Revista Argentina de Antropología Biológica

SUPPLEMENTARY INFORMATION

Effect of intentional cranial modification on cranial shape and size: Revisiting the contribution of radiographic data

Efecto de la modificación intencional del cráneo en la forma y tamaño craneales: revisión de la contribución de la información radiográfica

Efeito da modificação intencional do crânio na forma e tamanho craniano: revisão da contribuição da informação radiográfica

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Section S1: Patching, sliding and visualization procedures

In order to acquire a reference template, the following actions were carried out using the previous configuration: i) a generalized Procrustes analysis (GPA) and the "findMeanSpec" function available in the Geomorph R package (Adams & Otárola-Castillo, 2013) was applied for finding the closest to the average morphology individual, ii) the fixed landmarks, curves and surface semilandmarks were manually placed onto the corresponding average individual by the same observer (GM) using Stratovan Chekpoint software, iii) finally, the template's mesh, fixed landmarks, curves and surface points were all imported into R environment to create a reference template by trait using "createAtlas" function in Morpho R package (Schlager *et al*., 2018). For this study, the skull was defined by 481 semilandmarks (Fig. 2) based on previous works (Natahi *et. al*, 2021; Pugacheva *et. al*, 2022).

In each 3D model, the patching procedure, involving the semi-automatically projection of surface points onto each mesh through reference template was applied (Bardua *et al*., 2019; Schlager, 2017) by the "placePatch" function in the Morpho R package. Subsequently, in order to minimize the bending energy of the thin plate spline deformation, the sliding procedure was applied (Schlager, 2017) using the "slider2d" and "slider3d" function for 2D and 3D data, respectively available in the Morpho R package. Finally, the average distance between semilandmarks of 3D data (corresponding to the 10 closest semilandmarks) was calculated on the respective consensus shape (0.008 ± 0.001mm in AP; 0.008 ± 0.001mm in OB and 0.008 ± 0.001mm in ND individuals). The pattern of skull shape variation regarding artificial deformation type was assessed using the most informative PCs (accounting higher variance percentage) after running a PCA analysis applied to each group separately. With regard to 2D individual visualisation, the individuals which represent the extreme shape variation were showed by thin-plate spline deformation using "plotRefToTarget" in the Geomorph R package, while 3D individuals were displayed by a "heat map" using "localmeshdiff" function in Arothron R package (Profico *et al*., 2021) showing local differences in shape via mapping some areas of the object as "warm" (mainly red= expansion of the cranial surface), or "cold" (mainly blue= compression of the cranial surface) colours.

Section S2: Intra-observer error

In order to control the intra-observer reliability in the 2D sample, 40 lateral radiographs of artificially deformed skulls (20 antero-posterior, and 20 oblique types) were digitized twice in the lapse of two weeks by the same observer (GM) following the steps described above (see data acquisition section). After a Procrustes ANOVA for repeated measurements, both size and shape measurement mean squares were lesser than the mean squares explained by the differences existing among the individuals (Centroid size: MSindividuals = 1.5479, MSmeasurements = 0.0936, $F(19, 1) = 16.53$, $p < .0001$; Shape: MSindividuals = 9.56E-04, MSmeasurements = 4.67E-04, $F(114, 6)= 2.04$, $p < .0001$). Regarding the intra-observer reliability in the 3D sample, 30 models of artificially deformed skulls (15 antero-posterior, and 15 oblique types) were digitized twice in the lapse of two weeks by the same observer (BER) following the steps described above (see data acquisition section). After a Procrustes ANOVA for repeated measurements, both size and shape measurement mean squares were lesser than the mean squares explained by the differences existing among the individuals (Centroid size: MSindividuals = 4.06, MSmeasurements = 0.0158, $F(14, 1) = 257.34$, $p < .0001$; Shape: MSindividuals = 6.54E-04, MSmeasurements = 4.29E-05, $F(435, 6) = 9.31$, $p < .0001$

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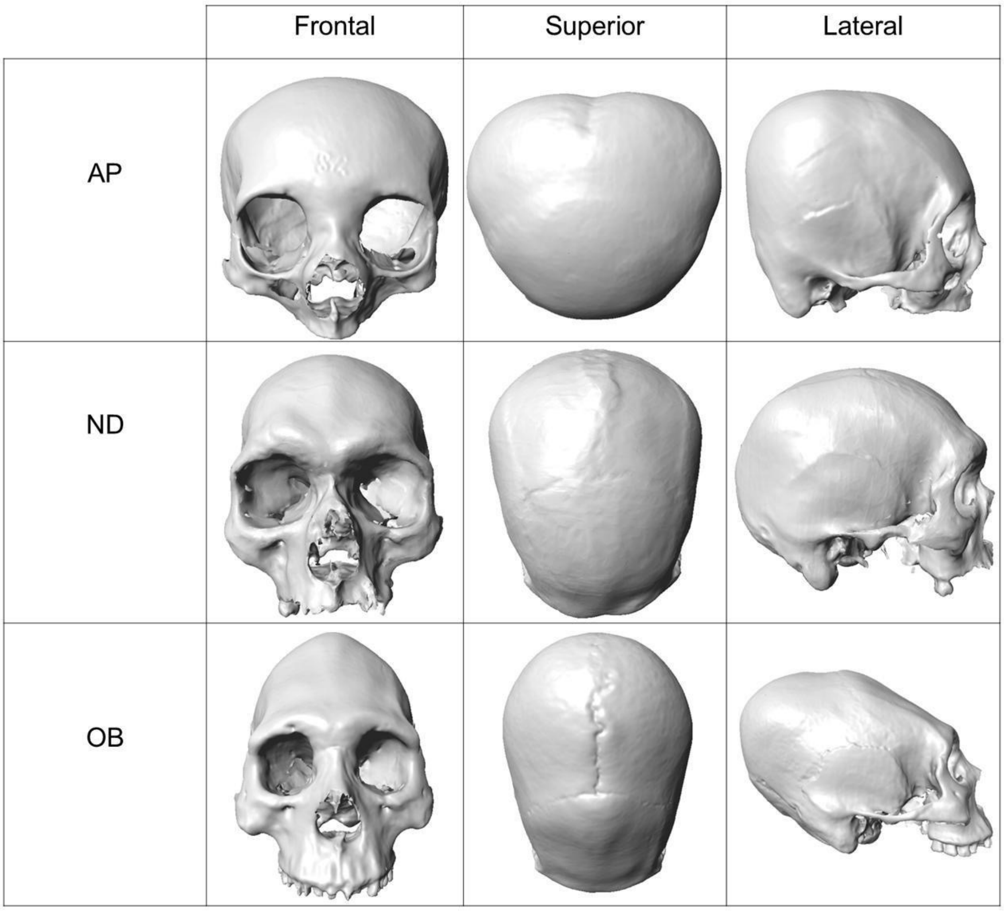

SUPPLEMENTARY FIGURE S1: Representative 3D models of antero-posterior (AP), non-deformed (ND), and oblique (OB) types of cranial modification.

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