

Surgical Correction of Unicoronal Synostosis: Fronto-Orbital Distraction versus Calvarial Switch

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Background: There is a need for a new, less-invasive surgical option for unicoronal synostosis (UCS). The aim of this study was to compare the resulting morphology and symmetry in patients with UCS after fronto-orbital distraction (FOD) or calvarial switch (CS).

Methods: A total of 79 patients with isolated UCS operated on between 2005 and 2021 were analyzed. Follow-up was until 3 years of age. Angles describing orbital dystopia and anterior cranial fossa deviation and cant were measured. Key linear dimensions, cranial cavities, and indices were calculated.

Results: A total of 66 patients were included (14 in the FOD group and 52 in the CS group). The 3-year follow-up revealed significant improvement in all angles in both groups, with significant superiority in orbital dystopia correction after FOD (median improvement of 5.7 degrees as compared with 3.3 degrees after CS). In addition, nasal and orbital volumes tended to be smaller, especially after CS; however, FOD resulted in a smaller absolute difference in orbital volume. Asymmetry in the orbital, nasal, and sphenoid regions also improved at the 3-year follow-up in both groups, although FOD resulted in normalization of the affected orbital shape and significantly improved overall asymmetry relative to that observed in the CS group.

Conclusions: This study found that FOD achieves superior overall symmetry, as well as better shape correction of the cranium, as compared with CS, while also being less invasive. These findings suggest FOD as a safe and effective alternative to correct UCS and, possibly, the preferred surgical method. (*Plast. Reconstr. Surg.* 156: 91e, 2025.)

CLINICAL QUESTION/LEVEL OF EVIDENCE: Therapeutic, III.

Unicoronal synostosis (UCS) occurs in approximately 0.7 in 10,000 births and is the second most common form of

craniosynostosis.¹ Patients present with ipsilateral retrusion and contralateral protrusion of the forehead, orbital dystopia with elevation of the ipsilateral orbital roof, nasal root deviation toward the affected side, zygomatic asymmetries, and affected dental occlusion.²⁻⁸ Some of the functional consequences of UCS include increased intracranial pressure and ocular disorders.⁹⁻¹² Patients with UCS may also have lower than average neurodevelopment.¹³⁻¹⁶

There is no consensus on the optimal treatment for UCS. The most common technique is fronto-orbital advancement remodeling (FOAR).^{17,18} Calvarial switch (CS) is an FOAR variant in which an appropriately curved bone flap

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from the calvaria replaces the skewed forehead.¹⁹ Although capable of improving forehead symmetry, FOAR methods have minimal effect on facial symmetry.^{20–25} Dynamic techniques have recently emerged as alternatives. Endoscopic strip craniectomy combined with helmet remolding produces satisfactory correction but requires consistent compliance and is best suited for early intervention.^{26–29} Spring-assisted surgery is another alternative.^{30–33} The first case report on spring-assisted surgery for UCS concluded that despite successful correction of facial scoliosis, issues remained concerning the unpredictability of using springs.³⁴ Fronto-orbital distraction (FOD), first described by Kobayashi et al.,³⁵ uses traditional distractors instead of springs, thereby reducing the observed issues. Despite growing interest in FOD, few case studies have been published.^{2,5,36–42} At our institution, the surgical standard has evolved to FOD from CS with positive preliminary results, including normalization of orbital dystopia and the anterior cranial fossa.² Similar results were recently reported by Park et al.⁴⁰

Several studies have used various methods to evaluate surgical outcomes for correcting UCS. These range from assessing improvements in perioperative morbidity to assessing improvements in ocular symptoms; however, such methods seldom use standardized points of reference, lack a control group, or both.^{3,9,17,36,38–40,43,44} In this study, we performed a direct comparison of surgical outcomes between FOD and CS in terms of improvements in perioperative morbidity and detailed asymmetry. Furthermore, this is the first study using a cohort of patients without UCS as a comparative control. Our aim was to analyze changes in facial symmetry before and after surgical correction of UCS to determine the optimal procedure for reducing morbidity.

PATIENTS AND METHODS

The study was conducted according to the principles stated in the Declaration of Helsinki. Ethical approval was obtained from the Gothenburg Ethics Committee (Dnr 784:11).

Study Design

This is a single-center, retrospective, comparative effectiveness study on all consecutive nonsyndromic patients with isolated UCS treated from June 22, 2005, to June 29, 2021. The 3-year follow-up period occurred from September 20, 2007, to December 18, 2023. Surgical outcomes in the form of anthropometric measurements

and morphologic analyses were compared against those in a previously published control data set of individuals without pathology ranging from 0 to 48 months of age ($n = 217$).⁴⁵

Participants

The patients were all treated at Sahlgrenska University Hospital in Gothenburg, Sweden, and retrospectively divided into 2 groups according to operation (FOD or CS) (Fig. 1). UCS diagnosis was made in the craniofacial unit through clinical examination and verified by computed tomography (CT), with follow-up CT at 3 years of age included in the analysis. Included patients were those who underwent either FOD or CS. Those with syndromic diagnoses or inadequate CT scans were excluded. Patients receiving FOD underwent CT before distractor removal.

