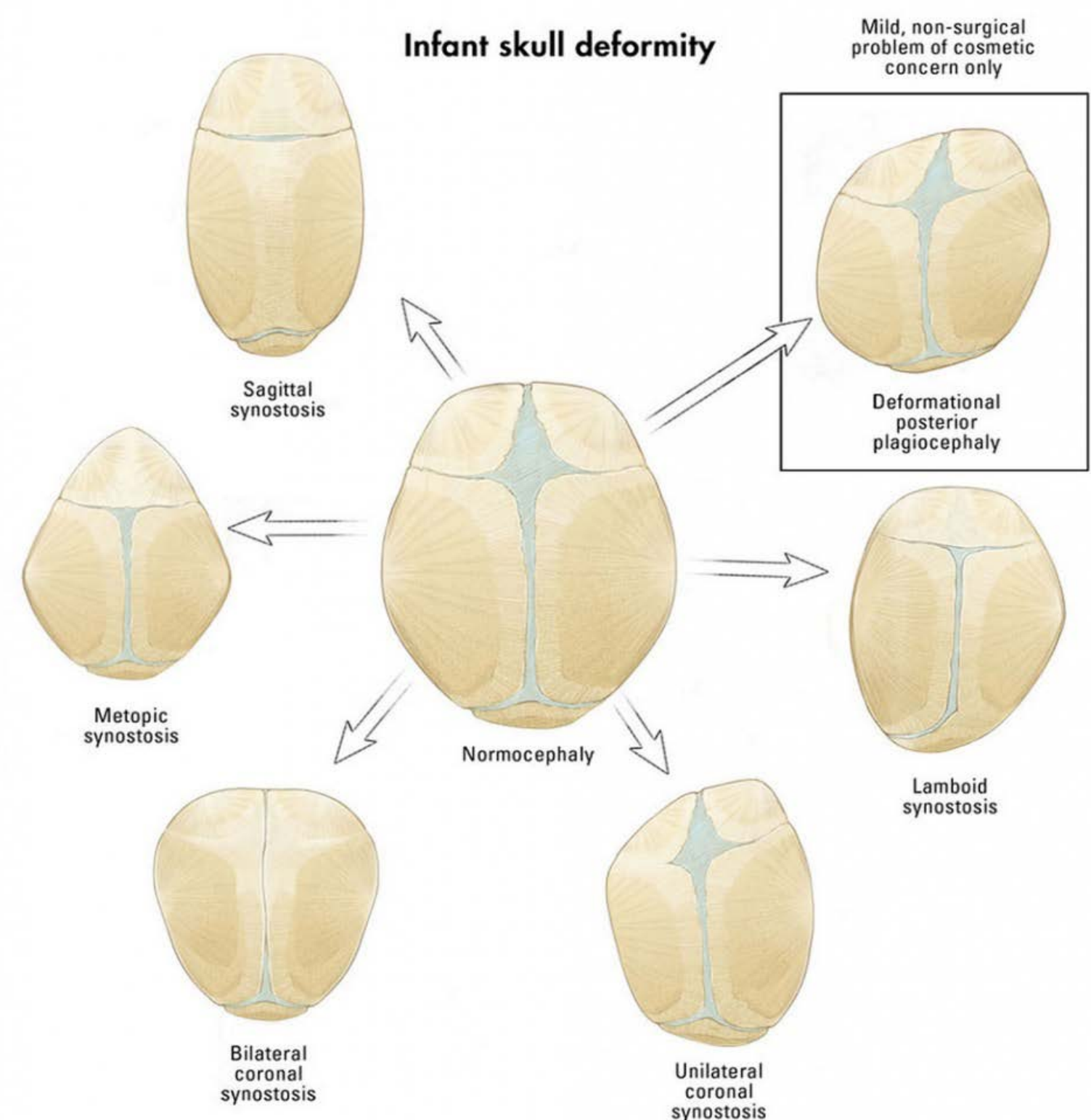# CranioRate: A Deep-Phenotyping Analysis Toolset, Repository, and Interface for Craniosynostosis

