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Age and sex prediction from Foramen Magnum Morphology and Morphometry Using CT-Scan in a Sample of Upper Egypt Population, Sohag Governorate

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Abstract

Background: Many studies examined the usefulness of foramen magnum (FM) parameters for sex and age prediction. **The aim** of the current study is to assess the possibility of using FM shape and size for sex and age prediction in a sample of Upper Egypt population. **Methods:** The study analyzed cranial CT (computed tomography) scans of 150 individuals (75 males and 75 females), aged <1 to 28. The scans were selected from the PACS (Picture archiving and communication system) database at Sohag University Hospital, Egypt. FM shape was visually examined, and anteroposterior diameter (APD) and transverse diameter (TD) were measured, followed by the calculation of FM index (FMI) and area using the Radinsky formula (area-R) and Teixeira formula (area-T). **Results:** The study found that the most frequent shapes were hexagonal in females and oval in males. Irregular "a" shape was the most common in the children's group. Age and sex significantly influenced FM shape. Regarding FM measurements, the children's group had statistically lower mean values than the adolescents' and adults' groups. There was a positive correlation between FM measurements and age in children. Linear regression analysis was used to predict age from FM parameters using regression equations. Males exhibited higher FM measurements than females in the adults' group; however, the difference was significant only for TD and FMI. Binary logistic regression indicated that TD could predict sex in the adults' group with a 64% accuracy rate, with higher accuracy for the female sex. **Conclusion:** FM morphology and morphometry can help determine age in early childhood and sex in adulthood.

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Key words Foramen magnum, morphology, morphometry, age, sexual dimorphism, CT

Introduction

One of the most important areas of forensic inquiry is personal identification. Age and sex identification are vital in cases involving unidentified individuals, skeletal remains, and mutilated bodies, such as those resulting from bombings and disasters (Lashin et al., 2019). The skull base holds particular value in identification, as it is more resilient to physical trauma and burial than other parts of the cranium (Jain et al., 2013). One of the key features of the skull base is the foramen magnum (FM), the largest opening in the skull base, which transmits the medulla oblongata and other critical structures (Yilma et al., 2020).

As a part of the skull, the size and shape of the FM change with the growth of skull bones. During early life—from the 7th intrauterine month until birth—the anteroposterior diameter (APD) of the FM expands faster than the transverse diameter (TD) by 5.4%. After birth and up to six months of age, the TD grows faster than the APD by 6.7%. The growth of the APD typically stops by the age of five, while the TD continues to grow until around the age of ten (Zdilla et al., 2017).

FM size and shape are also influenced by sex. Several studies across different populations have identified sexual dimorphism in the morphometric measurements of the FM (Abo El-Atta et al., 2020).

In addition to sex determination, clinicians must understand the normal anatomy and morphometric variations of the skull base in different populations—particularly concerning the FM and associated structures—to support more effective medical and surgical interventions (Yilma et al., 2020).

Radiological imaging is widely used in forensic work because it is quick, easy, and non-invasive, enabling the acquisition of essential data without damaging the specimens. Computed tomography (CT), in particular, eliminates the effects of overlapping structures and produces clear, high-resolution images, making it a reliable method for bone measurement (Lashin et al., 2019).

Because anatomical characteristics and sexual dimorphism in the human cranium may vary between populations, the present study aims to determine the variation in FM morphology and morphometry in relation to age and sex in a sample from the Upper Egypt population.

Materials and Methods

Type of the study:

This is a retrospective cohort study.

Study population:

This study included cranial CT radiographs of 150 individuals from the Sohag Governorate population (75 males and 75 females), with an age range of <1 to 28 years. The sample was categorized by age into three groups: children's group (≤10 years), adolescents' group (>10 years and <18 years), and adults' group (≥18 years) (Wei and Zaizhu, 2023). High-quality CT scans obtained between July 2022 and July 2023 were randomly selected from the institutional database, the Picture Archiving and Communication System (PACS), at the Department of Radiology, Sohag University Hospital, Egypt. These CT scans were originally performed as part of the patients' clinical assessments.

Inclusion criteria:

High-quality CT images of the skull base showing the entire extent of the foramen magnum (FM), with known sex and age of the patients, were included.

Exclusion criteria:

CT scans showing craniovertebral anomalies, trauma, surgical intervention, or any pathological lesions of the skull were excluded.