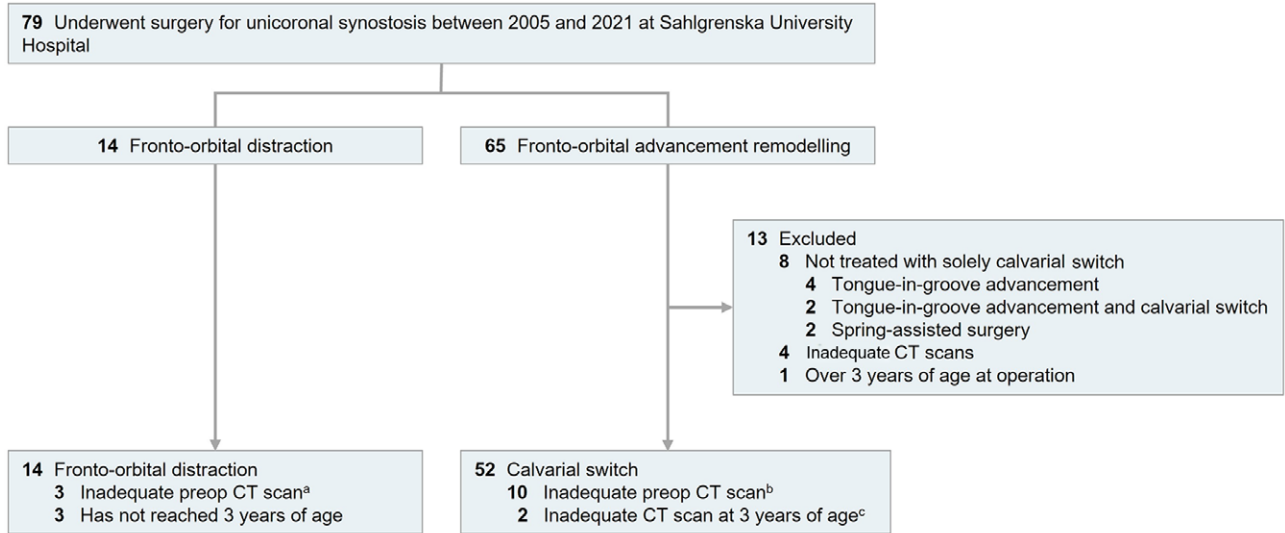
Interventions

Calvarial Switch

From 2005 to 2018, CS was the predominant surgical method for treating UCS at our center (Fig. 2). This method has been shown to be superior in achieving forehead symmetry compared with previous techniques, such as bilateral FOAR.¹⁹ However, it presents limitations, particularly its restriction to the supraorbital region. In short, after a bicoronal zigzag incision, subperiosteal dissection exposed the frontal bone and the calvaria. A suitably rounded bone flap was identified and harvested, and after removal of the deformed forehead, the bone flaps switched places. The supraorbital complex was removed, partitioned in the midline, and refixated to the new forehead. The new forehead was adjusted and fixated with sutures and resorbable plates. To enhance symmetry, barrel-staving and outfracturing of the parietal bone on the affected side were performed.

Fronto-Orbital Distraction

Since 2018, FOD has been exclusively used for UCS, regardless of severity. The general protocol includes surgery approximately 2 months after the initial evaluation and confirmation of diagnosis. This is followed by the distraction and consolidation phases, at the end of which all patients undergo a CT scan. An additional evaluation and CT scan are performed when the patient reaches 3 years of age. An anterior scalp flap is raised using a bicoronal incision to expose the orbital roof (Fig. 2). A temporal osteotomy then allows the desired distractor placement. The osteotomy extends from the fontanel to the squamous suture



^aOne case had movement disturbances and two had incomplete CT scans.
^bEight cases had inadequate CT scans and two cases had irretrievable CT scans.
^cOne case had an incomplete CT scan and one had an irretrievable CT scan.

Fig. 1. Patient enrollment and follow-up.