Prof. Shireen Elhabian, Prof. Jesse Goldstein (Children's Hospital of Pittsburgh), Prof. Ross Whitaker
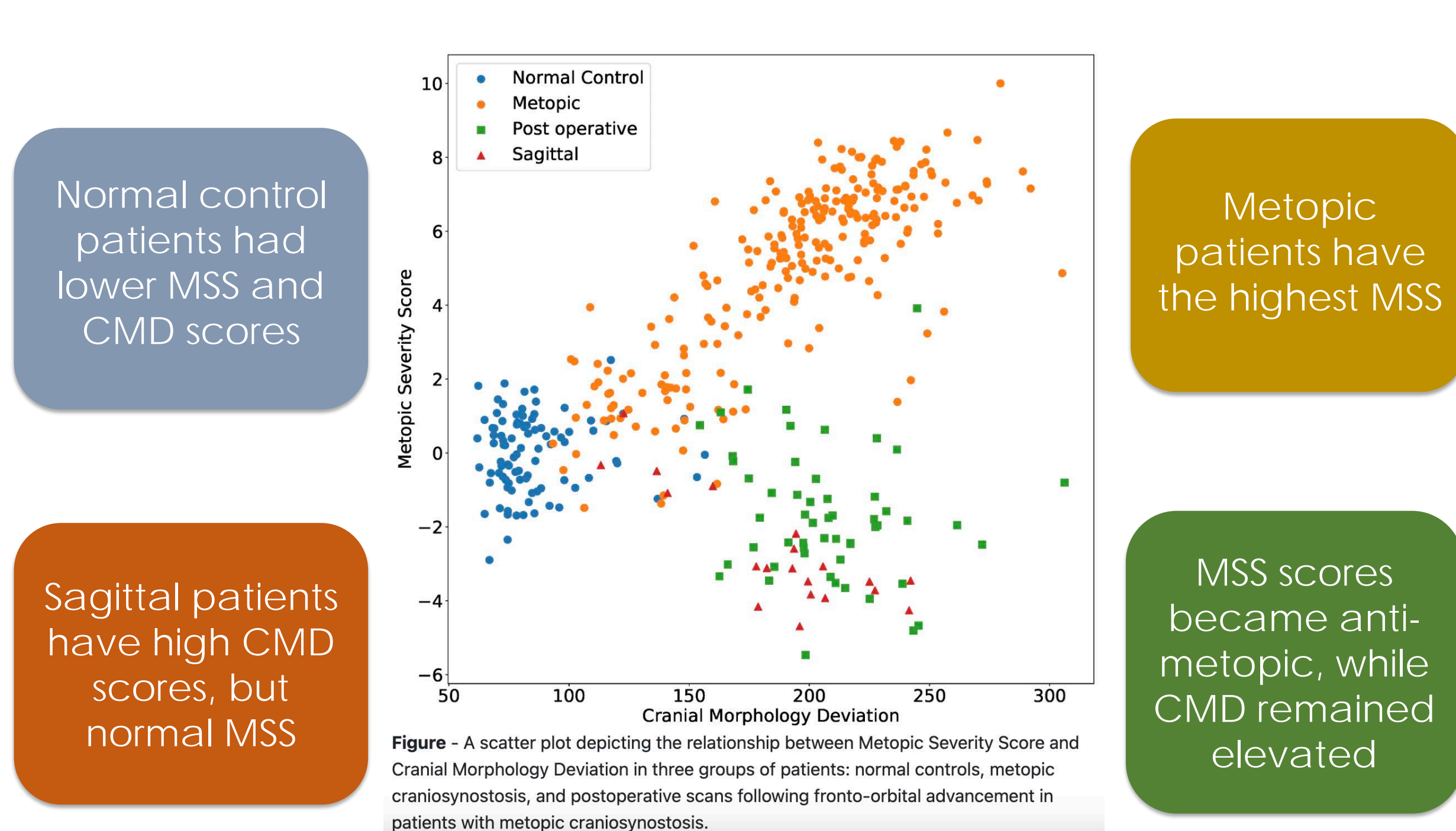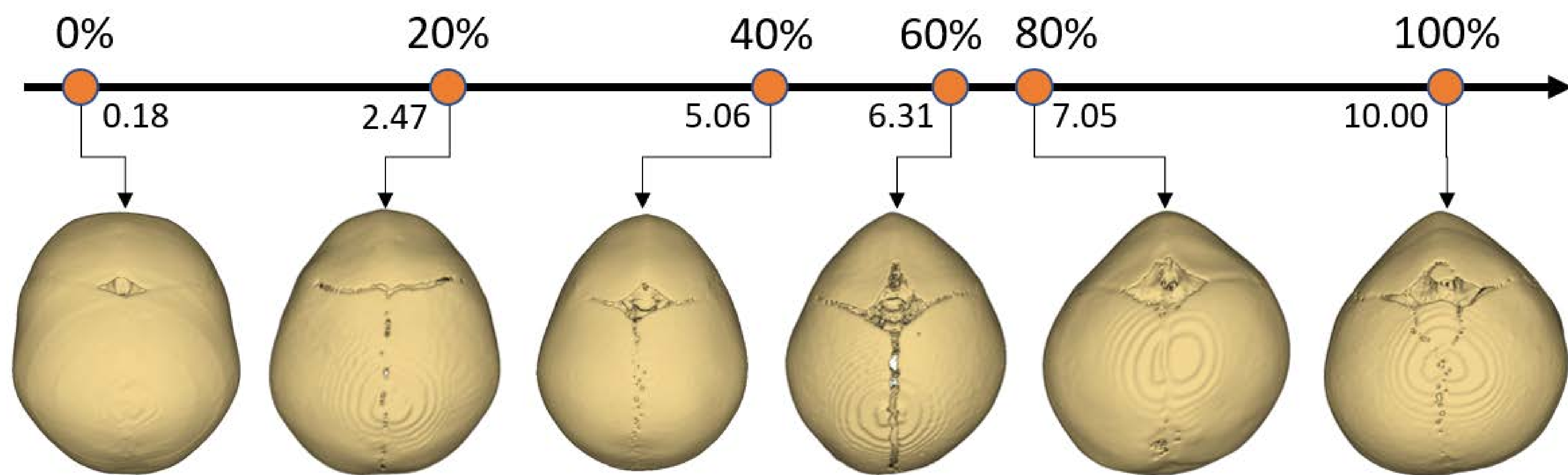
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Objective Measurements