Measurements:

The present study was carried out using previously archived skull CT scans, including axial, sagittal, coronal, and 3D reformatted views, on a workstation. The scans were acquired using a multi-slice CT machine (16-slice SOMATOM go.Now – Siemens, Germany) (Figures 1, 2, and 3). After reviewing continuous 5 mm thin slices, images showing a clearly defined foramen magnum were selected. Axial scans served as the primary source of data, while other scan planes were used to confirm any uncertain measurements. Classification of FM shape was performed through visual examination. The ruler feature included in the software was used to obtain the following measurements in millimeters (mm): (Bahşi et al. 2021):

1- The anteroposterior diameter (APD): The FM's maximum length from basion to opisthion in the midsagittal plane.
2- The transverse diameter (TD): The FM's maximum width which is the largest distance between its lateral margins and perpendicular to the mid-sagittal plane.
3- The APD and TD were used in the following formulas:
   a. Radinsky formula ($\frac{1}{4}\pi \cdot APD \cdot TD$) to calculate the area (mm^2) of the FM (area-R) (Bahşi et al. 2021).
   b. Teixeira formula ($\pi\left(\frac{APD+TD}{4}\right)^2$) to calculate the area (mm^2) of the FM (area-T) (Bahşi et al. 2021).
   c. The FM index (FMI) was calculated using the formula: $100\left(\frac{TD}{APD}\right)$.

Statistical analysis:

The Shapiro-Wilk test was used to assess the normality of the data. Qualitative data were presented as frequencies and percentages, and the Chi-square test was applied to compare FM shapes across age groups and between sexes. Quantitative data were expressed as mean ± standard deviation (SD). The independent t-test, one-way ANOVA, and post-hoc analysis were used to compare FM measurements between age groups and between males and females. Pearson correlation and linear regression analysis were performed to evaluate the relationship between FM measurements and age. Logistic regression was used to assess the association between FM measurements and sex. Statistical analysis was conducted using SPSS for Windows, version 21.0, and a p-value < 0.05 was considered statistically significant.

Ethical considerations:

The study was approved by the Ethical Committee of Sohag Faculty of Medicine (Approval Number: Soh-Med-22-07-37). As the data were collected retrospectively, the committee granted a waiver of informed consent. Permission was obtained to access the PACS archive system at the Department of Radiology. To maintain confidentiality, all patient information was anonymized. The study was conducted in accordance with the principles of the Declaration of Helsinki for medical research involving human subjects.

Results

The study included 150 individuals (75 males and 75 females), ranging in age from less than one year to 28 years, with a mean age of 14.40 ± 7.38 years (Table 1). All morphometric measurements were confirmed to follow a normal distribution.

The foramen magnum (FM) exhibited eight distinct shapes (Figure 4): oval, round, egg-shaped, tetragonal, pentagonal, hexagonal, and two irregular shapes referred to as "irregular a" and "irregular b." The oval shape was characterized by symmetry along both axes. The egg shape was symmetrical along the longitudinal axis, with one pointed and one broader end along the transverse axis. Based on the number of sides and angles, shapes were classified as tetragonal, pentagonal, or hexagonal.

The authors identified a specific recurring pattern that did not fit any of the six regular categories but had consistent morphological features, which was classified as "irregular a" (Figure 5). One of the authors noted that this shape resembled the parasitic worm Fasciola hepatica. When the FM appeared asymmetric along both axes, with unequal angles and sides and no identifiable pattern, it was categorized as "irregular b."

The most frequent FM shape observed was hexagonal (31.3%), followed by oval (22.0%), irregular "a" (17.3%), and egg-shaped (9.3%). Rounded (5.3%), tetragonal (6.0%), and pentagonal (6.0%) shapes showed nearly equal frequencies. The least common type was irregular "b" (2.7%).

According to sex (Table 2), the hexagonal shape was the most frequent among females (37.3%), while the oval shape was most common among males (33.3%). Regarding age (Table 3), the irregular "a" shape was the predominant FM shape in the children's group (35.8%), whereas the hexagonal shape was most common in both adolescents (31.9%) and adults

(46.0%). There was a significant association between FM shape and both age and sex ($p < 0.001$ for each).

In terms of APD, TD, area-R, and area-T (Table 4), the children's group had significantly lower mean measurements than the adolescents' group (p = 0.003, 0.002, 0.001, and 0.001, respectively). The children's group also showed significantly lower mean values than the adults' group for APD, TD, area-R, and area-T (p = 0.030, 0.009, 0.010, and 0.014, respectively). There were no statistically significant differences in any FM metric between the adolescent and adult groups. Additionally, no significant variation in the FM index (FMI) was observed across the age groups.

Correlation analysis showed that all FM measurements, except FMI, had a significant positive correlation with age within the children's group (Table 5). However, no significant correlation was found between age and FM measurements in the adolescent and adult groups. Linear regression analysis (Table 6) yielded the following equations to predict age based on FM parameters:

1. 0.200 x ADP - 2.838
2. 0.312 x TD - 4.538
3. 0.007 x area-R - 1.095
4. 0.006 x area-T - 0.923

When comparing the FM measurements throughout the entire study sample, males exhibited higher measurements than females in terms of foramen magnum characteristics: APD (males: 38.3 ± 6.2; females: 37.4 ± 4.9), TD (males: 30.4 ± 4.3; females: 29.4 ± 3.1), area-R (males: 929.3 ± 254.2; females: 869.8 ± 176.8), area-T (males: 945.3 ± 260.1; females: 885.6 ± 183.5), and FMI (males: 80.5 ± 10.4; females: 79.5 ± 9.9). However, there was no statistically significant difference between the study sample's male and female participants (p-values: 0.336, 0.095, 0.099, 0.107, and 0.529, respectively) (Table 4).

