The Quantitative Analysis of Coronal Suture Separation Due to Cranial Trauma

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Abstract

Morphometric analysis of cranial sutures can provide evidence of microfractures, diastasis, and early sutural closure. Recently, mCT has allowed for morphometric analyses on much smaller scales and has been used to differentiate normal cranial sutures from early sutural synostosis. Results suggest that more data may be available at microscopic levels. Here, I tested for asymmetrical separation in coronal sutures to determine if significant differences could be detected by comparing the sides that received trauma with the contralateral regions. Three human cranial trauma cases and one control specimen from the Southeast Texas Applied Forensic Science (STAFS) facility in Huntsville, TX were used in this study. All specimens were European adult males >56 years of age. Trauma cases included an intraoral gunshot wound (GSW) and blunt force trauma (BFT). Amira 6.7.0 was used to calculate the maximum distance of separation of the suture and total area of separation for individual scan slices. Asymmetry was determined by comparing the differences in coronal suture separation between the left and right sides delineated by intersection with the sagittal suture (bregma). To standardize data collection, imaging of the coronal sutures began at their origin (pterion) and terminated at bregma. Due to the tortuous nature of the coronal suture, a comb-based approach was used to standardize sampling sites. Avizo 9.7.0 was used to define and measure a chord length between bregma and pterion, which allowed for the placement of twenty equidistant sampling sites at orthogonal angles from the chord line. Maximum sutural width was measured as the largest distance observed, and total open area per slice was calculated. Paired t-tests were used to assess statistical significance in both quantitative measures for each specimen. Preliminarily results suggest asymmetry in both variables. Ultimately, these data could provide forensic scientists another method to assess injury and may lead to a more thorough understanding of sutural diastasis in adult human skulls.

Introduction

Cranial sutures are fibrous (synarthrotic) articulations between the margins of adjacent bones that hold the bones of the skull together while providing mechanical support and flexibility (1,2). Macroscopic assessment of cranial suture ossification has been widely viewed as unreliable and highly variable, shifting current examinations to more appropriate imaging techniques such as micro computed tomography (mCT) (3,4,5,6). Through mCT technology, we examined crania subjected to ballistic and blunt force trauma to determine asymmetrical separation of the coronal suture by observing maximum sutural width and and total open sutural area.

Figure 1: *Intraoral GSW specimen*

Figure 2: *BFT trauma specimen*

Figure 3: *Control specimen*

Materials and Methods

Two human cranial trauma cases and one control specimen from the STAFS facility were used in this study. Trauma cases included an intraoral gunshot wound (GSW) and blunt force trauma (BFT) (Fig. 1-3). Specimens were scanned at the University of Texas CT lab using mCT technology. Amira 6.7.0 was used to calculate the maximum distance of separation of the suture and total area of separation for individual scan slices. Asymmetry was determined by comparing the differences in coronal suture separation between the left and right sides delineated by intersection with the sagittal suture (bregma). To standardize data collection, imaging of the coronal sutures began at their origin (pterion) and terminated at bregma (Fig. 4). A comb-based approach was used to standardize sampling sites. Avizo 9.7.0 was used to define and measure a chord length between bregma and pterion, which allowed for the placement of twenty equidistant sampling sites at orthogonal angles from the chord line (Fig. 5 & 6). Maximum sutural width was measured as the largest distance observed, and total open area per slice was calculated (Fig. 7). Paired t-tests were used to assess statistical significance in both quantitative measures for each specimen.

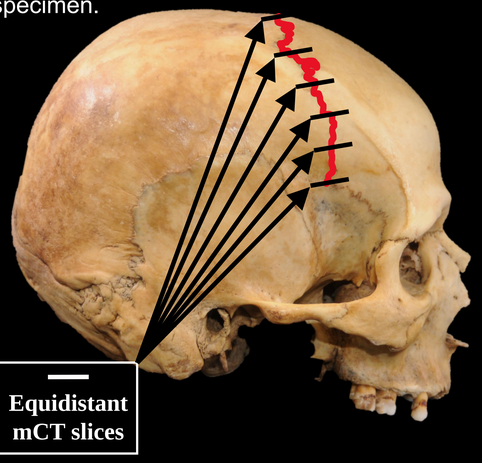

Figure 4: *Depiction of sampling strategy*

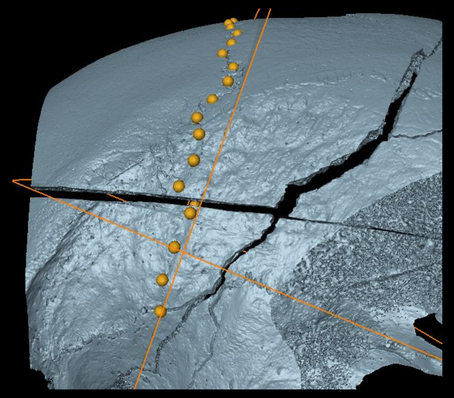

Figure 5: *Bregma and pterion chord line and orthogonal CT slice plane*

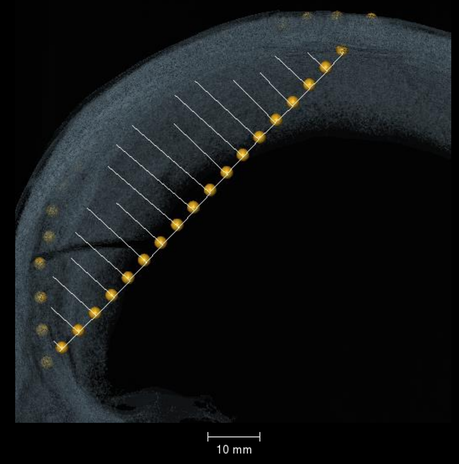

Figure 5: *Comb-based sampling approach*

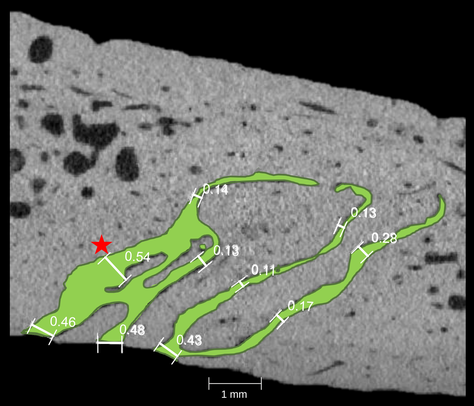

Figure 5: *CT slice of maximum sutural width and total open area*

Results

Specimen	Left Suture $\bar{X}$	Left Sutural Range	Right Suture $\bar{X}$	Right Sutural Range	T-Stat (Paired)	P-value
Area (mm²)						
Control	3.30	0.00 – 13.04	47.49	0.21 – 119.21 ★	-7.25	<0.0001
BFT	5.77	0.00 – 13.05	8.99	0.00 – 20.32	-3.16	0.0049
GSW	2.75	0.29 – 6.20	1.53	0.15 – 3.00	3.58	0.0019
Max Width (mm)						
Control	0.58	0.12 – 1.10	2.21	0.55 – 3.71 ★	-7.89	<0.0001
BFT	0.78	0.00 – 2.56	0.94	0.00 – 1.92	-1.42	0.17
GSW	0.49	0.21 – 0.77	0.47	0.20 – 0.89	0.42	0.67

★ Outlier

Discussion

With the use of mCT technology, coronal suture asymmetry may provide additional information about the direction and type of traumatic forces. Further studies will include additional blunt force and ballistic trauma specimens and our results indicate that the methodology used is reliable enough to expand the scope of our project.

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