Craniosynostosis: Wide Spectrum, No Consensus

Infant skull deformity

Cranial Morphology Deviation: Dysmorphology Beyond Metopic Severity

Normal control patients had lower MSS and CMD scores

Metopic patients have the highest MSS

Sagittal patients have high CMD scores, but normal MSS

MSS scores became anti-metopic, while CMD remained elevated

Figure – A scatter plot depicting the relationship between Metopic Severity Score and Cranial Morphology Deviation in three groups of patients: normal controls, metopic craniosynostosis, and postoperative scans following fronto-orbital advancement in patients with metopic craniosynostosis.

Metopic Severity Score: Regression from Shape Based on Surgeon Ratings on CT

0%	20%	40%	60%	80%	100%
0.18	2.47	5.06	6.31	7.05	10.00

Clinical Applications

Post-op Skulls Move from "Anti-metopic" to Normal over Time

MSS and CMD Long-Term Follow-Up

Pre-op Severity is Independent of Immediate Post-op Severity Associated with Late Post-op Severity

Preop vs. Postop and Long-Term Severity

Preoperative severity correlates with late postoperative morphology

No correlation between pre-op severity and immediate post-op

CranioRate Analysis and Visualization

MSS=10.0, CMD=257.5

MSS Metopic Severity Score

CMD Cranial Morphology Deviation

MSS=0.5, CMD=61.9

Case [scan-2021-06-02-111724]: Deviation from the Normal Mean

Metopic Severity Score: 4.20
Metopic Severity Percentile: 25.81%
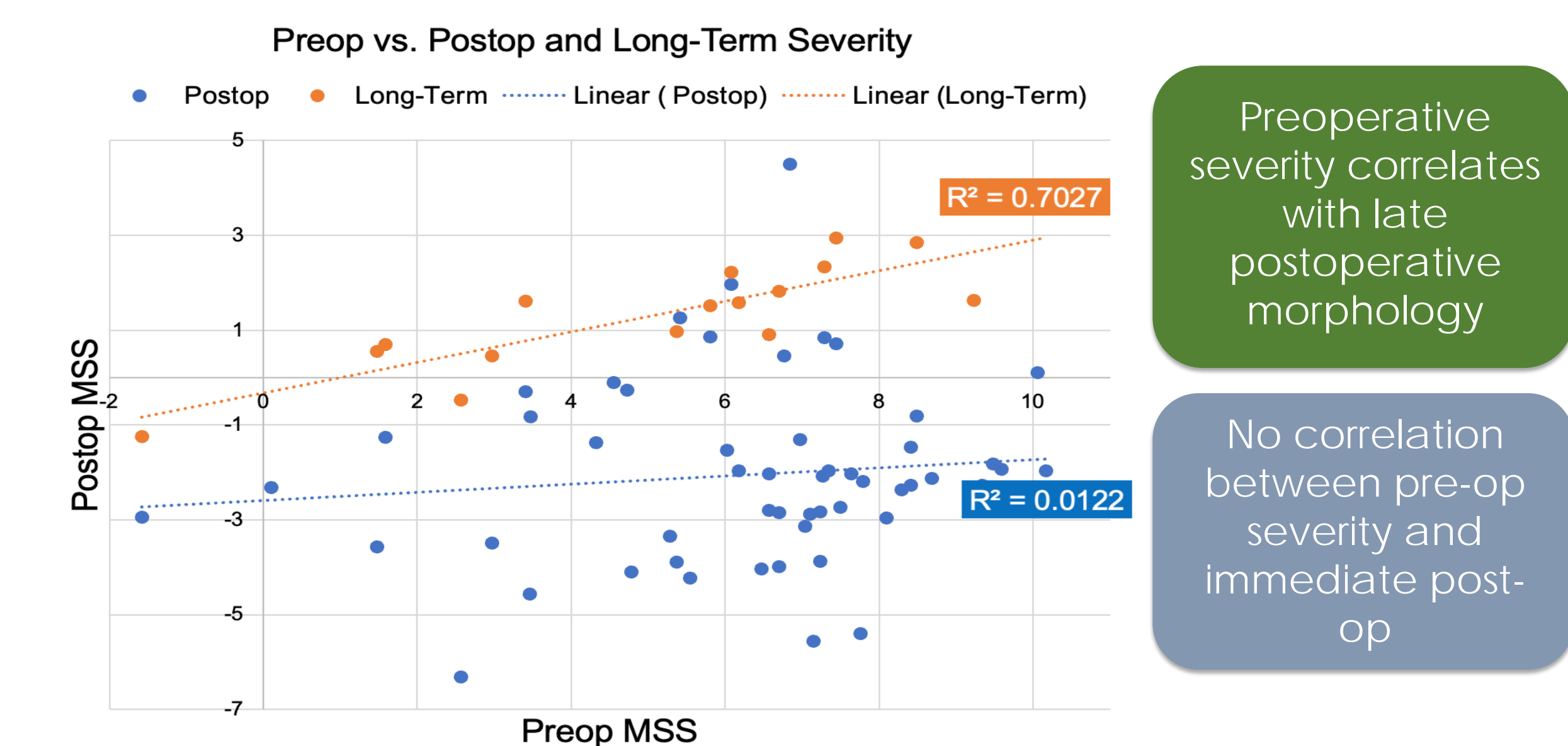
Extending Capabilities

