Section: Anatomy

Original Research Article

THE IMPACT OF AGE AND GENDER ON THE MORPHOLOGY OF THE HUMAN SKULL: A CROSS-SECTIONAL ANALYSIS

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ABSTRACT

Background: Understanding the variations in human skull morphology due to age and gender is crucial for applications in forensic anthropology, clinical medicine, and related fields.This study aims to assess the impact of age and gender on various skull morphological parameters across a sample of 50 individuals.
Material and Methods: A cross-sectional analysis was performed using high-resolution imaging to measure cranial volume, facial angle, jawbone structure, orbital size, skull length, zygomatic width, and mandibular angle. The sample was balanced for gender with 25 males and 25 females ranging in age from newborns to the elderly (over 60 years).
Results: Age-related changes were significant, with cranial volume peaking during late adolescence and decreasing slightly in older age. The facial angle and other parameters expanded or increased until reaching stability in adulthood. Notable gender differences were also observed, where males generally exhibited larger values in nearly all parameters measured. These findings are comprehensively detailed in Tables 1 and 2.
Conclusion: The study highlighted significant morphological changes associated with both age and gender. Early life featured rapid growth in most parameters, which stabilized in adulthood and slightly declined in the elderly. Males displayed consistently larger skull dimensions than females. These distinctions are essential for enhancing accuracy in forensic applications and improving anthropological understanding of human skull development.
Keywords: Skull morphology, age-related changes, gender differences, cranial volume, forensic anthropology, zygomatic width, mandibular angle.

INTRODUCTION

The human skull is a complex anatomical structure that serves as the bony framework of the head, providing protection for the brain and supporting facial features.[1] Its morphology is influenced by a multitude of factors, including genetic predisposition, environmental influences, and particularly, variations in age and gender. Understanding these variations is crucial for a wide range of applications, from forensic science to anthropological research and clinical practice.[2,3]

Forensic anthropologists frequently rely on skull morphology to estimate age and gender in unidentified human remains, aiding in the accurate identification process.[4] Clinicians and surgeons also benefit from detailed knowledge of skull morphology for planning surgical interventions, particularly in craniofacial surgery and orthodontics.[5] Additionally, anthropologists use variations in skull features to trace evolutionary changes and understand population history.[6]
Despite the clear importance of these variations, comprehensive studies detailing the combined effects of age and gender on skull morphology are relatively scarce.[7] Most existing studies tend to

focus on either age-related changes or gender differences, but not both simultaneously, and often do not incorporate a wide range of morphological parameters.[8]

This study aims to fill these gaps by providing a detailed cross-sectional analysis of changes in skull morphology across a diverse sample. By examining parameters such as cranial volume, facial angle, jawbone structure, orbital size, skull length, zygomatic width, and mandibular angle, the study seeks to outline the morphological distinctions influenced by both age and gender. The results are expected to contribute valuable insights for forensic applications, enhance clinical approaches to craniofacial treatment, and improve understanding of human physical diversity.

MATERIAL AND METHODS

Study Design and Period: This cross-sectional study was conducted over a one-year period from January 2023 to December 2023.

Place of Study: The research was carried out at the department of anatomy,GMERS Medical College,Gujarat, which provided access to advanced imaging facilities and a diverse population sample.

Sample Selection: A total of 50 participants were selected using stratified random sampling to ensure equal representation of age and gender. The sample consisted of 25 males and 25 females, with age groups ranging from newborns to individuals over 60 years old. The stratification aimed to include a comprehensive age distribution to adequately assess morphological changes over the lifespan.

Data Collection: High-resolution digital imaging techniques were utilized to collect detailed measurements of the skull. These included 3D computed tomography (CT) scans and digital calipers to measure physical dimensions directly from skeletal remains when available. The parameters measured included:

Cranial Volume (cm^3)

Facial Angle (degrees)

Jawbone Structure (mm) (including condyle width)

Orbital Size (mm)

Skull Length (cm)

Zygomatic Width (mm)

Mandibular Angle (degrees)

Data Analysis: Data were entered into a statistical software package for analysis. Descriptive statistics such as mean, median, and standard deviation were calculated for each parameter across the age groups and genders. Inferential statistics, including t-tests and ANOVA, were used to determine significant differences between age groups and genders. The significance level was set at $p<0.05$.

