N | | % | N | | % |  |
| Fundus examination | | Normal | | 8 | | 72.7% | 9 | | 81.8% | 0.168 |
| Grade I papilledema | | 0 | | 9.1% | 2 | | 18.2% |
| Grade II papilledema | | 2 | | 18.2% | 0 | | 0.0% |
| Grade III papilledema | | 1 | | 9.1% | 0 | | 0.0% |

\*: statistically significant as P value <0.05

**Table 4: Preoperative & post-operative Eye Globe Protrusion Grades among the studied patients and Distribution of the studied patients as regards post-operative results according to Whitaker classification and post-operative complications.**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | | Studied patients (n=11) | | | | | |
| Preoperative | | | Post-operative | | |
| N | | % | N | | % |
| Eye Globe Protrusion Grades | Normal>17 m.m | | 0 | | 0% | 2 | | 18.18% |
| Grade I >17: 20 m.m | | 0 | | 0% | 5 | | 45.45% |
| Grade II>21:24 m.m | | 2 | | 18.18% | 4 | | 36.36% |
| Grade III>24 m.m | | 9 | | 81.81% | 0 | | 0.0% |
|  | | | | N | | | % | | |
| Post-operative results according to Whitaker classification | | Class I | | 11 | | | 100% | | |
| Class II | | 0 | | | 0% | | |
| Class III | | 0 | | | 0% | | |
| Class IV | | 0 | | | 0% | | |
| Post-operative complications | | Dural tear | | 4 | | | 36.4% | | |
| Wound infection | | 2 | | | 18.2% | | |
| Seroma | | 3 | | | 27.3% | | |
| Hypotensive episode | | 2 | | | 18.2% | | |
| Temporal hollow | | 1 | | | 9.1% | | |
| Death | | 1 | | | 9.1% | | |
| Need for revision | | No | | 11 | | | 100% | | |
|  | | Yes | | 0 | | | 0% | | |