A87 Ancestral Variation in Orbital Rim Shape: A 3D Pilot Study

Katie M. Rubin, MS, CA Pound Human ID Laboratory, PO Box 103615, Gainesville, FL 32610; and Valerie DeLeon, PhD, University of Florida, Dept of Anthropology, Turlington Hall, Rm 1112, Gainesville, FL 32611*

After attending this presentation, attendees will better understand how curviplanar relationships along the orbital rim may inform ancestry analyses and may begin to evaluate orbital shape in 3D.

This presentation will impact the forensic science community by highlighting the need to investigate non-metric traits more rigorously as forensic anthropology moves into the future.

Traditional non-metric methods of ancestry assessment posit that orbital shape can be used to help discriminate among broad ancestral groups.[1,2] These claims are based upon visual assessment of crania (rendering them prone to high inter- and intra-observer error) and are supported by limited frequency data. Recently, a handful of studies have used geometric morphometrics to reassess ancestral differences in 2D orbital shape.[3,4] A study by Urbanová assessed ancestral variation in orbital shape in three dimensions; however, this study looked at differences between Czech and Portuguese populations only.[5] To this study's knowledge, no published studies assess 3D orbital variation for the three broad ancestral groups commonly discussed in United States ancestry assessment literature. The results of this pilot study suggest a need to fill this research gap, especially as the demand for forensic scientists to offer statistical support for their methods increases.

The cranial sample used in this study is part of the evidentiary collection of the C.A. Pound Human Identification Laboratory at the University of Florida. The study sample consists of 9 individuals of primarily Asian ancestry (broadly defined), 10 individuals of primarily African ancestry, and 12 individuals of primarily European ancestry.

All crania were digitized using a MicroScribe®. Bregma, nasospinale, and staphylion were digitized to establish a homologous midline plane. Each orbital rim was divided into upper (vault) and lower (facial) curves using dacryon and frontomalare orbitale as homologous start and end points and digitized using the MicroScribe® scan setting. To minimize intra-observer error, each curve was digitized three times. Curve coordinates for each trial were resampled (10 semilandmarks for the upper curve; 15 for the lower) and subjected to sliding semilandmark analysis within specimens using IMP8 Simple3D ChainMan3D executable software. The mean orbital shape for each specimen was calculated with Simple3D. All mean shapes were re-slid together in ChainMan3D to minimize arbitrary differences among specimens. The final configurations underwent generalized Procrustes analysis. Principal Components Analysis (PCA) was conducted using IMP8 ThreeDPCA8, which generates Principal Components (PCs) based on partial warp scores.

A one-way Multivariate Analysis of Variance (MANOVA) was used to assess the effect of ancestry on the first eight PCs, which account for more than 80% of the total inter-individual variation in orbital shape (p=0.0003). The results of the MANOVA appear to be driven by the first two PCs (47.2% of total variation). Post hoc ANOVAs indicated a significant effect of ancestry on PC1 (p<0.0001) and PC2 (p=0.0026). PC3 through PC8 did not provide any additional discrimination. Centroid size did not differ significantly between the ancestral groups and did not have a significant effect on either PC1 or PC2 scores. Differences among groups are driven primarily by curviplanar relationships between contralateral orbital rim margins.

"European" orbits are distinguished from both "African" and "Asian" orbits along PC1. "European" orbits display more marked folding of the orbit in the sagittal plane; the lateral and medial orbital margins extend further posteriorly relative to the superior margin, and the superior orbital rim projects more anteriorly relative to the inferior border.

In contrast, "African" and "Asian" orbits are distinguished from each other along PC2, which describes relationships between the lateral and medial orbital margins. The lateral margin of "African" orbits lies further posteriorly relative to the medial margin when compared to the relatively co-planar "Asian" orbital rims.

The traditional anterior view of the orbits shows apparent differences based on ancestry; however, these are strongly influenced by the curviplanar relationships described above and prone to error based on orientation of the skull.

The study is severely limited by the size and nature of the sample analyzed, but may help guide future studies of a similar nature. Together, this study and that of Urbanová suggest that curviplanar relationships may be the most ancestrally informative aspect of orbital rim shape. If future studies address the limitations of these studies, they may provide valuable insight into, and statistical support for, the use of non-metric ancestry assessment in forensic analyses.

Reference(s):

1. Rhine S. Non-metric skull racing. In: Rhine S., Gill G.W., editors. *Skeletal attributions of race: methods for forensic anthropologists*. Alburquerque: Maxwell Museum of Anthropology, Anthropological Papers No.4., 1990;9-20.
2. Gill G.W. Craniofacial criteria in the skeletal attribution of race. In: Reichs K.J., editor. *Forensic osteology: advances in the identification of human remains*. Springfield, IL: Charles C Thomas, 1998;293-315.
3. Gore T., Nawrocki S.P., Langdon J., Bouzar N. The use of elliptical Fourier analysis on orbital rim shape in human skeletal remains. In: Lestrel P., editor. *Biological shape analysis: proceedings of the 1st international symposium*. Singapore: World Scientific Publishing Co, 2011;242-265.
4. Xing S., Gibbon V., Clark R., Liu W. Geometric morphometric analyses of orbit shape in African, Asian, and European human populations. *Anthropol Sci* 2013;121(1):1-11.
5. Urbanová P. Variation of the orbital rim using elliptic Fourier analysis. In: Lestrel P., editor. *Biological shape analysis: proceedings of the 1st international symposium*. Singapore: World Scientific Publishing Co, 2011;221-241.

Ancestry, Orbit, Morphometrics