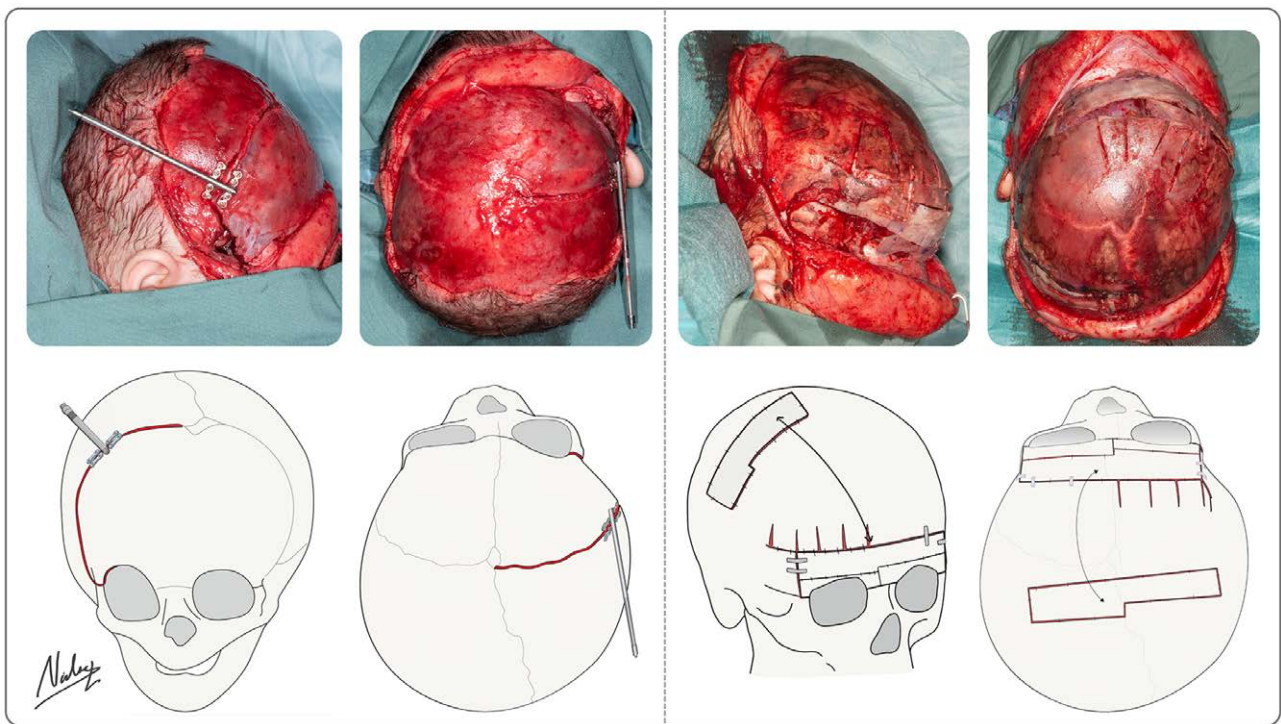


Fig. 2. Perioperative photographs and schematic illustrations of FOD (left) and CS (right). Copyright © 2024 Niclas Löfgren. Used with permission.

along the fronto-sphenoidal suture and into the orbit through the fronto-zygomatic suture. The distractor, a 30-mm Arnaud device (KLS Martin), is affixed with 8 MatrixMIDFACE screws at a pre-planned location. Minor angle adjustments are

possible at this stage, but are preferably avoided, as any removal of bone to adjust the angle would inevitably reduce the total distraction capacity. Distraction commences immediately with 3 daily turns until reaching 30 mm. Distractor removal

occurs after a 3-month consolidation period under general anesthesia.

Primary Outcomes

We performed morphologic analysis and 3 primary anthropometric measurements of angles, indices, and volumes to evaluate various aspects of cranial size, shape, and symmetry. These occurred both preoperatively and to assess changes at the 3-year follow-up.

Orbital dystopia angle (ODA), anterior cranial fossa deviation (ACFD), and anterior cranial fossa cant (ACFC)^{2,46} were measured and compared between the 2 surgical interventions preoperatively and at the 3-year follow-up. (See **Figure, Supplemental Digital Content 1**, which shows angle measurements and landmark configuration used for linear dimensions, <http://links.lww.com/PRS/H772>.) See Mellgren et al.² for details concerning the angle measurements. See Liang et al.⁴⁵ for definition of the 88 anatomic landmarks. In addition, 5 common cranial indices⁴⁵—the cephalic index, upper facial index, nasal index, orbital index at affected (AOI) and nonaffected sides (NAOI), and I index for the sphenoid wing (SWI; defined by the authors)—were calculated using linear dimensions and landmarks to estimate shape changes at specific cranial regions (see **Figure, Supplemental Digital Content 1**, <http://links.lww.com/PRS/H772>). Volumetric changes were quantified through measurements of intracranial volume, nasal cavity volume (NCV), and orbital volume at both affected and nonaffected sides (AOV and NAOV).

Overall asymmetry was assessed through principal component analysis (PCA)⁴⁷ based on the landmark configurations⁴⁵ of 88 anatomic landmarks and 1152 pairs of bilateral surface semi-landmarks placed on the reconstructed skulls of all evaluated individuals. The function show.asymmetry in the R statistical environment (R Core Team) was used to calculate the amount of cranial asymmetry.⁴⁷ The surface shape variation along the first 2 principal component scores were visualized, and the level of asymmetry in different subgroups was quantified and reported using density distribution plots.⁴⁸

Secondary Outcomes

Demographic and operative data, including operation time, perioperative bleeding and transfusion, length of stay (LOS), and complications, were collected from the Gothenburg Craniofacial Registry and medical charts. All complications were graded using the Oxford system and registered

until 30 days postoperatively, including after the initial operation and after distractor removal.⁴⁹

Statistical Analysis

Analyses were conducted using SPSS (version 29.0; IBM Corp.). Demographics were analyzed with a chi-square test, and Mann-Whitney *U* test was used to compare operative data between groups. Pre- and postoperative measurements within each group were compared using Wilcoxon signed-rank tests, and FOD and CS outcomes were compared using the Mann-Whitney *U* test. Wilcoxon signed-rank tests was used to evaluate overall asymmetry at different periods. All *P* values were 2-sided, with a value of *P* < 0.05 considered significant.