In the adults' group, there was a significant difference between males and females regarding TD and FMI (p-values: 0.007 and 0.048, respectively). Despite higher measurements in the adult males group compared to adult females regarding APD (males: 38.7 ± 5.3; females: 37.8 ± 4.1), area-R (males: 971.3 ± 225.6; females: 872.2 ± 146.9), and area-T (males: 983.8 ± 230.6; females: 889.3 ± 152.8), the differences were statistically insignificant (p-values: 0.534, 0.072, and 0.094, respectively) (Table 4).

There were no statistically significant differences regarding APD, TD, area-R, area-T, and FMI between males and females in the children's group (p-values: 0.956, 0.684, 0.972, 0.999, and 0.911, respectively) and the adolescents' group (p-values: 0.351, 0.464, 0.298, 0.290, and 0.657, respectively) (Table 4).

Binary logistic regression for TD and FMI to predict sex in the adults' group is shown in Table 7. The result indicated that TD could predict sex with a 64% accuracy rate (female sex prediction, 72%, and male sex prediction, 56%). The following equation can predict sex: 0.295 × TD - 8.955. Sex is male if the logit value is positive, or female if the logit value is negative.

Table 1: Descriptive statistics of the study sample.

Variable	Summary statistics
Age (year)	
Mean ± SD	14.40±7.38
Median (range)	15 (<1:28)
Sex	**Frequency (percentage)**
Female	75 (50.00%)
Male	75 (50.00%)
Age group	**Frequency (percentage)**
Children (≤10 years)	39 (26%)
Adolescents (>10: <18 years)	61 (40.7%)
Adults (≥18 years)	50 (33.3%)

Table 2: Comparison of the frequencies of FM shapes between males and females in the study sample.

Shape	**Female** No. (%)	**Male** No. (%)	**Total** No. (%)	**Chi-square X^2 (p- value)**
Egg	13 (17.3%)	1 (1.3%)	14 (9.3%)	**25.66 (0.001*)**
Oval	8 (10.7%)	25 (33.3%)	33 (22.0%)	
Rounded	3 (4.0%)	5 (6.7%)	8 (5.3%)	
Tetragonal	3 (4.0%)	6 (8.0%)	9 (6.0%)	
Pentagonal	7 (9.3%)	2 (2.7%)	9 (6.0%)	
Hexagonal	28 (37.3%)	19 (25.3%)	47 (31.3%)	
Irregular a	11 (14.7%)	15 (20.0%)	26 (17.3%)	
Irregular b	2 (2.7%)	2 (2.7%)	4 (2.7%)	
Total	**75 (100.0%)**	**75 (100.0%)**	**150 (100.0%)**	

No.: Number. X^2: Chi-square test. *: significant (p-value is significant if <0.05 and non-significant if >0.05).

Table 3: Comparison of the frequencies of FM shapes among different age groups in the study sample.

Shape	Children No. (%)	Adolescents No. (%)	Adults No. (%)	Total No. (%)	Chi-squareX^2 (p- value)
Egg	3 (7.7%)	5 (8.2%)	6 (12.0%)	14 (9.3%)	**44.18 (0.001*)**
Oval	6 (15.4%)	19 (31.1%)	8 (16.0%)	33 (22.0%)	
Rounded	1 (2.6%)	2 (3.3%)	5 (10.0%)	8 (5.3%)	
Tetragonal	1 (2.6%)	4 (6.6%)	4 (8.0%)	9 (6.0%)	
Pentagonal	4 (10.3%)	4 (6.6%)	1 (2.0%)	9 (6.0%)	
Hexagonal	7 (17.9%)	17 (27.9%)	23 (46.0%)	47 (31.3%)	
Irregular a	17 (43.6%)	6 (9.8%)	3 (6.0%)	26 (17.3%)	
Irregular b	0 (0%)	4 (6.6%)	0 (.0%)	4 (2.7%)	
Total	**39 (100.0%)**	**61 (100.0%)**	**50 (100.0%)**	**150 (100.0%)**	

No.: Number. X2: Chi-square test. *: significant (p-value is significant if <0.05 and non-significant if

Table 4: Comparison of the FM parameters between different study groups in the study sample.

