

Can We “Overcorrect” Our Way to Normal Appearance in Metopic Craniosynostosis?: A Single-Center’s 33 Year Odyssey

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BACKGROUND

Fronto-orbital advancement (FOA) is the most widely performed technique for correcting metopic craniosynostosis. While consistent early results are well reported, recurrence of trigonocephaly, temporal hollowing, bony and soft tissue contour irregularities of the forehead and brow, and supraorbital retrusion are commonly seen in long-term follow-up, often requiring a secondary revision surgery. To address these challenges, our team shifted towards overcorrecting in FOA to provide greater bi-temporal widening of the metopic deformity to account for growth and relapse.



Study Objectives

- Compare **surgical complication rates and revision** burden between traditional fronto-orbital advancement (T-FOA) and overcorrection FOA (O-FOA).
- Assess **long-term aesthetic outcomes** using Whitaker classification and specific phenotype-based deformity metrics (e.g., temporal hollowing, lateral orbital retrusion, frontal irregularities).
- Identify **independent predictors** of poor aesthetic outcome.

METHODS

A retrospective review was performed of all children who underwent FOA for isolated metopic craniosynostosis from 1987 to 2020. Patients with ≥ 4 years follow-up and had a documented Whitaker classification or facial photography were included. Clinical and aesthetic outcomes were compared between T-FOA (prior to 2012), and O-FOA (2012-2020).



Figure 1. FOA with interpositional calvarial bone grafts and lateral strut grafts, seen more aggressively and widened and "overcorrected" on the right

RESULTS

Between 1987 and 2020, 270 patients underwent surgical correction of isolated metopic synostosis. Among these, 166 (61.5%) patients met inclusion criteria, of which 100 (60.2%) underwent traditional FOA (T-FOA) and 65 (39.8%) underwent FOA with overcorrection (O-FOA). Operative details are listed in **Table 1**. There were 13 complications (7.8%) and 40 (24.1%) patients underwent at least one secondary surgery at an average 10.7 ± 4.6 years after initial surgery. T-FOA were more likely to have palpable hardware (41.0% vs 24.2%, $p=.026$), bony irregularities (64.0% vs 21.2%, $p<.001$), visible irregularities (68.0% vs 48.5%, $p=0.012$), and lateral orbital retrusion (48.0% vs 15.2%, $p<.001$) compared to O-FOA. Similarly, average Whitaker scores were higher in patients who underwent T-FOA compared to O-FOA (2.2 ± 1.0 vs 1.5 ± 0.8 , $p<0.001$). In a subgroup of patients ≥ 10 years old ($n=85$, 51.2%), revision rates (48.6 vs 26.7%, respectively, $p=0.122$) and average Whitaker scores (2.4 ± 1.0 vs 2.0 ± 1.0 , $p=0.167$) were comparable between the two cohorts (**Table 3**). Length of follow-up was a significant predictor of revision ($\beta=0.054$, $p<0.001$), higher Whitaker score ($\beta=0.079$, $p<0.001$), and temporal hollowing ($\beta=0.038$, $p=0.001$).

Table 1. Operative Characteristics				
	FOA	FOA with Overcorrection	<i>p</i>	
No. of Patients	100	66		
Interfrontal angle, degrees	108.7 $\pm$ 5.5	110.1 $\pm$ 9.3	.492	
Surgeon				
A	8 (8.0)	40 (60.6)	<.001	
B	58 (58.0)	21 (31.8)		
C	34 (34.0)	0 (0.0)		
E	0 (0.0)	5 (7.6)		
Operative Time (minutes)				
Anesthesia time	346.6 $\pm$ 68.1	321.6 $\pm$ 59.7	.037	
Surgical time	244.1 $\pm$ 60.3	216.0 $\pm$ 42.8	.003	
Operative Details				
Interposition bone graft	96 (96.0)	66 (100.0)	.100	
Intranasal bone graft	26 (26.0)	2 (3.0)	<.001	
Lateral canthopexy	20 (20.0)	0 (0.0)	<.001	
Resorbable fixation	65 (65.0)	66 (100.0)	<.001	
Width Interpositional Bone Graft (mm)	16.1 $\pm$ 3.3	17.9 $\pm$ 2.6	<.001	
Bitemporal Width (mm)				
Preoperative	73.5 $\pm$ 7.6	75.6 $\pm$ 6.1	.098	
Postoperative	91.9 $\pm$ 7.5	100.1 $\pm$ 6.9	<.001	
Change	18.0 $\pm$ 5.1	24.8 $\pm$ 5.4	<.001	
Increase (%)	25.4 $\pm$ 8.1	33.3 $\pm$ 9.0	<.001	
Blood (mL)				
Estimated blood loss	652.9 $\pm$ 323.9	491.1 $\pm$ 212.7	.001	
Blood transfused	774.1 $\pm$ 477.5	494.5 $\pm$ 236.6	<.001	
Hospital Length of Stay (days)	4.2 $\pm$ 0.9	5.1 $\pm$ 1.4	<.001	