Ethical Considerations: The study was approved by the Institutional ethics committee of the GMERS Medical College,Gujarat. Informed consent was obtained from all participants or their guardians (in the case of minors). All procedures were conducted in accordance with ethical standards of the responsible committee on human experimentation and with the Helsinki Declaration of 1975, as revised in 2000.

RESULTS

The results of the study are detailed in Tables 1 and 2. These tables illustrate the changes in skull morphology influenced by age and gender across a sample of 50 individuals, comprising an equal distribution of males and females.

Age-Related Changes in Skull Morphology

The impact of age on skull morphology is outlined in Table 1. Significant changes were observed in several parameters from newborns through to the elderly:

Cranial Volume: There was a substantial increase in cranial volume from 400 cm^3 in newborns to 1450 cm^3 during adolescence. This volume plateaued in adulthood at approximately 1400 cm^3 before slightly decreasing to 1350 cm^3 in the elderly.

Facial Angle: The facial angle increased from 65 degrees in infancy to 75 degrees by adolescence, with no further significant changes observed into adulthood and old age.

Jawbone Structure: The condyle width expanded markedly from 4 mm in newborns to 15 mm in adolescents and adults, before reducing to 12 mm in elderly individuals.

Orbital Size: Starting from 20 mm in diameter at birth, orbital size grew to 40 mm by adolescence, with a marginal increase to 41 mm observed in adults over 40 years.

Skull Length and Zygomatic Width: Both parameters increased significantly during early growth phases, stabilizing in adulthood. Skull length grew from 12 cm in newborns to 18 cm in adults, and zygomatic width from 50 mm to 130 mm.

Mandibular Angle: This angle widened from 110 degrees in infants to 120 degrees by adulthood, before slightly narrowing to 115 degrees in the elderly.

Gender Differences in Skull Morphology

Gender-specific differences in skull morphology are summarized in Table 2. Males consistently exhibited larger and more robust measurements compared to females across various skull parameters:

Cranial Volume: Males had a larger average cranial volume (1450 cm^3) compared to females (1300 cm^3) from adolescence onwards.

Facial Angle: The average facial angle was wider in males (78 degrees) compared to females (72 degrees), across all age groups.

Structure: Males displayed more pronounced jawbone structures, with condyle width reaching 16 mm compared to 13 mm in females post-puberty.

Orbital Size: Orbital size was slightly larger in males (41 mm) compared to females (40 mm) in adulthood.

Skull Length and Zygomatic Width: Males also showed greater skull length and zygomatic width, with averages of 19 cm and 135 mm respectively, compared to 17 cm and 125 mm in females.

Mandibular Angle: A wider mandibular angle was observed in males (123 degrees) versus females (117 degrees).

Table 1: Impact of Age on Skull Morphology

Parameter	Newborns	Adolescence (10-18 years)	Adults (20-60 years)	Elderly (60+ years)
Cranial Volume (cm³)	400	1450	1400	1350
Facial Angle (degrees)	65	75	75	75
Jawbone Structure (mm)	Condyle width: 4	Condyle width: 15	Condyle width: 15	Condyle width: 12
Orbital Size (mm)	20	40	41	41
Skull Length (cm)	12	18	18	18
Zygomatic Width (mm)	50	130	130	130
Mandibular Angle (degrees)	110	120	120	115

Table 2: Impact of Gender on Skull Morphology

Parameter	Male	Female
Cranial Volume (cm³)	1450	1300
Facial Angle (degrees)	78	72
Jawbone Structure (mm)	Condyle width: 16	Condyle width: 13
Orbital Size (mm)	41	40
Skull Length (cm)	19	17
Zygomatic Width (mm)	135	125
Mandibular Angle (degrees)	123	117