Parameter		APD (mm) Mean ± SD	TD (mm) Mean ± SD	Area-R $(mm)^2$ Mean ± SD	Area-T $(mm)^2$ Mean ± SD	FMI Mean ± SD
Comparison of FM parameters between males and females (independent t-test)						
Male		38.3± 6.2	30.4± 4.3	929.3± 254.2	945.3± 260.1	80.5± 10.4
Female		37.4± 4.9	29.4± 3.1	869.8± 176.8	885.6± 183.5	79.5± 9.9
p-value		**0.336**	**0.095**	**0.099**	**0.107**	**0.529**
Comparison of FM parameters between different age groups (ANOVA, Post Hoc "Tukey HSD")						
Children		35.3± 6.3	28.1± 3.6	788.2± 204.6	803.9± 214.6	81.3± 13.8
Adolescents		39.1± 5.3	30.7± 3.9	952.5± 227.2	969.4± 232.8	79± 8.4
Adults		38.3± 4.7	30.4± 3.2	921.7± 194.9	936.6 ± 199.4	80.1± 8.6
p-value		**P=0.003* P1=0.003* P2=0.030* P3=0.718**	**P=0.002* P1=0.002* P2=0.009* P3=0.930**	**P=0.001* P1=0.001* P2=0.010* P3=0.725**	**P=0.001* P1=0.001* P2=0.014* P3=0.709**	**P=0.537 P1=0.508 P2=0.839 P3=0.841**
Comparison of FM parameters between males and females in different age groups (independent t-test)						
Children	Male	35.4± 7.5	27.8± 3.3	786.9± 243.1	804± 255.8	81.1± 13.8
	Female	35.2± 5.1	28.3± 3.8	789.3± 166.4	803.9± 173.4	81.6± 14.2
	p-value	**0.956**	**0.684**	**0.972**	**0.999**	**0.911**
Adolescents	Male	39.7±5.7	31.0±4.8	982.6±256.9	1000.7±260.8	78.5±9.3
	Female	38.4±4.9	30.3±2.8	921.5±191.1	937.1±198.9	79.5±7.5
	p-value	**0.351**	**0.464**	**0.298**	**0.290**	**0.657**
Adults	Male	38.7±5.3	31.6±3.5	971.3±225.6	983.8±230.6	82.5±8.5
	Female	37.8±4.1	29.2±2.6	872.2±146.9	889.3±152.8	77.7±8.2
	p-value	**0.534**	**0.007***	**0.072**	**0.094**	**0.048***

FM: Foramen magnum. ADP: Antro-posterior diameter. TD: Transverse diameter. Aea-R: area using Radinsky formula. Area-T: area using Teixeira formula. FMI: Foramen magnum index. P-value: comparing all groups, P1: comparing children & adolescent, P2: comparing children & adult, and P3: comparing adolescent & adult.
****: significant (p-value is significant if <0.05 and non-significant if >0.05).***

Table 5: Correlation analysis between age and FM measurements.

Measurement		Age (years)			
		Total sample	Children	Adolescents	Adults
ADP	r p	0.252 0.002*	0.447 0.004*	0.027 0.839	0.069 0.632
TD	r p	0 .274 0.001*	0.392 0.014*	0.111 0.394	0.013 0.929
Area-R	r p	0.275 0.001*	0.487 0.002*	0.066 0.611	0.032 0.825
Area-T	r p	0.268 0.001*	0.485 0.002*	0.065 0.618	0.033 0.822
FMI	r p	-0.067 0.416	-0.189 0.249	0.118 0.365	-0.083 0.565

*ADP: Antro-posterior diameter. TD: Transverse diameter. Aea-R: area using Radinsky formula. Area-T: area using Teixeira formula. FMI: Foramen magnum index. r: Pearson correlation coefficient, p: p-value, *: significant (p-value is significant if <0.05 and non-significant if >0.05).*

Table 6: Simple linear regression for FM measurements (ADP, TD, area-R and area-T) to predict age in children's group.

Predictor variable	Unstandardized Coefficients		Standardized Coefficients	2-tailed test		95.0% Confidence Interval for B	
	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
(Constant) ADP	-2.838 0.200	2.359 0.066	0.447	-1.203 3.041	0.236 0.004*	-7.617 0.067	1.940 0.333
(Constant) TD	-4.538 0.312	3.410 0.120	0.392	-1.331 2.590	0.191 0.014*	-11.447 0.068	2.371 0.556
(Constant) Area-R	-1.095 0.007	1.618 0.002	0.487	-.677 3.395	0.503 0.002*	-4.373 0.003	2.183 0.011
(Constant) Area-T	-0.923 0.006	1.578 0.002	0.485	-0.585 3.372	0.562 0.002*	-4.121 0.003	2.275 0.010

*ADP: Antro-posterior diameter. TD: Transverse diameter. Aea-R: area using Radinsky formula. Area-T: area using Teixeira formula. *: significant (p-value is significant if <0.05 and non-significant if >0.05).*

Table 7: Univariate binary logistic regression for FM measurements (TD and FMI) to predict sex in adults' group.