Surface Scans: Regression from Skin Surface to Skull

Comparison of MSS Derived from CT Skull vs. 3D Photograph
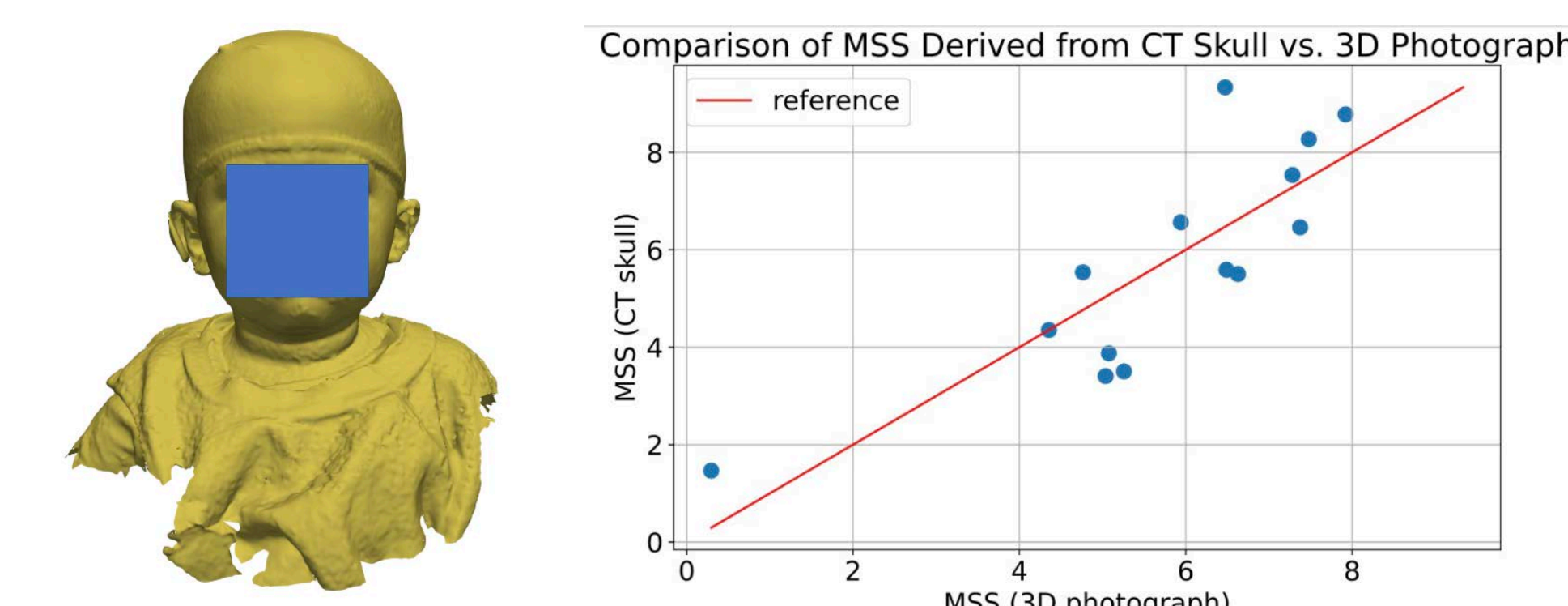
