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PURPOSE: Previous investigations of intracranial volume (ICV) in patients with metopic craniosynostosis have yielded mixed results and are limited by the number of patients included in the study sample. Additionally, no studies have characterized the impact of metopic synostosis on intracranial volume change accompanying growth. In this study, we sought to determine if metopic patients had significantly different intracranial volumes than normal, healthy children. We also compare standardized growth curves of intracranial volume change in normal patients and patients with metopic craniosynostosis.

METHODS: An IRB-approved retrospective review was performed of patients with metopic craniosynostosis at our institution. Intracranial volumes were calculated from manually segmented preoperative CT scans. Structural MRI data for normal children were acquired from the NIH Pediatric MRI Data Repository. Intracranial volumes were calculated in FreeSurfer.

Multivariate linear regression including age, gender and diagnosis (i.e. metopic and normal) was performed to determine the impact of metopic craniosynostosis on intracranial volume.

To compare intracranial volume growth in normal patients and patients with metopic craniosynostosis, a term defining the interaction between age, diagnosis and their effect on intracranial volume was added to the linear regression model. A best fit logarithmic curve of intracranial volume growth was generated for metopic patients and compared to a best fit logarithmic curve for normal patients.

RESULTS: Data were available for 73 metopic craniosynostosis patients (52 males, 21 females; age 1–21 months). 270 MRIs of normal, healthy children were available (141 males, 129 females, age 1–24 months).

Mean metopic ICV was lower than normal ICV within the first 3–6 months (14 metopic patients, mean ICV 646.59cc vs 28 normal patients, mean ICV 903.91cc, p=0.002), 6–9 months (26 metopic patients, mean ICV 737.92cc vs 33 normal patients, mean ICV 868.81cc, p=0.005) and 9–12 months of life (19 metopic patients, mean ICV 848.01cc vs 29 normal patients, mean ICV 956.62cc, p=0.038). When controlling for age and gender, the difference in intracranial volume associated with metopic synostosis ranged from 112.67cc (13%) to 304.37cc (32%), with the most significant effect from age 3–6 months (304.4cm³, 32%). There was no difference in intracranial volume after 12 months of age (8 metopic patients, mean ICV 997.65cc vs 96 normal patients, mean ICV 1000.11cc, p=0.916).

Intracranial volume growth in patients with metopic synostosis was defined by a significantly different growth equation than normal patients (metopic: y=230.61ln(x)+323.0, normal: y=103.89ln(x)+390.4; p=0.005). Compared to normal patients, metopic patients demonstrated more rapid growth velocity from 1–3 months (126.7 vs 57.1cm³/month), 3–6 months (53.3 vs 24.0cm³/month), 6–9 months (31.2 vs 14.1cm³/month) and 9–12 months (22.1 vs 9.9cm³/month).

CONCLUSION: In the first year of life, patients with metopic synostosis have significantly reduced intracranial volumes, yet greater than normal intracranial volume growth velocity. It appears the restrictive effect of metopic synostosis relative to normal patients originates, in part, from disparities of intracranial volume at birth, rather than restricted calvarial growth in early life. As a result, cranial vault reconstruction targeting volume expansion should be performed in early life to more rapidly achieve normal volumes in these patients.

Distraction Osteogenesis for Unicoronal Craniosynostosis Results in Decreased Rates of Postoperative Strabismus

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BACKGROUND: Traditional fronto-orbital advancement (FOA) is the standard of care for patients with isolated unicoronal craniosynostosis (UCS), however it is associated with significant intraoperative blood loss and high rates of
strabismus, both of which have been shown to be lessened by fronto-orbital distraction. This study will describe our current experience with distraction osteogenesis (DO) in the treatment of UCS with regards to perioperative morbidity and the resultant development of new-onset strabismus (are we sure they didn’t have strabismus preoperatively?).

METHODS: All patients undergoing DO for isolated UCS at our institution (13 patients) were examined and compared to the most recent 11 patients undergoing traditional FOA for UCS. Patient age, operative time, blood loss, blood replacement, technical details of the surgery, length of stay (LOS), complications, and the development of new onset strabismus following surgery were documented and compared statistically.

RESULTS: A chi-square analysis and student’s t test with a significance value of .05 was utilized for analysis. Mean follow-up time was 21.7 months in the DO group and 31 months in the FOA group (p=0.32). Patients undergoing DO compared to FOA trended towards being younger (6.3 and 9.1 months, p = 0.05), experienced significantly less operative time for the initial procedure (115 vs 192 minutes, p < 0.01), significantly less blood loss (26 vs. 55 % of total blood volume, p < 0.05), and significantly less blood replacement (40 vs. 63 % of total blood volume, p < 0.05). DO also trended towards a decreased LOS (3.1 and 4.5 days, p = 0.10). The mean age of distractor removal was 8.9 months with a mean operative time of 32 minutes, blood loss of 18cc, and length of stay of 24 hours. The mean distance distracted was 36mm. One patient in the DO group experienced a new-onset strabismus postoperatively compared with 5 in the FOA group (p < 0.05). There were no complications requiring a return to the operating room in either group.

CONCLUSION: DO for the treatment of isolated UCS provides a favorable perioperative morbidity profile and decreased incidence of post-operative strabismus compared with traditional FOA. These positive factors are tempered by the need for an additional procedure for removal of the device and lack of long-term follow-up data on the stability of the advancement. Further investigation is warranted on both of these fronts.

**Functional Network Development in Sagittal Craniosynostosis Treated with Whole Vault Cranioplasty**

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**PURPOSE:** The purpose of this study is to understand the neurological changes before and after (infants and adolescents) whole vault cranioplasty (WVC) for patients born with sagittal craniosynostosis, by studying aberrations in functional brain connectivity and white matter microstructure utilizing functional MRI (fMRI) and diffusion tension imaging (DTI), respectively.

**METHODS:** A case control study was performed that included thirty fMRI scans, from twenty-five individual patients. Five infant patients before (5±2 months of age) and after (9±2 months of age) underwent data collection by fMRI and DTI data in WVC for patients born with sagittal craniosynthesis. Patients on average were operated on at age 6±2 months. Ten adolescent patients (12.1 years of age) that have been diagnosed with sagittal craniosynthesis and treated with a whole vault cranioplasty and ten age-matched controls were also scanned. fMRI data was analyzed with BioImageSuite (Yale University, USA). The fMRI images were registered to Montreal Neurological Institute (MNI) space. All nine functional networks were analyzed with appropriate regions of interest were utilized for analysis. For the DTI data, three diffusion runs were averaged, processed utilizing FMRIB Software Library (Oxford University, UK).

**RESULTS:** Comparing the infants after WVC vs. infants before WVC group, after WVC demonstrated a increased connectivity in the left frontoparietal (LFPN) in the right (MNI: 37,6,2) and left (MNI: -35,9,3) insula, right putamen (MNI: 32,3,2), and inferior frontal gyrus (MNI: -39,5,8) (p<0.001). The right frontoparietal (RFPN) had decreased connectivity despite surgery in the left dorsal (MNI: -6, -53,39) and ventral (MNI: -2, -53,26) posterior cingulate (p<0.001). The secondary (V2) and third (V3) visual network has increased connectivity despite surgery in the insula (MNI: 37,-2,10), inferior frontal gyrus (MNI: -42,9,7), and right putamen (MNI: 30,-6,7) (p<0.001). There is also a decrease and increase in anisotropy, measure of brain maturity, in the cingulum and precuneus after