Predictor variable	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B)		Correct prediction F (%)	Correct prediction M (%)	Mean correct prediction (%)
							Lower	Upper			
TD Constant	0.295 -8.955	0.122 3.692	5.866 5.885	1 1	0.015* 0.015*	1.344 0.000	1.058	1.707	72.0	56.0	64.0
FMI Constant	0.072 -5.752	0.038 3.024	3.632 3.617	1 1	0.057 0.057	1.075 0.003	0.998	1.157	68.0	56.0	62.0

*TD: Transverse diameter. FMI: Foramen magnum index. F: female. M: male. B: coefficient, S.E.: standard error, df: degree of freedom, Exp(B): exponentiation of B (odds ratio), *: significant (p-value is significant if <0.05 and non-significant if >0.05).*

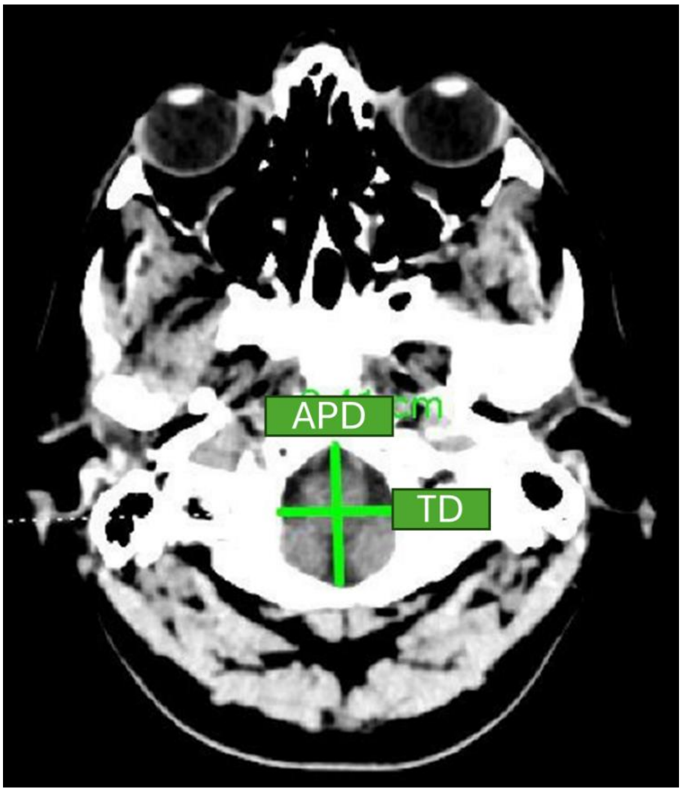

Figure (1): CT scan axial view showing the foramen magnum (FM). APD: Anteroposterior diameter — the maximum length of the FM measured from the basion to the opisthion in the midsagittal plane. TD: Transverse diameter — the maximum width of the FM, defined as the largest distance between its lateral margins, measured perpendicular to the midsagittal plane.

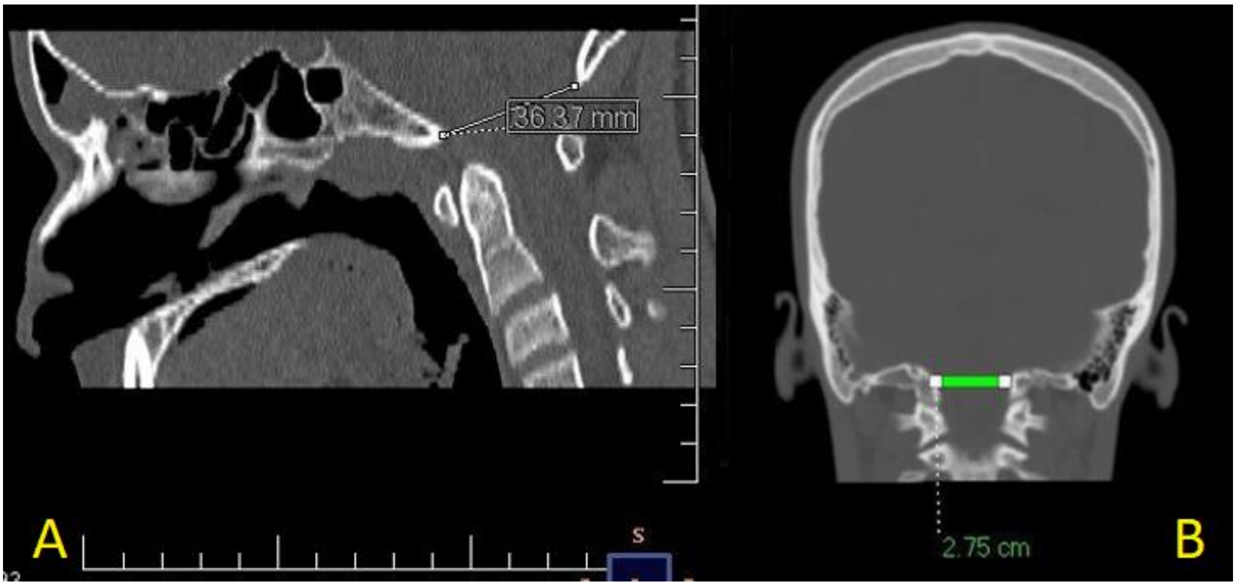

Figure 2: Confirmation of FM diameters using reformatted CT images. A: Anteroposterior diameter measured in the sagittal reformatted image. B: Transverse diameter measured in the coronal reformatted image.