Sagittal CSS: More Complex Phenotype, Survey for Clinicians Released in Feb 2024
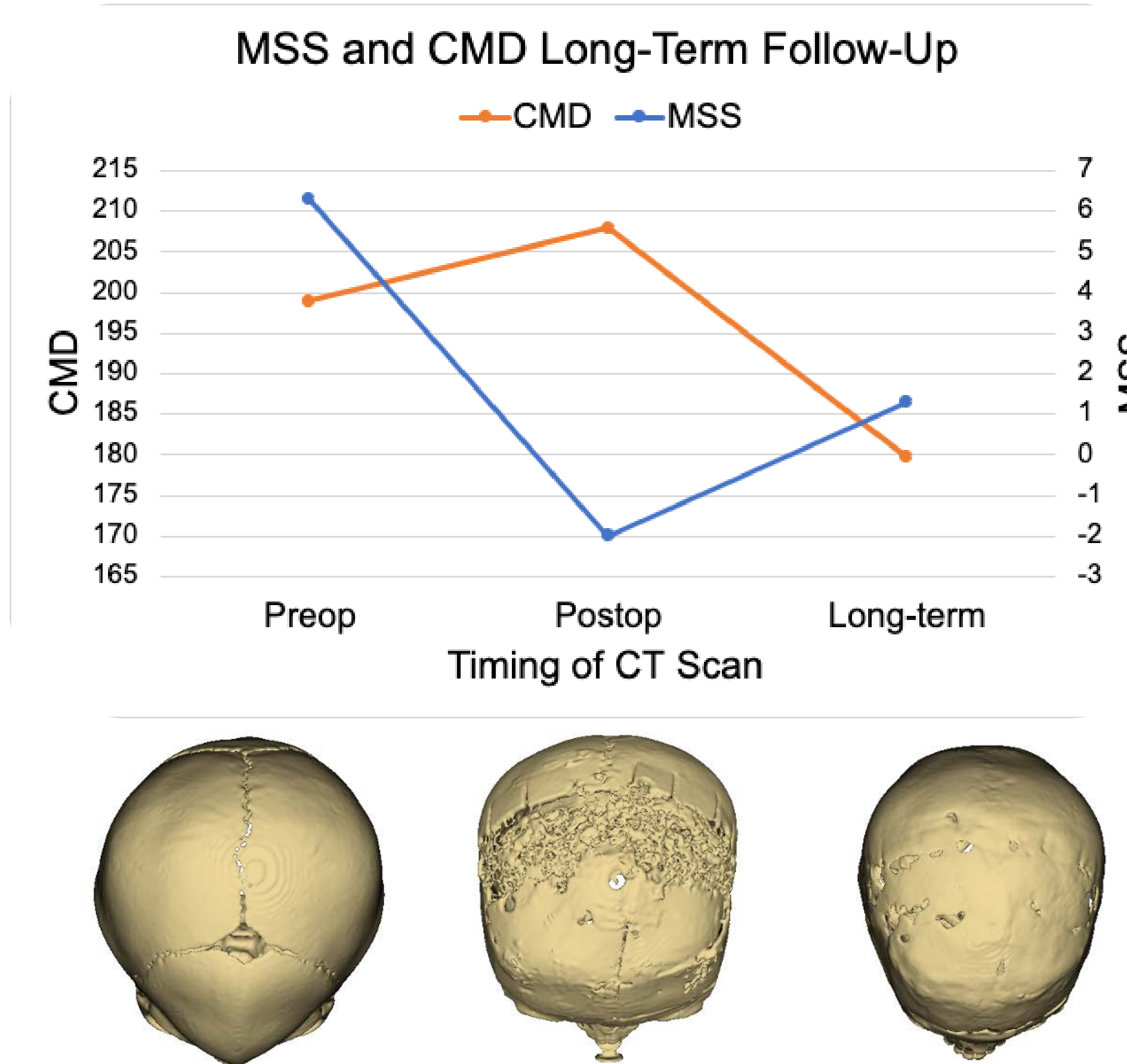