RESULTS

Patient Characteristics

A total of 79 patients underwent surgery for UCS between 2005 and 2021 at Sahlgrenska University Hospital. Of these, 14 underwent FOD and 65 FOAR. In the CS group, 8 patients lacked adequate preoperative CT scans, and 2 lacked these at the 3-year follow-up for angle measurements. For linear dimensions and volumes, 10 patients lacked preoperative CT scans, and 2 lacked these at the 3-year follow-up. All FOD cases had sufficient CT scans for angle measurements at all stages, although the low image quality of some scans precluded analysis of linear dimensions and volumes.

As a result, this study included 66 patients (**Table 1**). (See **Table, Supplemental Digital Content 2**, which shows detailed patient information, <http://links.lww.com/PRS/H773>.) Mean age at the preoperative CT scan was 5.7 months (range, 0.8 to 15.2 months) and 6.4 months (range, 0.0 to 23.6 months) for the FOD and CS groups, respectively. Mean age at operation was 8.0 months (range, 4.3 to 16.6 months) and 8.7 months (range, 4.6 to 25.5 months) for the FOD and CS groups, respectively. Mean age at distractor removal and duration of distraction in the FOD group was 12.5 months (range, 8.0 to 21.2 months) and 4.5 months (range, 2.6 to 6.2 months), respectively. Mean age at the 3-year follow-up was 38.1 months (range, 35.6 to 44.7 months) and 36.9 months (range, 32.5 to 41.5 months) for the FOD and CS groups, respectively.

Primary Outcomes

Angle Deviation

Comparison at the 3-year follow-up between the 2 groups identified a significant difference

Table 1. Patient Information and Measurements^a

Demographic Data	FOD Group	CS Group	<i>P</i> ^b
No. of cases	14	52	
Sex			
Female	7	32	0.640
Male	7	20	
Affected side			
Right	8	33	0.900
Left	6	19	
Operative and postoperative data			
Age at preoperative CT, mo	5.7 (0.8–15.2)	6.4 (0.0–23.6)	0.610
Age at operation, mo	8.0 (4.3–16.6)	8.7 (4.6–25.5)	0.370
Duration of operation, min	89.5 (63.0–121.0)	153.5 (60.0–209.0)	<0.001
Perioperative bleeding, mL/kg	6.1 (2.0–15.2)	22.1 (1.2–72.2)	<0.001
Perioperative transfusion, mL/kg	3.3 (0.0–14.0)	14.3 (0.0–36.2)	<0.001
Length of stay, d	4.3 (3.0–6.0)	5.8 (4.0–8.0)	<0.001
Age at distractor removal, mo	12.5 (8.0–21.2)	NA	NA
Duration of distraction, mo	4.5 (2.6–6.2)	NA	NA
Age at 3-yr follow-up, mo	38.1 (35.6–44.7)	36.9 (32.5–41.5)	0.250
Comparison of measurements			
No. of cases	11	42	
Degrees changed			
ODA	5.7 ± 3.1	3.3 ± 3.8	0.008
ACFD	7.4 ± 4.9	5.5 ± 10.7	0.190
ACFC ^c	2.5 ± 3.6	1.6 ± 2.0	0.430

ACFC, anterior cranial fossa cant; ACFD, anterior cranial fossa deviation; NA, not available; ODA, orbital dystopia angle.

^aOperative and postoperative data are presented as mean (range) and comparisons of measurements are presented as median ± interquartile range.

^bDemographic data were analyzed with the chi-square test; operative and postoperative data analysis and comparison of fronto-orbital distraction (FOD) and calvarial switch (CS) were performed with the Mann-Whitney *U* test.

^cThe computed tomography scan of 1 case (patient 61) did not capture the mastoid processes and was not included in the analysis.

in correction of ODA ($P = 0.008$), with FOD improving ODA by a median of 5.7 degrees (interquartile range, 3.1 degrees) as compared with 3.3 degrees (interquartile range, 3.8 degrees) after CS (Table 1). ACFD improved by a median of 7.4 degrees and 5.5 degrees after FOD and CS, respectively ($P = 0.188$), and ACFC improved by a median of 2.5 degrees and 1.6 degrees after FOD and CS, respectively ($P = 0.430$). ODA and nasal root deviation in both groups consistently occurred preoperatively toward the affected side. Similarly, ACFD consistently occurred preoperatively with the nonsynostotic angle greater than the synostotic angle. All but 2 patients (1 in each group) had ACFC, where the superior orbital fissure on the affected side deviated upwards preoperatively.