Figure 3: 3D reformatted images were used in some cases to confirm the shape of the foramen magnum (FM).

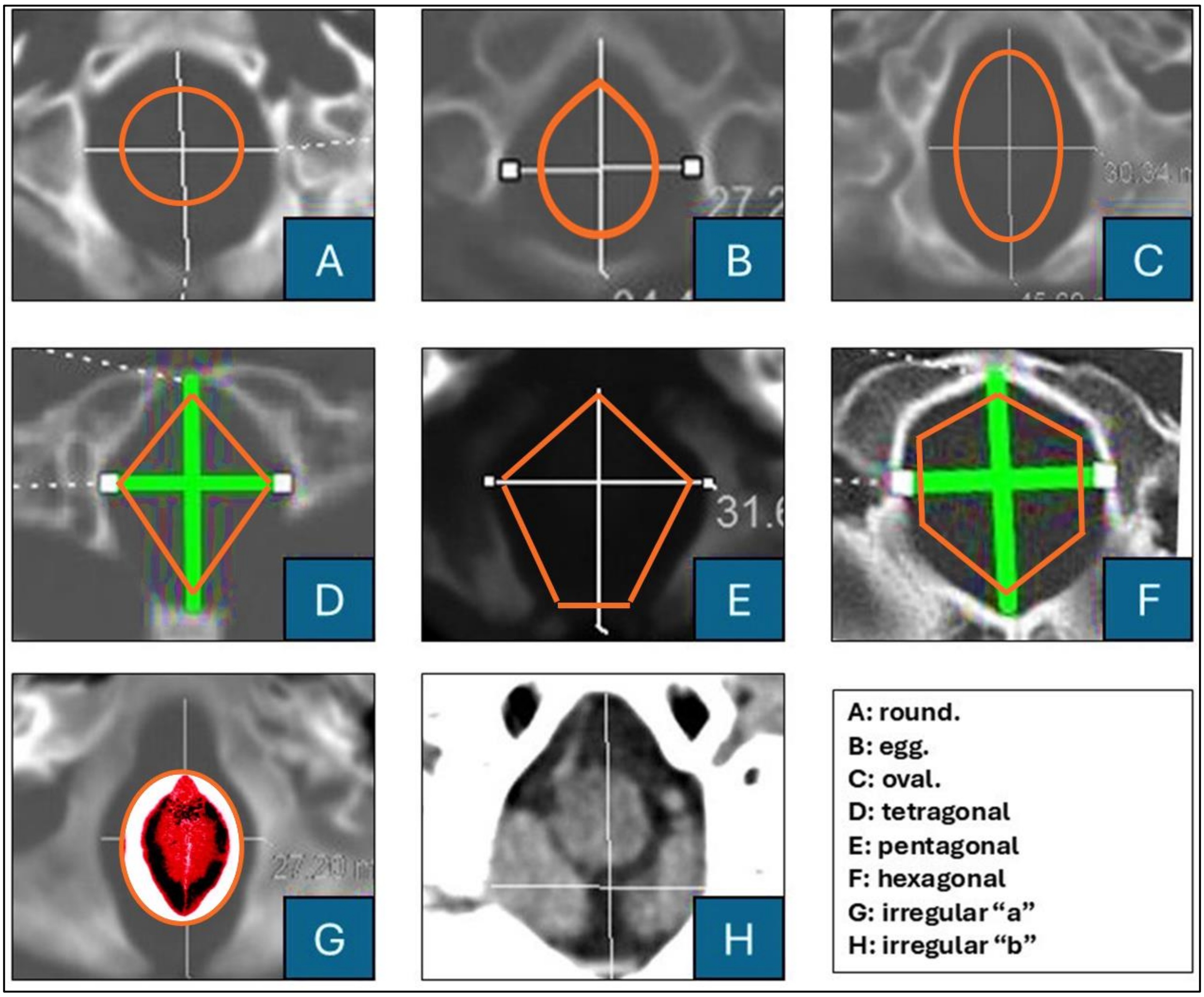

Figure 4: FM shapes observed in the studied population. The foramen magnum (FM) exhibited eight distinct shapes: A: rounded, B: egg, C: oval, D: tetragonal, E: pentagonal, F: hexagonal, G: irregular "a," and H: irregular "b."