Table 2. Clinical and Aesthetic Outcomes				
	FOA	FOA with Overcorrection	<i>p</i>	
No. of Patients	100	66		
Minor Complications	3 (3.0)	1 (0.0)	.541	
Seroma	1 (1.0)	0 (0.0)		
Hematoma	1 (1.0)	0 (0.0)		
Wound dehiscence	0 (0.0)	1 (1.5)		
Venous thrombosis	1 (1.0)	0 (0.0)		
Major Complications	8 (8.0)	1 (1.5)	.071	
Hardware removal	7 (7.0)	0 (0.0)		
Abscess	1 (1.0)	0 (0.0)		
Hematoma	0 (0.0)	1 (1.5)		
Aesthetic Assessments				
Palpable Hardware Irregularity	41 (41.0)	16 (24.2)	.026	
Palpable Bony Irregularity	64 (64.0)	14 (21.2)	<.001	
Visible Irregularity	68 (68.0)	32 (48.5)	.012	
Temporal Narrowing	65 (65.0)	33 (50.0)	.054	
Lateral Orbital Retrusion	48 (48.0)	10 (15.2)	<.001	
Frontal Bone Irregularity	36 (36.0)	26 (39.4)	.658	
Whitaker Class				
Average score	2.2 $\pm$ 1.0	1.5 $\pm$ 0.8	<.001	
I	35 (35.0)	44 (66.7)	<.001	
II	12 (12.0)	14 (21.2)	.110	
III	48 (48.0)	6 (9.1)	<.001	
IV	5 (5.0)	2 (3.0)	.537	
Revision	35 (35.0)	5 (7.6)	<.001	
Cranioplasty	30 (30.0)	2 (3.0)		
FOA	4 (4.0)	3 (4.5)		
Bone flap switch	1 (1.0)	0 (0.0)		

Table 3. Clinical and Aesthetic Outcomes in Patients ≥ 10 Years				
	FOA	FOA with Overcorrection	<i>p</i>	
No. of Patients	70 (70.0)	15 (22.7)	<.001	
Bitemporal Width (mm)				
Preoperative	73.5 $\pm$ 7.6	75.6 $\pm$ 6.1	.048	
Postoperative	92.3 $\pm$ 7.5	101.1 $\pm$ 7.7	<.001	
Change	18.2 $\pm$ 5.0	23.8 $\pm$ 6.2	.001	
Increase (%)	25.1 $\pm$ 7.8	31.1 $\pm$ 9.7	.025	
Revision	34 (48.6)	4 (26.7)	.122	
No. Surgical Interventions				
1	36 (51.4)	11 (74.4)	.121	
2	22 (31.4)	4 (26.7)	.947	
3	11 (15.7)	0 (0.0)	.100	
4	1 (1.4)	0 (0.0)	.641	
Aesthetic Assessments				
Palpable Hardware Irregularity	28 (40.0)	4 (35.7)	.333	
Palpable Bony Irregularity	48 (68.6)	4 (35.7)	.003	
Visible Irregularity	45 (64.3)	10 (66.7)	.886	
Temporal Narrowing	53 (75.7)	9 (60.0)	.214	
Lateral Orbital Retrusion	33 (47.1)	2 (13.3)	.016	
Frontal Bone Irregularity	27 (38.6)	7 (46.7)	.561	
Whitaker Class				
Average score	2.4 $\pm$ 1.0	2.0 $\pm$ 1.0	.167	
I	19 (27.1)	6 (40.0)	.321	
II	10 (14.3)	4 (26.7)	.240	
III	36 (51.4)	4 (26.7)	.081	
IV	5 (7.1)	1 (6.7)	.947	
Follow-up (Years)	13.4 $\pm$ 2.9	9.7 $\pm$ 1.7	<.001	



Figure 2. Patient with nonsyndromic isolated metopic synostosis who underwent fronto-orbital advancement with overcorrection seen at 4 years postoperatively (middle), and 10 years postoperatively (right). He had excellent contour and did not require revision surgery.

