The Spectrum of Severity in 368 Patients with Metopic Craniosynostosis: An Update to the CranioRate™ Machine Learning Algorithm

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Background

- Metopic craniosynostosis is characterized by the premature fusion of the metopic suture, which results in altered skull growth and pathologic head-shape.
- CranioRate™ is a publicly available, point-of-care analysis tool which utilizes machine learning to quantify morphologic severity in patients with metopic craniosynostosis.

Objectives

- To understand the spectrum of severity and to quantify drivers of clinically appreciable severity in metopic craniosynostosis.

Methods

- The CranioRate™ machine learning algorithm provides two objective, holistic metrics for quantifying severity in metopic craniosynostosis

Metopic Severity Score (MSS): A supervised, specific metric for quantifying morphologic deviation in a metopic direction

Cranial Morphology Deviation (CMD): An unsupervised, non-specific metric of skull dysmorphology

Results

CT Scans
- A total of 460 CT scans (92 normal patients, 368 metopic patients) from five institutions across the U.S. were uploaded to CranioRate™.

Population Characteristics
- Average age at CT was 0.75 □ 0.51 years, and 74.0% of patients were male.
- Among normal controls, average MSS was 0.00 □ 1.04, and average CMD was 85.23 □ 19.32.
- Among metopic patients, MSS averaged 5.02 □ 2.41, and CMD averaged 192.20 □ 44.62.

Figure 1: MSS and CMD in Normal vs. Control Patients
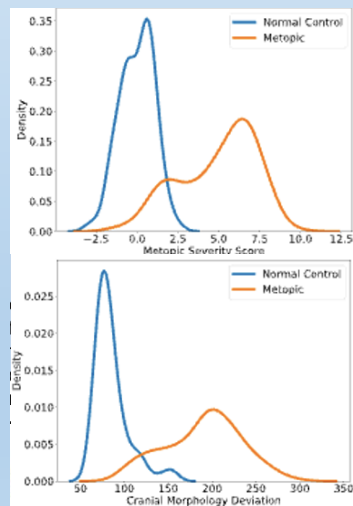
Both MSS and CMD were significantly different between control and metopic patients (p<0.0001).

Figure 2: Range of Metopic Severity Scores
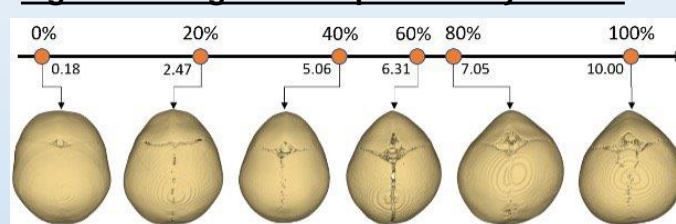
Areas of the Skull Associated with Metopic Severity

- Regression analysis identified the following regions as areas most associated with severity differences (p<0.05)
- Central frontal bone
- Lateral orbit
- Supraorbital rim

Figure 3: Predictors of Metopic Severity
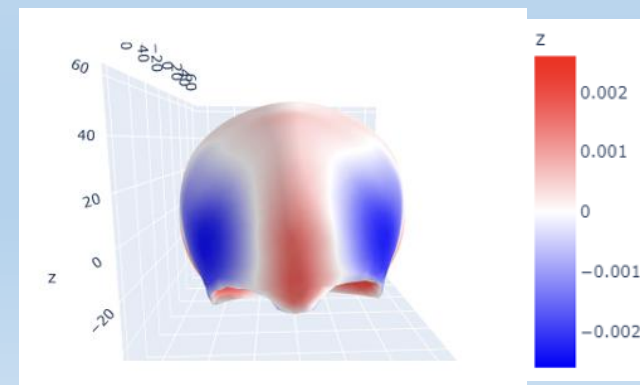
Conclusions

- Over the past five years, our institution has collaborated with five outside institutions to collate the largest collection of metopic CT scans to date.
- We used our machine-learning algorithm to present an objective quantification of the full spectrum of severity in metopic craniosynostosis.
- We reverse analyzed CT scans to derive regions of the skull most predictive of metopic craniosynostosis severity

Limitations/Future Directions

- **Limitation:** Limited to U.S. institutions and metopic CS
- **Next Steps:** Apply our algorithm to other types of craniosynostosis (sagittal, coronal) and collaborate with international institutions

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