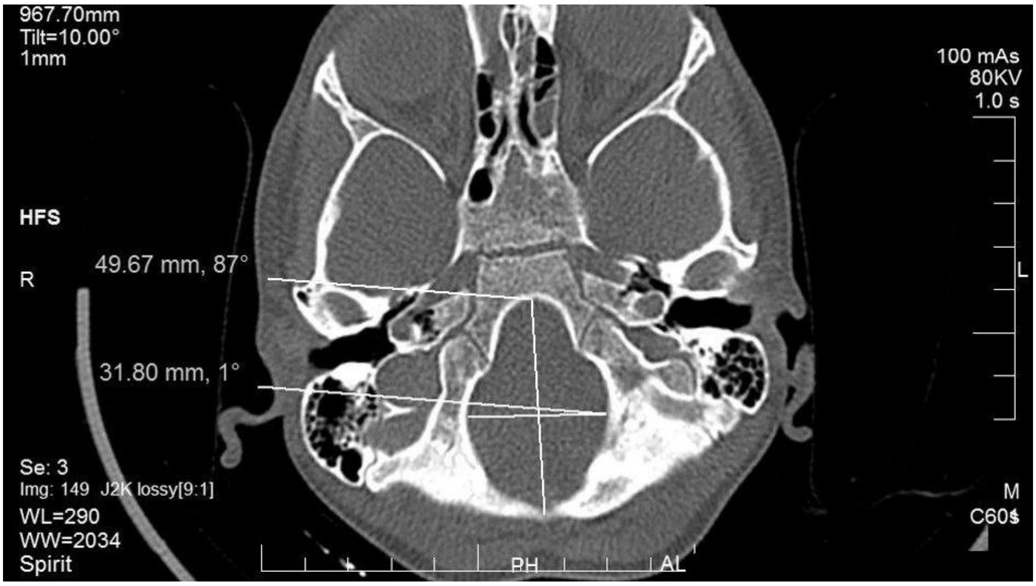

Figure 5: FM irregular "a" shape.

Discussion

The shape and dimensions of the foramen magnum are influenced by ethnic groups, which is the cause of the morphometric heterogeneity in FM shape and size seen in different studies (Kamath et al. 2015). The present study is exploring the FM shape and size in a sample of Sohag population across age groups and sexes.

Morphology: The development of a specific FM shape is determined by the ossification of different parts of occipital bones at varying locations to produce a variety of morphologies (Vinutha et al., 2018). FM shapes have been categorized; however, the shape descriptor categories vary from study to study. In the present study, eight different FM shapes were distinguished: oval, rounded, egg, tetragonal, pentagonal, hexagonal, and two irregular shapes, "a" and "b."

The results showed that the most frequent FM shape in the present study was hexagonal followed by oval shape. The FM shape was found to be different in relation to age. The most frequent FM shape in children was irregular "a," while in adolescents it was oval, and hexagonal in adults. Moodley et al. (2019) found similar results in the adults' group; though, in children and adolescents' groups the most frequent shape was egg shape. The change in shape across age groups could be attributed to the difference in growth rate between APD and TD of FM (Zdilla et al. 2017).

Regarding sexual dimorphism, the present results revealed that oval shape was the frequent shape followed by hexagonal in males, while in females hexagonal was the most frequent. Lashin et al. (2019) studied FM shape in an Egyptian sample living in the Nile Delta region and found that the most frequent were hexagonal shape in males and irregular shape in females.

In a Saudi Arabian sample, Aljarrah et al. (2022) noticed that the most prevalent FM shape was hexagonal in males and females, while Samara et al. (2017) found irregular shape was the most frequent in a sample of a Jordanian population in both sexes.

Vinutha et al. (2018), Kumar et al. (2022), and Kotha et al. (2023) found that the most frequent shape was oval in both sexes in patients' CT scans of South Indian origin. The same result was reported by Bahşi et al. (2021) and Çelik and Akman (2023) who examined CT scans of Turkish individuals.

Morphometry: During early childhood, the foramen magnum acquires its full size. By the age of ten, almost all the parts of the occipital bone partaking in FM development have fully fused (Zdilla et al. 2017 and Vinutha et al., 2018). The majority of morphometric studies of the FM have taken into account the area of FM as well as the APD and TD.

The measurements made on adults provided the data for the majority of FM research. There is little research on children. In the present study, morphometric analysis of FM was studied in children, adolescents, and adults. The mean values of APD and TD in children were 35.3 ± 6.3 mm and 28.1 ± 3.6 mm, respectively. In adolescents' group, the mean values of APD and TD were 39.1 ± 5.3 and 30.7 ± 3.9, respectively. There was a statistically significant difference between both groups. This came in line with the results by Wilk et al. (2023) who studied FM dimensions in children and adolescents and found that the entire sample mean APD was 35.63 ± 4.23 mm, and the mean TD was 29.08 ± 3.4 mm, with a statistically significant increase of FM dimensions between groups up to the age of 36 months.

The difference was statistically significant between adults' group and children's group. However, there was no statistically significant difference between the adults' group and adolescents' group. This could be explained by the fact that both diameters of the foramen magnum stop growing by the age of 10 (Zdilla et al. 2017).