Changes in Size and Shape

Although both FOD and CS similarly resulted in improved nasal shape to levels comparable with measurements in the control group at the 3-year follow-up (Fig. 3, above, left), NCV showed different variations: NCV was similar to control values preoperatively, larger upon distractor removal,

and smaller at the 3-year follow-up (Fig. 3, above, right). Preoperative AOI differed significantly from control values, with orbital height larger than the width. After distractor removal, AOI in the FOD group was similar to that of the control group and persisted until the 3-year follow-up (Fig. 3, center, left), with NAOI following a similar pattern (Fig. 3, below, left). Notably, measurements of AOV and NAOV were similar to control values preoperatively, with both FOD and CS resulting in overall volume reductions at the 3-year follow-up (Fig. 3, center, right, and below, right). However, fewer patients showed a greater than 10% absolute difference between AOV and NAOV at the 3-year follow-up, with absolute differences of less than 5% more common in the FOD group. (See Figure, Supplemental Digital Content 3, which shows changes in additional cranial indices based on linear dimensions and volumes. [Above, left] cephalic index = maximum cranial width/maximum cranial length × 100. [Above, center] Upper facial index = upper facial height/bizygomatic breadth × 100. [Above, right] SWI = length of frontal and parietal margin of the greater sphenoid wing on the synostotic side/length of frontal and

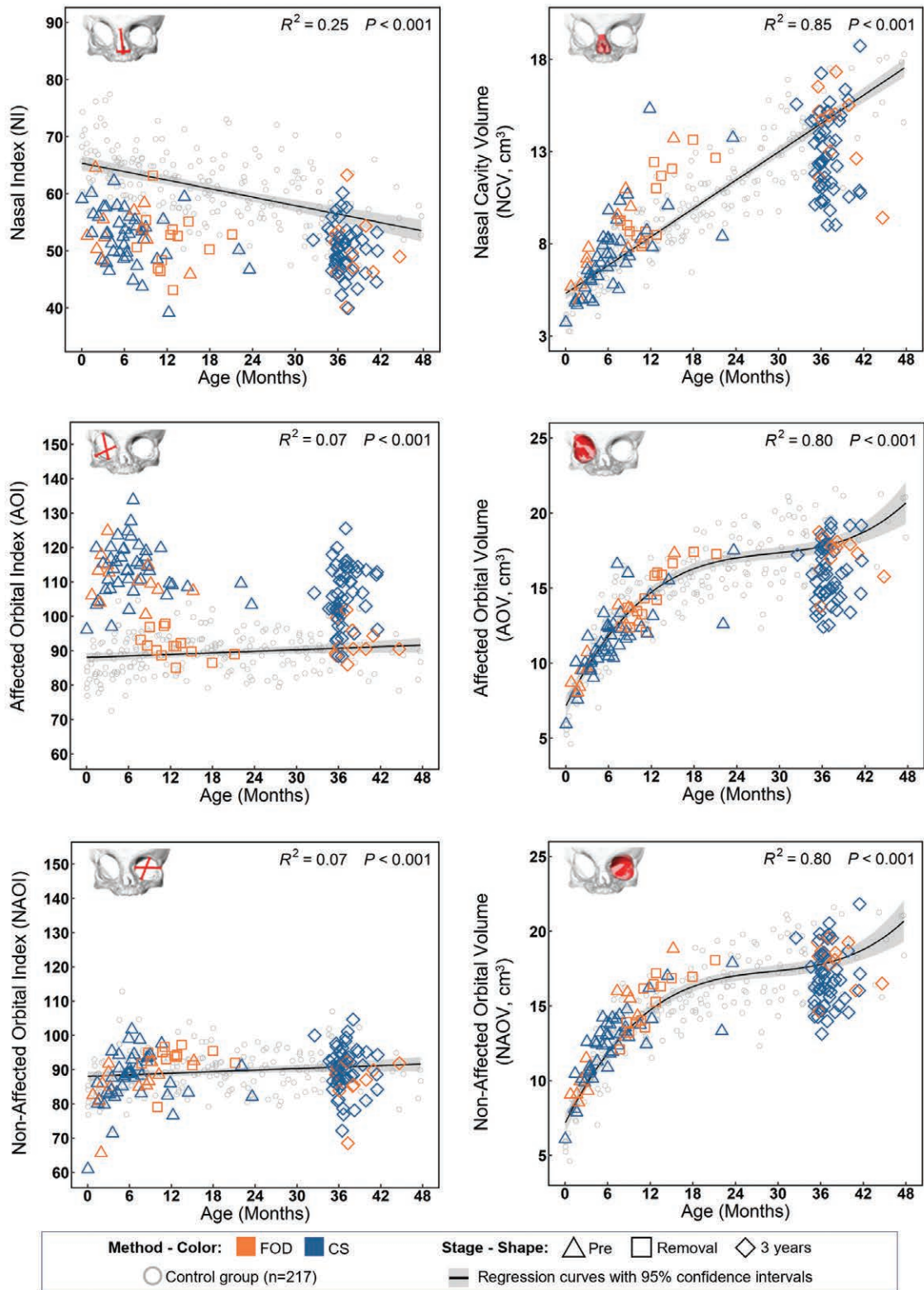


Fig. 3. Changes in selected cranial indices based on linear dimensions and volumes. (Above, left) Nasal index (nasal breadth/nasal height \times 100). (Above, right) NCV. (Center, left) AOI = affected orbital height/affected orbital width \times 100. (Center, right) AOV. (Below, left) NAOI = nonaffected orbital height/nonaffected orbital width \times 100. (Below, right) NAOV. All regression curves (using linear or third-order polynomial functions) were computed on the basis of the control data set ($n = 217$; age, 0 to 48 months) and reported with 95% confidence intervals.

