

# Frontal bone shape and sinus size across US based populations

Colton Dee, OMS-II | Anatomy | DMU  
Lauren N. Butaric, PhD

## Introduction

Human facial sinus cavities have long been a mystery bringing about many questions—particularly regarding individualistic and group variation in structure<sup>1,2</sup> However limited information is known about the growth, development, and variation of this structure. This study was performed to determine if frontal sinus volume correlates specifically with midline frontal curvature. This assumption has been suspected in previous studies<sup>3</sup>, but has yet to be fully investigated. Specifically, this study investigates, if/ how the frontal sinus varies with skull size and shape, genetically determined sex, and ancestral origins.

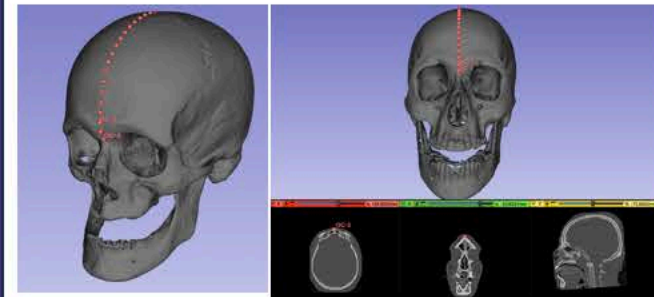


Figure 1. Screenshot 3D slicer, showing midline frontal bone landmarks and corresponding CT scans.

## Methods

Using Slicer3D, skull shape and midline frontal bone curvature was measured via landmark and principal component analyses (PCA) (see Figure 1).

Principal components illustrating frontal bone shape was compared to pre-collected frontal sinus volume. A total of 233 pre-formed 3D skull models, created from CT scans was utilized.

The sample included: 113 individuals from the Smithsonian collection (African Female=22; African Male=39; European Female=18; European Male=34) and 120 individuals from the New Mexico Decedent Imaging Database<sup>4</sup> (African Female=30; African Male=30; European Female=29; European Male=29).

Regression analyses and t-tests were run in SPSS to assess potential associations between the variables.

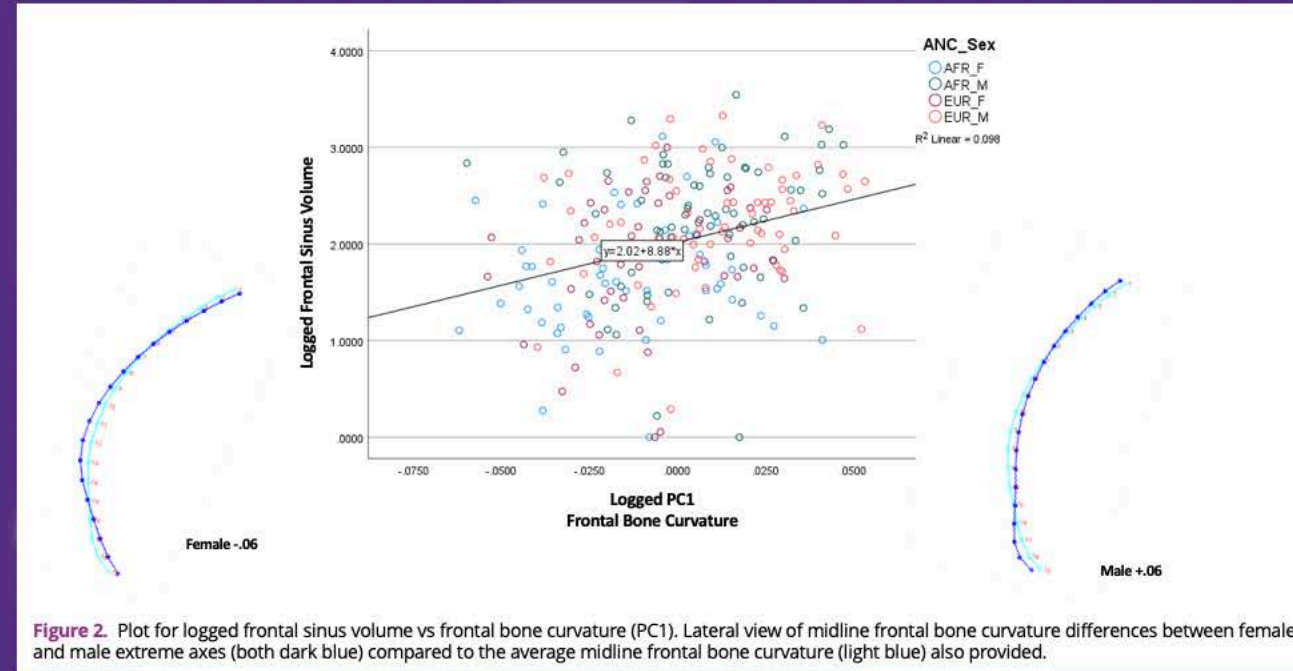


Figure 2. Plot for logged frontal sinus volume vs frontal bone curvature (PC1). Lateral view of midline frontal bone curvature differences between female and male extreme axes (both dark blue) compared to the average midline frontal bone curvature (light blue) also provided.