NORMAL — SAGITTAL CRANIOSYNOSTOSIS

References

[1] Bhalodia, Riddhish, Lucas A. Dvoracek, Ali M. Ayyash, Ladislav Kavan, Ross Whitaker, and Jesse A. Goldstein. "Quantifying the severity of metopic craniosynostosis: a pilot study application of machine learning in craniofacial surgery." Journal of Craniofacial Surgery 31, no. 3 (2020): 697-701.

[2] Anstadt, Erin E., Wenzheng Tao, Ejay Guo, Lucas Dvoracek, Madeleine K. Bruce, Philip J. Grosse, Li Wang, Ladislav Kavan, Ross Whitaker, and Jesse A. Goldstein. "Quantifying the severity of metopic craniosynostosis using unsupervised machine learning." Plastic and reconstructive surgery 151, no. 2 (2023): 396-403.

[3] Beiriger, Justin W., Wenzheng Tao, Madeleine K. Bruce, Erin Anstadt, Cameron Christensen, John Smetona, Ross Whitaker, and Jesse Goldstein. "CranioRate TM: An Image-Based, Deep-Phenotyping Analysis Toolset and Online Clinician Interface for Metopic Craniosynostosis." Plastic and Reconstructive Surgery (2024): 10-1097.
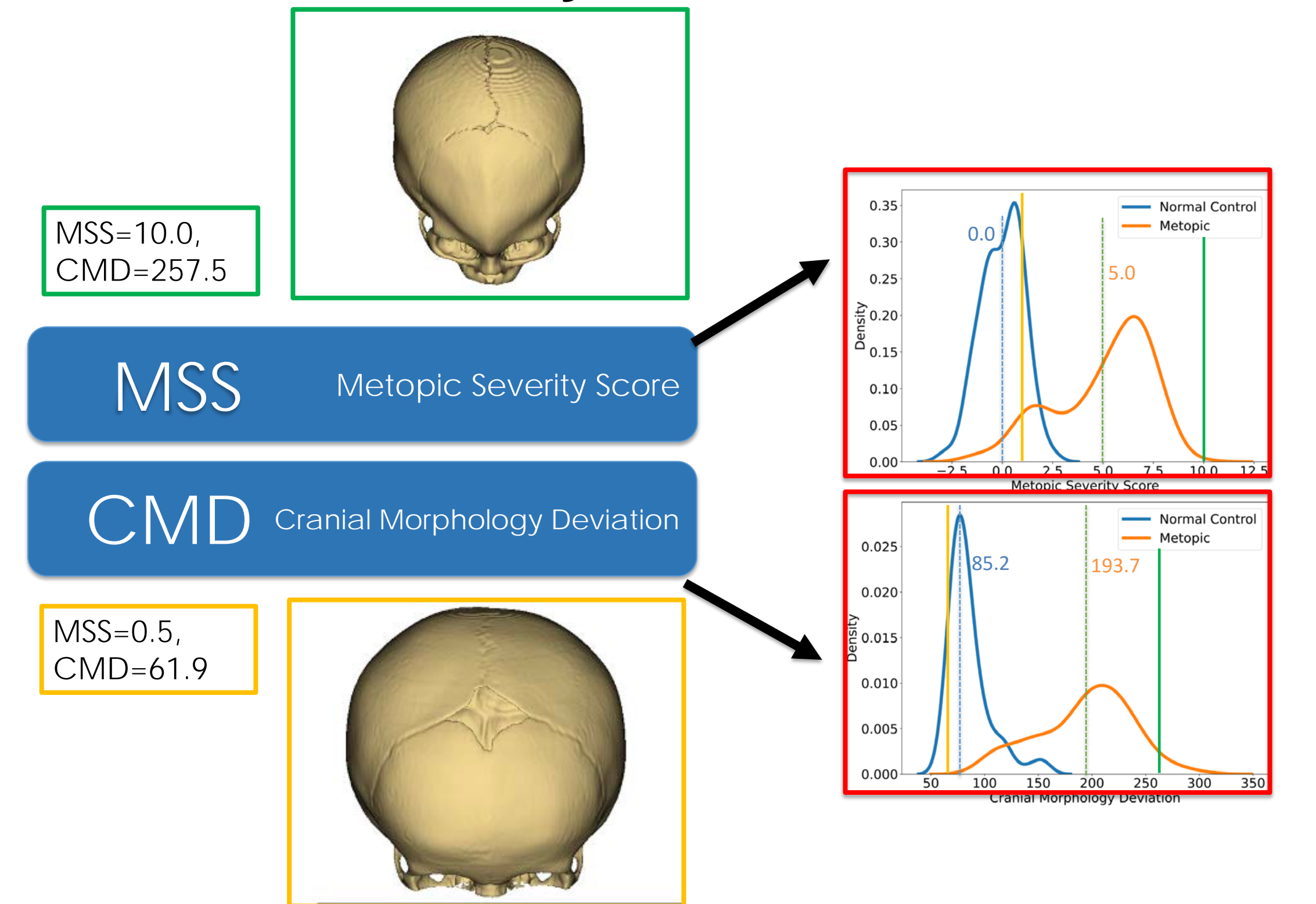
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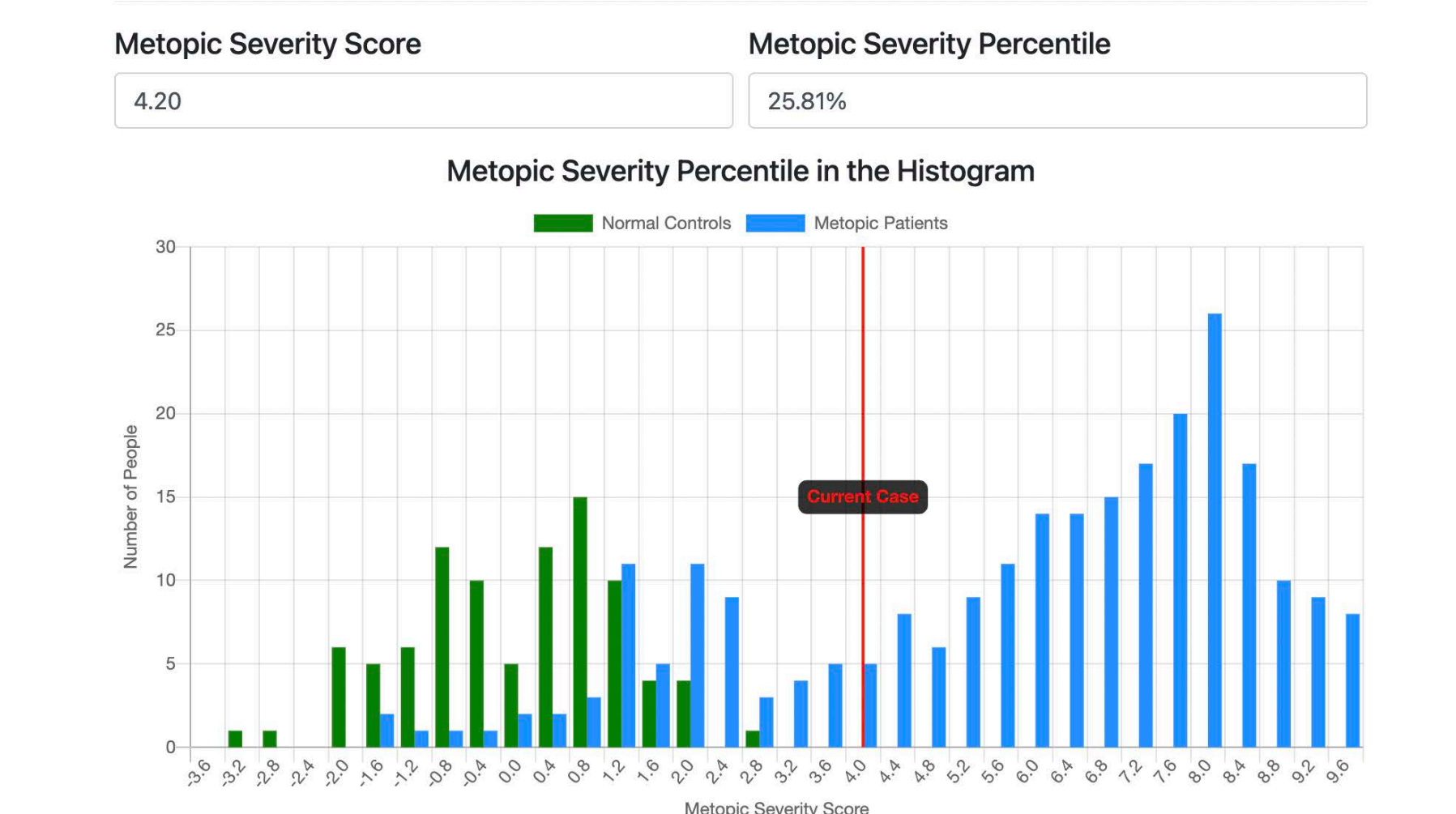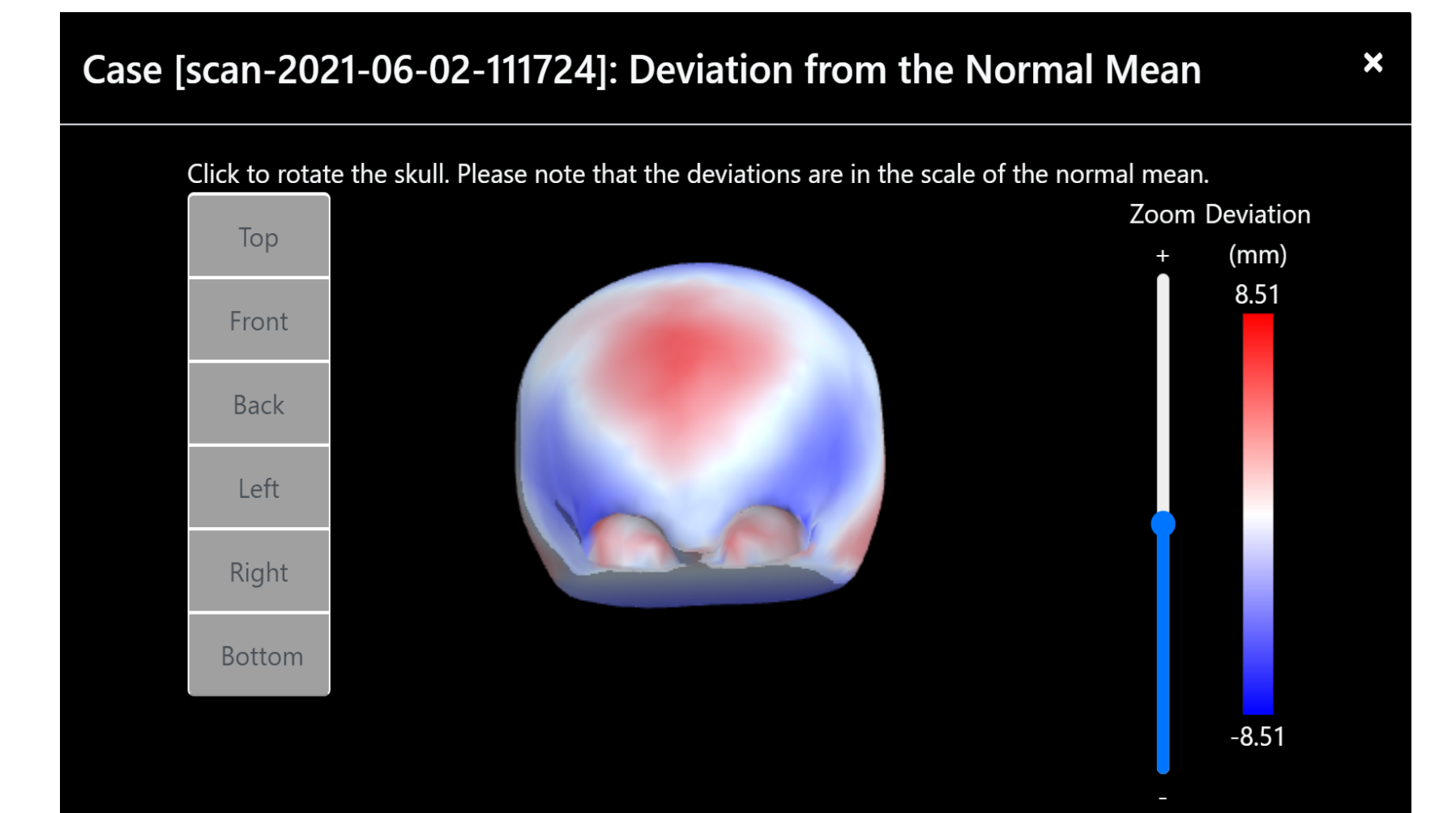
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