parietal margin of the greater sphenoid wing on the nonsynostotic side $\times 100$. [*Below, left*] Intracranial volume. [*Below, right*] Absolute difference between AOV and NAOV [10% difference; *red dotted line*]. All regression curves [using linear or third-order polynomial functions] were computed on the basis of the control data set [$n = 217$; age, 0 to 48 months] and reported with 95% confidence intervals, <http://links.lww.com/PRS/H774>.) Overall changes in the shape and size of facial and calvarial regions followed similar patterns at preoperation, distractor removal, and the 3-year follow-up in both groups, resulting in measurements comparable to those in the control group (see **Figure, Supplemental Digital Content 3, above, left; above, center; and below, left**, <http://links.lww.com/PRS/H774>). The greater sphenoid wing length on the affected side was consistently approximately 50% smaller than that on the unaffected side preoperatively in both groups, resulting in a low SWI. After distractor removal, FOD resulted in an SWI closer to that measured in the control group relative to CS at distractor removal, although no apparent difference in overall improvement was observed between groups at the 3-year follow-up. (See **Figure, Supplemental Digital Content 3, above, right**, for detailed information on additional calculated cranial indices and volumetric changes in cranial cavities, <http://links.lww.com/PRS/H774>.)

Overall Asymmetry

PCA revealed major asymmetry variations in the cranial morphology of all patients in both groups at different stages (PC1 explained 67.09% of the variability), with the data showing that FOD-treated patients demonstrated higher levels of similarity with the controls (**Fig. 4, above and below, left**). Results for PC2 (explaining 7.62% of the variability) indicated marginal changes primarily affecting the posterior portion of the neurocranium and with less impact on the facial complex. (See **Figure, Supplemental Digital Content 4**, which shows postsurgical variations in head shape according to PCA. Left-lateral [*above*] and antero-superior [*below*] views. PC2 analysis revealed marginal changes that primarily affected the posterior portion of the neurocranium, with less impact on the facial complex, <http://links.lww.com/PRS/H775>.) PCA results suggested no significant differences in overall asymmetry between preoperation and at the 3-year follow-up in the CS group ($P = 0.256$). However, the FOD group showed significant improvements in asymmetry at distractor removal ($P < 0.001$) and the 3-year

follow-up ($P = 0.029$) relative to both preoperative measurements and as compared with the CS group. (See **Figure, Supplemental Digital Content 5**, for the density distribution plots of each group describing postsurgical asymmetry changes, <http://links.lww.com/PRS/H776>. See **Table, Supplemental Digital Content 6**, which presents P values [Wilcoxon signed-rank test] from group comparisons of asymmetry values, <http://links.lww.com/PRS/H777>.)

Secondary Outcomes

The FOD group demonstrated significantly better outcomes than the CS group across all assessed areas. Mean duration of operation was 89.5 minutes (range, 63.0 to 121.0 minutes) and 153.5 minutes (range, 60.0 to 209.0) for FOD and CS, respectively ($P < 0.001$). Mean perioperative bleeding was 6.1 mL/kg (range, 2.0 to 15.2 mL/kg) and 22.1 mL/kg (range, 1.2 to 72.2 mL/kg) for FOD and CS, respectively ($P < 0.001$). Mean perioperative blood transfusion was 3.3 mL/kg (range, 0.0 to 14.0 mL/kg) and 14.3 mL/kg (range, 0.0 to 36.2 mL/kg) for FOD and CS, respectively ($P < 0.001$). Mean LOS was 4.3 days (range, 3.0 to 6.0 days) and 5.8 days (range, 4.0 to 8.0 days) for FOD and CS, respectively ($P < 0.001$).

In the FOD group, 3 patients received antibiotics for suspected infection (Oxford 1), and 1 experienced a broken distractor arm due to trauma and required reoperation (Oxford 3). After distractor removal, 1 patient underwent débridement for a suspected superficial abscess (Oxford 3). In the CS group, 3 patients presented with superficial skin infections: 1 was managed with local wound care (Oxford 1), and the other 2 required intravenous antibiotics (Oxford 1 and 2). Of these cases, 1 also needed wound resuturing at a primary health care center (Oxford 1). One patient experienced postoperative obstipation and vomiting, but recovered fully within 1 month (Oxford 2).

DISCUSSION

Asymmetry in UCS morphology is typically assessed through various methods: linear dimensions and angles,^{2,3,6,7,18,21,38,40,50–55} 3-dimensional volume comparisons,^{5,6,17,51–53,56–61} and geometric morphometric analysis.^{8,62–64} This study is the first to incorporate all 3 methods to directly compare FOD with CS for treating UCS and examine operative morbidity. Our findings indicated that FOD, which is less invasive than CS, achieves significantly better asymmetry correction than CS.