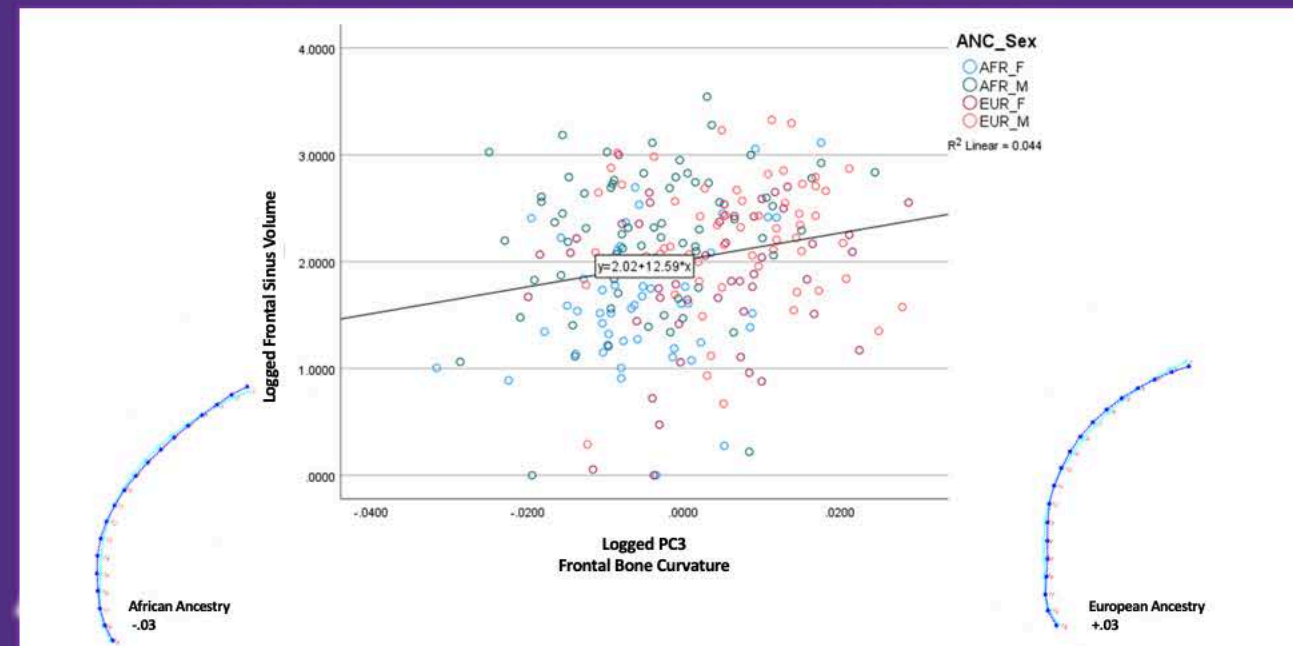


Figure 3. Plot for logged frontal sinus volume vs frontal bone curvature (PC3). Lateral view of midline frontal bone curvature differences between African and European extreme axes (both dark blue) compared to the average midline frontal bone curvature (light blue) also provided.

## Results

Analyses comparing sinus volume and midline frontal bone curvature showed **no** significant correlation. However, there were several trends noted.

- PC1 indicated sex based differences. Males had more prominent supraglabellar depression in midline curvature compared to females (PC1:  $t=6.77$ ,  $p<.001$ ).
- PC3 indicated ancestral based differences. Individuals of African descent had more rounded frontal bones, while Europeans had flatter frontal bones (PC3:  $t=7.53$ ,  $p<.001$ ).
- These results can be seen in **Figures 2 and 3**.

## Conclusion

- These findings depart from the proposed assumption<sup>3</sup> of larger supraglabellar depression correlating with smaller frontal sinus size.
- As such, further investigation into what may be driving frontal sinus size and variation is necessary.
- This study and others in its field pose theoretical uses in various fields: Osteoarchaeology, Forensics, Clinical management of sinus related conditions, and Surgery approaches.

## References

1. Pondé, J. M., Metzger, P., Amaral, G., Machado, M., & Prandini, M. (2003). Anatomic variations of the frontal sinus. *min-Minimally Invasive Neurosurgery*, 46(01), 29-32.
2. Shamlou, A. A., & Tallman, S. D. (2022). Frontal sinus morphological and dimensional variation as seen on computed tomography scans. *Biology*, 11(8), 1145.
3. Zollikofer, C. P. E., & Weissmann, J. D. (2008). A morphogenetic model of cranial pneumatization based on the invasive tissue hypothesis. *Anatomical Record*, 291(11), 1446-1454.
4. Edgar, H. J. H., Daneshvari Berry, S., Moes, E., Adolphi, N. L., Bridges, P., Nolte, K. B. (2020). New Mexico Decedent Image Database. Office of the Medical Investigator, University of New Mexico

## Acknowledgements

The authors would like to thank curators of the Smithsonian Institution and New Mexico Decedent Image Database for access to CT scans, as well as DMU alumni M Wright and C Amundson for collecting frontal sinus volumes in previous studies. Author C Dee would also like to thank DMU's MSRP program for the opportunity. Portions of this research was funding by NIJ grant award #2020-CX-0013.