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AGE-RELATED MORPHOLOGICAL CHANGES OF THE HUMAN SKULL

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Abstract:

Age-related morphological changes of the human skull represent a dynamic and continuous biological process influenced by growth, maturation, and aging. These transformations affect cranial thickness, sutural fusion, facial proportions, and overall cranial architecture. Understanding such changes is essential for anatomy, forensic science, neurosurgery, and craniofacial reconstruction.

The present study aimed to investigate age-dependent morphological variations of the skull using morphometric analysis and modern imaging techniques. A cross-sectional observational study was conducted at the Department of Human Anatomy, Tashkent State Medical University. Computed tomography (CT) scans of adult individuals were analyzed across different age groups to assess cranial bone thickness, degree of sutural closure, and cranial indices.

The findings revealed progressive sutural fusion, regional alterations in cranial thickness, and measurable changes in craniofacial proportions with increasing age. These results confirm that the skull remains morphologically adaptable throughout adulthood rather than being a static structure. The study highlights the importance of integrating classical anatomical knowledge with modern imaging technologies to improve clinical diagnostics, forensic identification, and surgical planning.

Keywords: Age-related changes, skull morphology, cranial sutures, morphometry, computed tomography, human anatomy.

Introduction

The human skull is a highly specialized anatomical structure that undergoes continuous morphological transformation throughout the human lifespan. These changes reflect a complex interaction between growth, functional adaptation, mechanical stress, metabolic activity, and aging-related degeneration. From early adulthood to senescence, cranial bones demonstrate measurable variations in thickness, shape, suture morphology, and facial proportions. Understanding these age-related transformations is essential not only for anatomical science but also for clinical medicine, forensic investigations, anthropology, and evolutionary biology.

In classical anatomy, skull morphology has traditionally been described using macroscopic observation of dry skulls. However, advances in radiological imaging and digital morphometry have significantly expanded the ability to study cranial structures in living individuals with high precision. Computed tomography (CT), in particular, enables detailed evaluation of both external and internal cranial features, providing valuable insights into subtle age-dependent changes that may not be visible through conventional methods. Despite extensive research conducted in Western populations, data regarding age-related cranial morphology in Central Asian populations remain limited, creating a need for region-specific anatomical studies.

This study was conducted to analyze age-related morphological changes of the human skull using CT-based morphometric methods in a cohort examined at Tashkent State Medical

University. The primary objective was to identify structural trends associated with aging and to evaluate their anatomical and clinical significance.

Materials and methods

The investigation was designed as a cross-sectional observational study and carried out at the Department of Human Anatomy in collaboration with the Radiology Unit of Tashkent State Medical University. A total of ninety individuals were included in the study, equally distributed by sex, who underwent head CT examinations for diagnostic purposes unrelated to trauma or craniofacial pathology. Subjects with congenital anomalies, fractures, neoplastic processes, or a history of cranial surgery were excluded to ensure anatomical integrity of the examined structures.

Participants were divided into three age groups representing early adulthood, middle age, and older adulthood. High-resolution CT scans were obtained using standardized imaging protocols to ensure consistency across all cases. Morphometric analysis focused on parameters known to exhibit age-related variability, including cranial suture closure, cranial bone thickness, cranial index, facial height, bizygomatic width, and cranial base angle. Measurements were performed digitally using specialized imaging software, and each parameter was independently assessed to minimize observer-related bias.

Results

Analysis of the collected data revealed clear morphological trends associated with aging. In younger adults, cranial sutures were predominantly open or only minimally fused, reflecting retained skeletal plasticity. With increasing age, progressive fusion of major sutures was observed, particularly along the sagittal and coronal lines. In older individuals, advanced or complete suture obliteration was common, supporting the well-established association between suture closure and aging, despite individual variability.

Cranial bone thickness demonstrated a non-linear pattern across age groups. An increase in thickness was observed from early adulthood to middle age, likely reflecting peak bone mineral density and adaptive remodeling. In contrast, older individuals exhibited a slight reduction in thickness, consistent with age-related bone resorption and decreased osteogenic activity. These findings align with current understanding of skeletal aging and its systemic metabolic influences.

Changes in cranial shape and facial proportions were also evident. While the cranial index remained relatively stable, facial height showed a gradual decrease with advancing age. This reduction was most pronounced in older individuals and appeared to correlate with alveolar bone resorption and dental loss. Additionally, alterations in the cranial base angle were observed, suggesting ongoing structural remodeling of the skull base throughout adulthood. Such changes may have important implications for craniofacial biomechanics and neurosurgical access routes.

Discussion

The results of this study confirm that skull morphology is dynamic rather than static during adult life. Age-related cranial changes reflect cumulative biological processes rather than isolated anatomical events. These transformations are influenced by functional demands, hormonal regulation, nutritional status, and genetic factors. Importantly, the findings highlight

the value of CT-based morphometric analysis as a reliable and reproducible method for studying cranial aging in vivo.

From a clinical perspective, understanding age-related skull morphology is essential for accurate interpretation of radiological images, surgical planning, and implant design. In forensic medicine, population-specific morphological data enhance the accuracy of age estimation and personal identification. Furthermore, the study contributes to anatomical education by demonstrating how modern imaging technologies can complement classical morphological approaches.

Conclusion

In conclusion, age-related morphological changes of the human skull represent a complex and continuous process with significant anatomical, clinical, and forensic relevance. The present study provides original morphometric data from a Central Asian population and underscores the importance of integrating modern imaging techniques into anatomical research. Future investigations incorporating three-dimensional geometric morphometrics and larger sample sizes may further refine our understanding of cranial aging and its practical applications.

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