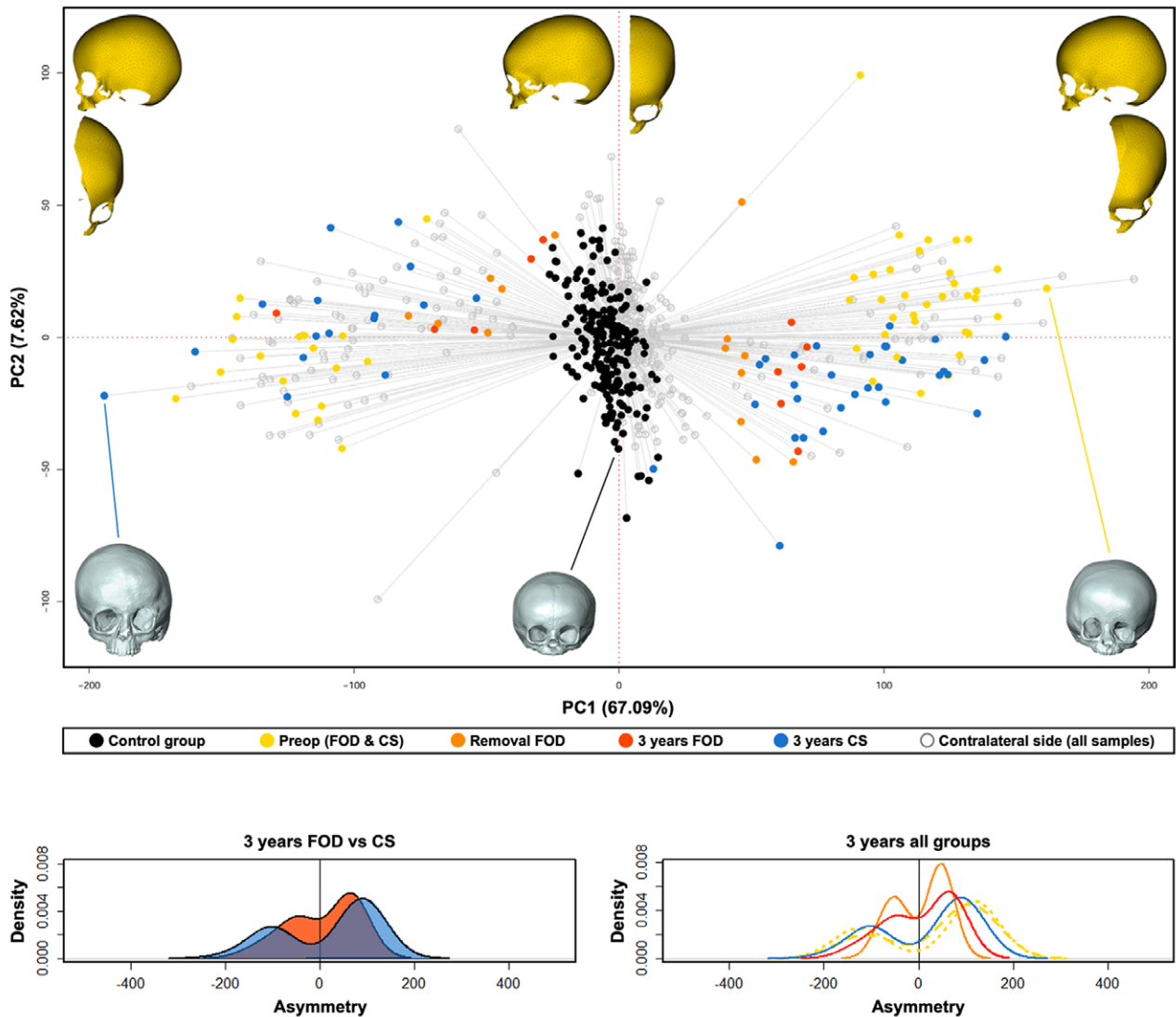


Fig. 4. PCA scatterplot (*above*) and density distribution plots (*below*) describing postsurgical asymmetry changes. Surface shape variations along the PC1 axis are shown with *yellow* crania. Three individuals demonstrating extreme fluctuating asymmetry conditions (*left and right*) and normal asymmetry (along the 0 line) are shown in *cyan*. The *dashed yellow line* in the density plot represents the preoperative FOD group; the *dotted line* represents the preoperative CS group. (See **Figure, Supplemental Digital Content 5**, for the density distribution plots of each group describing postsurgical asymmetry changes, <http://links.lww.com/PRS/H776>. See **Table, Supplemental Digital Content 6**, which presents *P* values [Wilcoxon signed-rank test] from group comparisons of asymmetry values, <http://links.lww.com/PRS/H777>.)

A general concern for FOD when used to treat older patients was that distraction would show limited success due to decreased bone pliability. However, our examination of older patients (age 16.6 and 13.8 months at the time of operation) confirmed this concern to be unwarranted. In fact, these patients tended to exhibit overcompensation in ODA and ACFD upon distractor removal. Kamel et al.⁴¹ reported a significantly longer surgical time with FOD, with no significant differences in transfusion,

LOS, or postoperative complications. However, the authors also reported increased frequency of dural tear and contour relapse after FOAR. In addition, Kim et al.⁶⁰ reported a significantly shorter surgical time for FOD but increased perioperative bleeding. Tahiri et al.⁴³ reported shorter surgery time, less bleeding, and shorter LOS after FOD relative to FOAR, which agreed with the current findings. Villavisanis et al.⁴² reported similar findings regarding the reduction of perioperative morbidity after FOD, along with a higher degree

of asymmetry correction. McKee et al.⁵ reported no significant difference between FOD and FOAR regarding correction of the orbital region. There were no reoperations within 30 days after surgery in either group, and no major complications or permanent sequelae were observed with FOD, although there was a higher incidence of suspected skin infection in this group.