Although the FM measures were higher in males than females in children and adolescents' groups, the difference was statistically insignificant. This was similar to the results reported by Wilk et al. (2023). In contrast, Li et al. (2024) studied FM dimensions in children and found significant differences between Chinese boys and girls. The result is different from our study, which could be attributed to either their larger sample size (389) or ethnic differences.

Males had significantly larger FM diameters than females in nearly all of the available studies (Kamath et al. 2015). Samara et al. (2017), Vinutha et al. (2018), and Zdilla et al. (2017) were among the authors that noted this. This is in line with our findings, which indicated that males had higher mean FM measurements than females. Nonetheless, in the adult group, these variations were statistically significant in two measures (TD and FMI). The limited sample size following the elimination of children and adolescents (total study sample = 150, adults group no. = 50; 25 males and 25 females) may be the cause of the insignificant differences between males and females in the remaining measurements. Binary regression analysis showed that sex could be predicted from TD with a 64% accuracy rate. It showed higher accuracy for female sex prediction (72%) compared to male sex prediction (56%). Lashin et al. (2019) found that all FM measurements could predict sex with higher accuracy for female sex prediction.

Conclusion

Determination of age from FM morphology and morphometry could be valuable in early childhood, while sex prediction could be of significant value in adulthood. Although FM parameters couldn't be used solely for 100% accuracy in age and sex determination, they could be used alongside other measurements to increase accuracy or in cases of incomplete skeletal remains.

Morphological and morphometric parameters of FM vary greatly between different populations; thus, more research and meta-analyses are required to create databases and cut-off values that are specific to each population.

Recommendations

Further studies on the same population across different ages of both sexes, followed by a systematic review are recommended.

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تحديد السن والجنس من خلال أشكال وأبعاد الثقب الأكبر لقاع الجمجمة باستخدام الأشعة المقطعية لعينة من سكان صعيد مصر بمحافظة سوهاج

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الملخص العربي

الخلفية العلمية: تناولت بعض الدراسات فائدة استخدام أشكال وأبعاد الثقب الأكبر لقاع الجمجمة في التنبؤ بالجنس والعمر في جنسيات مختلفة.

الهدف: تهدف الدراسة الحالية إلى فحص إمكانية تطبيق استخدام شكل وأبعاد الثقب الأكبر لقاع الجمجمة للتنبؤ بالجنس والعمر على عينة من سكان صعيد مصر.

الطريقة: تم تحليل الأشعة المقطعية للجمجمة لـ١٥٠ فردًا (٧٥ ذكرًا و٧٥ أنثى)، تتراوح أعمارهم بين أقل من سنة وحتى ٢٨ سنة. وقد تم اختيار هذه الأشعة من قاعدة بيانات نظام أرشفة الصور والاتصالات (PACS) في مستشفى سوهاج الجامعي، مصر. تم فحص شكل الثقب الأكبر لقاع الجمجمة بصريًا، وتم قياس القطر الأمامي الخلفي والقطر العرضي، تلا ذلك حساب دليل الثقب الأكبر لقاع الجمجمة والمساحة باستخدام معادلتي Radinsky وTeixeira.

النتائج: أظهرت الدراسة أن الأشكال الأكثر شيوعًا كانت الشكل السداسي لدى الإناث، والشكل البيضاوي لدى الذكور. وكان الشكل غير المنتظم هو الأكثر شيوعًا في مجموعة الأطفال. وقد وُجد أن العمر والجنس لهما تأثير ذو دلالة احصائية على شكل الثقب الأكبر لقاع الجمجمة. أما بالنسبة للقياسات، فقد سجلت مجموعة الأطفال متوسطات أقل إحصائيًا مقارنةً بالمراهقين والبالغين. كما وُجد ارتباط إيجابي بين قياسات الثقب الأكبر لقاع الجمجمة والعمر في مجموعة الأطفال. وتم استخدام تحليل الانحدار الخطي للتنبؤ بالعمر من خلال أبعاد الثقب الأكبر لقاع الجمجمة باستخدام معادلات انحدارية. وقد أظهرت نتائج البالغين أن الذكور يمتلكون قياسات أعلى من الإناث، لكن الفروق كانت ذات دلالة احصائية فقط في القطر العرضي ودليل الثقب الأكبر لقاع الجمجمة. وأشارت نتائج تحليل الانحدار اللوجستي الثنائي إلى أن القطر العرضي يمكن أن يتنبأ بالجنس في مجموعة البالغين بدقة تصل إلى ٦٤% (دقة أعلى في التنبؤ بجنس الإناث عن الذكور).

الاستنتاج: يمكن أن تساعد خصائص شكل وأبعاد الثقب الأكبر لقاع الجمجمة في تحديد العمر في مرحلة الطفولة المبكرة وتحديد الجنس بعد مرحلة البلوغ.

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