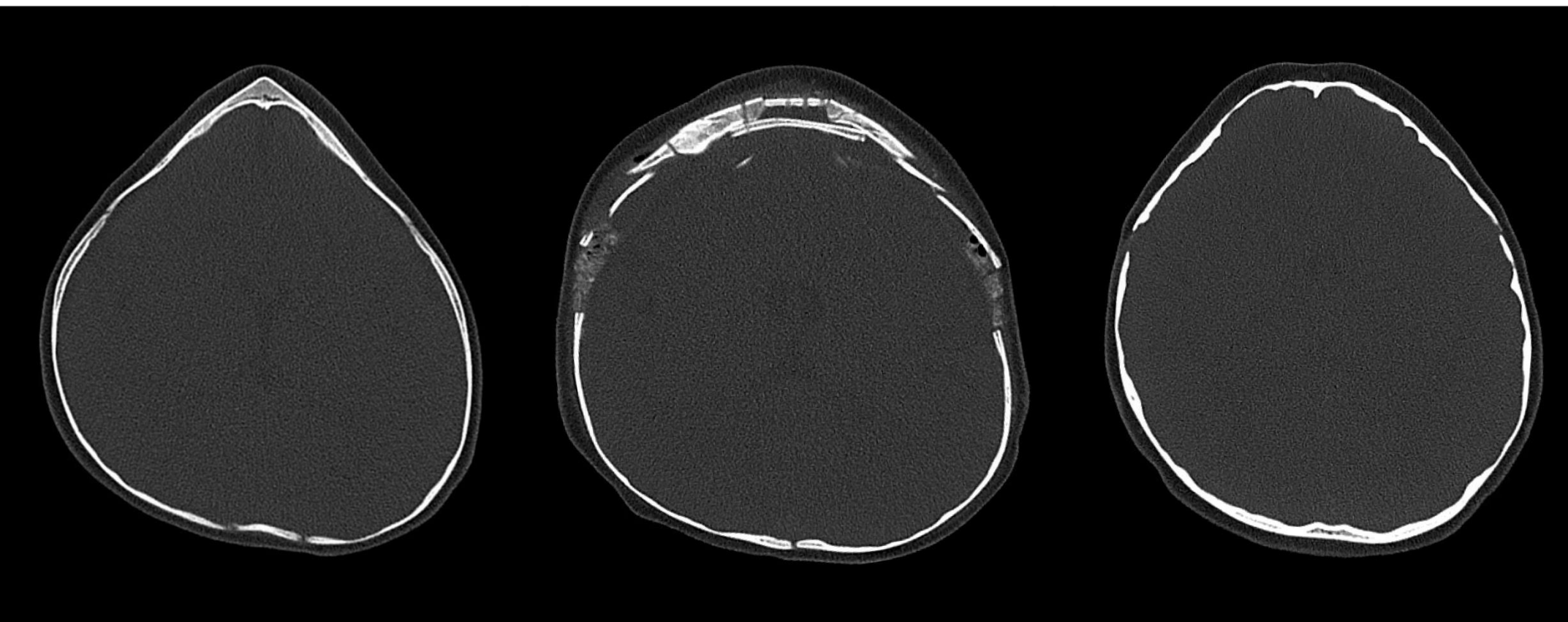


Figure 3. Axial CT scan of a 5-month-old patient with metopic craniosynostosis (left) who underwent FOA with overcorrection at 9 months old (middle), and seen at 4.5 years postoperatively (right) with relapse of his trigonocephaly.

LIMITATIONS



Retrospective Study
Subjective Aesthetic Classification System
Differences in Follow-up Time

CONCLUSIONS

Despite incorporation of a more aggressive attempt to bitemporally “overcorrect” metopic deformity at time of frontal orbital advancement, similar levels of aesthetic deterioration were seen in patients 10 years or older at follow-up. Though safe and effective at achieving its primary surgical goals with improved aesthetic scores in the intermediate-term follow-up, the FOA technique, even with overcorrection, is associated with a high incidence of aesthetic deformity over time.



Figure 4. Patient with nonsyndromic isolated metopic synostosis who underwent fronto-orbital advancement with overcorrection seen at two months postoperatively (left middle), 4 years postoperatively (right middle), and 9 years postoperatively (right). At age 10, he required cranioplasty of the bilateral frontal region for deterioration of the frontal contour, bitemporal narrowing, temporal narrowing, and left lateral canthal descent.