One advantage of CS is that it allows a 1-stage intervention with possible instant improvement in cranial symmetry while addressing the contralateral protruding forehead, which FOD traditionally does not. However, complete forehead symmetry might not be the end goal, given that the contralateral forehead protrudes more than a normal infant's skull, suggesting that correction might result in a bilaterally protruding forehead. The downside of CS is its status as a static procedure that takes into consideration neither the natural expansion and growth of the calvaria nor the surrounding soft tissue, often leading to progressive relapse.^{18,21,54,65–68} To compensate for this, some surgeons attempt to estimate the extent of overcompensation.^{54,55,66,68–70}

We observed that FOD corrected ODA significantly better than did CS, demonstrating the efficacy of distraction in the orbital region. In addition, both ACFD and ACFC demonstrated greater degrees of improvement after FOD compared with CS. Moreover, FOD resulted in smaller differences between NOAV and AOV, as well as similarities with volume and shape measurements in controls, which is in line with previous studies.^{5,51–54,56,57,61,62,71–73} At the 3-year follow-up, both orbital shape and volume remained similar to controls to a larger extent after FOD relative to CS. Furthermore, FOD resulted in greater postoperative improvements in overall symmetry, according to PCA.

Öwall et al.⁷⁴ found that only 1 in 11 patients with minimal preoperative symmetry achieved facial symmetry comparable with that measured in a normal control after FOAR. By contrast, the patients in our cohort presenting preoperative asymmetry demonstrated improvements in ODA, ACFD, and ACFC after FOD. (See **Table, Supplemental Digital Content 7**, which shows measurements of angles preoperatively and at the 3-year follow-up, <http://links.lww.com/PRS/H778>. See **Table, Supplemental Digital Content 8**, which shows measurements of angles in the FOD group, <http://links.lww.com/PRS/H779>.)

Although FOD is used in various centers worldwide, there are differences in surgical approach, including osteotomy placement,

distraction regimens, and the number of distractors used. A 1-piece bilateral coronal osteotomy with 2 distractors that resulted in improved skull base symmetry but required a relatively long mean surgery duration (322 minutes) was described by Park et al.,⁴⁰ Choi et al.,⁵⁰ and Jeong et al.⁷⁵ A recent study by Kim et al.⁷⁶ compared the bilateral 1-piece approach with a technique similar to that described in the current study. Their results showed that this method improved both morphology and operative morbidity (mean operation time, 168 minutes versus 89.5 minutes in the current study), and that it may be unnecessary to distract the unaffected suture. The technique described by Kim et al.⁷⁶ differs from that used in the current study by its use of 2 distractors and an osteotomy involving the nasofrontal suture. The technique described by Hoppe and Taylor,¹¹ Taylor et al.,³⁹ and Tahiri et al.⁴³ involved an osteotomy placed inferiorly along the orbital roof to facilitate horizontal expansion of the orbit; a contralateral vertical osteotomy was performed at a point along the transition of the forehead deformity. The authors reported a mean operation time ranging from 111 to 127 minutes, along with a favorable perioperative bleeding profile. Brandel et al.⁵⁹ used a combination of anterior cranial vault reconstruction and release of a fronto-orbital bandeau with distraction osteogenesis. They reported larger perioperative bleeding than that observed in the current study (mean, 14.17 versus 6.1 mL/kg), but showed that distraction osteogenesis is effective for volume expansion. At our center, we use a single continuous osteotomy line extending from the anterior fontanel to the lateral third of the orbital roof along with a single distractor. Despite the absence of additional osteotomies at the orbital rim in the current study, orbital symmetry developed favorably. In the literature, distraction lengths range from 18 to 30 mm. Our protocol includes a 30-mm distraction in all cases. However, given the slight undercorrection in facial symmetry observed in the current study, further investigation into the use of a 40-mm distractor would be valuable.

Limitations

This study has several limitations. The small sample size is notable but difficult to avoid, given the infrequency of UCS diagnosis (approximately 8 children in Sweden annually). This cohort represents the majority of patients with UCS among the Swedish population, given that our center handles approximately 80% of cases in Sweden. In addition, because we compared FOD with CS

as a remodeling technique, further studies comparing other FOAR variations would be relevant. Although the primary disadvantage of FOD is the requirement for distractor removal, Corkum et al.⁷⁷ reported more unplanned reoperations after FOAR compared with FOD.

CONCLUSIONS

The results of this case–control study showed that facial and skull symmetry were significantly better after FOD compared with CS at the 3-year follow-up, with significant improvements observed in the orbital region. In addition, FOD resulted in shorter surgical time (89.5 versus 153.5 minutes), less perioperative bleeding (6.1 versus 22.1 mL/kg), and shorter LOS (4.3 versus 5.8 days). Furthermore, FOD achieved superior cranial symmetry relative to CS, while also being substantially less invasive. Given the continuing debate regarding the optimal surgical approach to UCS, these findings could promote a definitive shift in pediatric surgery.

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DISCLOSURE

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