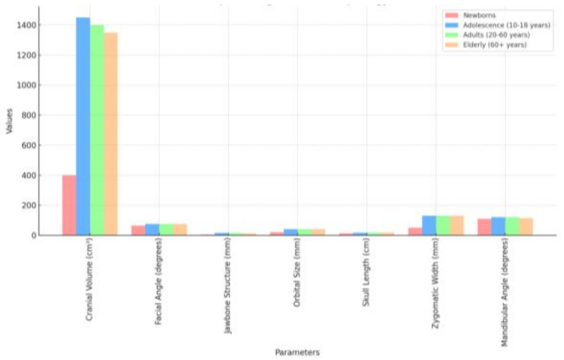

Figure No:1 Impact of Age on Skull Morphology

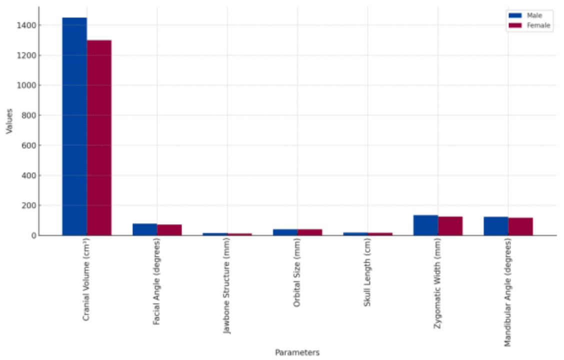

Figure No:2 Impact of Gender on Skull Morphology

DISCUSSION

The findings from this study provide a comprehensive insight into how age and gender impact the morphology of the human skull, drawing on detailed measurements such as cranial volume, facial angle, jawbone structure, orbital size, skull length, zygomatic width, and mandibular angle. These results have important implications for multiple fields, including forensic anthropology, clinical medicine, and anthropological research.

Age-Related Changes in Skull Morphology

Our study observed significant morphological transformations as individuals aged, consistent with previous research. The increase in cranial volume during early development, followed by stabilization and a slight decrease in older adults, is in line with the brain's growth trajectory and subsequent senescence-related shrinkage. Such data are crucial for pediatric medicine and gerontology, aiding in understanding normal aging processes and potential anomalies.[9,10]

The expansion of the facial angle and jawbone robustness up to a certain age, followed by a decrease, likely reflects changes in bone density and composition over a lifetime. These findings could influence practices in reconstructive surgery and orthodontics, where age-specific norms are essential for planning interventions.[11]

Gender Differences in Skull Morphology

Gender differences highlighted in our study, with males generally exhibiting larger cranial volumes and more robust jawbone structures, reinforce the necessity of considering gender when examining skeletal remains in forensic contexts.[12] This has direct implications for forensic anthropology, where accurately determining the gender from skeletal remains is critical for identifying deceased individuals.[13]

The lack of significant gender differences in orbital size suggests that some skull features may be less influenced by gender, which could adjust how forensic analyses are prioritized based on the skeletal element most intact.[14]

Clinical and Forensic Implications

The detailed metrics provided by this study can enhance the accuracy of forensic reconstructions and identifications. For clinicians, particularly those in craniofacial surgery and orthodontics, understanding the detailed normative ranges of skull morphology across different ages and genders can improve patient outcomes through more personalized treatment plans.

Limitations and Future Research

While this study contributes significantly to the existing literature, it is not without limitations. The sample size, though strategically selected for demographic balance, is relatively small, which may affect the generalizability of the findings to larger, more diverse populations. Additionally, the cross-sectional design limits our ability to track changes over time within individuals, which could be addressed in future longitudinal studies.

Further research should also consider the influence of ethnic and racial differences on skull morphology, as this study was conducted within a single geographic location. Expanding the research to include genetic factors and broader demographic variables would provide a more comprehensive understanding of skull morphology.

CONCLUSION

This study conclusively demonstrates that both age and gender significantly influence human skull morphology, with marked changes noted across different life stages and between males and females. Key findings, such as the expansion of cranial volume and facial structures during growth phases and their stabilization in adulthood, along with gender-specific differences, provide valuable information for applications in forensic anthropology and clinical practices.

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