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Anatomical Impact of Neurocranial Deformation on Stomatognathic Asymmetry

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Human craniofacial anatomy results from complex genetic, epigenetic, and environmental interactions, with the cranium and palatal arch being fundamental for brain protection and oral and respiratory functions. However, the influence of these factors on palatal arch morphology and asymmetry – especially in the presence of mechanical alterations of the cranium during growth – remains poorly understood, particularly with regard to the stomatognathic system. Artificial cranial modification (ACM) applied to the cranium, a common practice among pre-Hispanic Andean populations[1] and used as a marker of group identity[2,3], provides a model for studying non-physiological mechanical alterations in the developing stomatognathic system. The comparative analysis of cranial and palatal morphology between adult individuals with ACM (applied during the prepubertal period of high bone plasticity) and unmodified individuals allowed us to clarify the long-term effects of mechanical forces on craniofacial development.

We analyzed 20 adult Peruvian skulls (19th–20th century) preserved at the Museum of Anthropology and Ethnology, University of Florence (Italy), divided into two groups: 10 with clear evidence of artificial cranial modification (ACM) and 10 belonging to the unmodified group. The skulls were digitized using high-resolution 3D scanning and analyzed with threedimensional geometric morphometric methods, applying 41 semi-landmarks to the palatal surface[4] and 286 semi-landmarks to the cranium[5], in order to observe morphological variation. Subsequently, directional asymmetry of the palatal arch[4] was assessed to compare individuals with and without cranial modification.

Statistically significant cranial differences between modified and unmodified skulls confirm the effectiveness of ACM, while palatal arch morphology showed no significant differences. Most of the variance in palatal shape was due to individual variability, but directional asymmetry was greater in modified individuals (24% vs. 16%), indicating an increase in asymmetry rather than a consistent directional bias. The absence of differences in the palatal arch suggests that unfused cranial synchondroses during puberty help dissipate the mechanical stresses of ACM by providing growth centers and flexibility. However, the greater asymmetry in modified individuals indicates that the biomechanical effects of ACM can persist beyond skeletal maturation, inducing compensatory remodeling within the stomatognathic system to maintain functional balance.

In conclusion, the persistence of unfused cranial synchondroses during growth[6,7] buffers mechanical forces on adjacent structures such as the stomatognathic apparatus. Nevertheless, the directional asymmetry observed in adulthood highlights the lasting impact of early cranial modifications and the compensatory capacity of the masticatory system. These findings underscore the need to consider the craniofacial complex as an integrated unit in clinical practice.

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