RESEARCH ARTICLE

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# Does Foramen Magnum Based on Computed Tomography Measurements Change with Age and Gender?

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## Abstract

**Objectives:** The aim of the study was to determine the development rate of foramen magnum (FM) with age by performing morphometric analysis of FM using computed tomography (CT) examination in children at different ages, accounting for sagittal and transverse dimensions for FM as well as sex.

**Methods:** Two hundred and fifty-one children aged 0-18, who had CT imaging at our institution for any reason between January and December 2024 had their anterior-posterior diameter and transverse diameter (TD) measured in this retrospective study. The information was statistically analyzed.

**Results:** The study included 251 children, 156 boys (62.2%) and 95 girls (37.8%). The mean sagittal diameter (SD) of all children was 36, and the mean TD was 29. Age, and SD and TD values had a substantial positive connection ($p<0.05$). There were no appreciable variations in SD and TD measurements between boys and girls at any age.

**Conclusion:** Morphometric research in anthropology aids in determining anthropometric variations among populations, which may be influenced by factors such as ethnicity, gender, age, and genetics, and may influence bone size and shape. Additionally, it can differentiate between a pathogenic situation and typical variations. For many abnormalities, it is essential to ascertain the size of FM and how it changes with age.

**Keywords:** Anthropology, morphometry, children, foramen magnum

## Introduction

The entire occipital bone encloses the foramen magnum (FM), which joins the posterior fossa and the vertebral canal, ensuring interaction between the skull and the cervical vertebrae. Numerous biological fields, including anatomy, forensic medicine, and anthropology, are interested in studying FM.[1] Skull, FM morphology show sex-specific traits and can identify sex with 80% accuracy in anthropology and forensic medicine.[2] It is unknown how children's FM dimensions change as they get older.[3]

Morphometric measurements of a child's skull are used to evaluate the course of a disease or the effectiveness of treatment for certain developmental abnormalities, or skull deformities caused by various illnesses. Developmental variations in FM's size in response to the child's age are significant in these situations.

Anthropometric studies related to FM show differences according to gender, and studies conducted on skulls have proven that the transverse and sagittal dimensions of FM are higher in males than in females.[4] However, it is not known exactly how FM dimensions change as children age.[3]

Determining the average FM dimensions in children for each age group and based on gender[5] seems reasonable. The purpose of this study was to measure the sagittal and transverse dimensions of the FM using computed tomography (CT) examination in children of various ages, accounting for gender. This was done to perform a morphometric analysis and ascertain how the FM changes with age.

## Methods

This study was approved by the Non-Interventional Clinical Research Ethics Committee of Erzincan Binali Yıldırım University (decision no: 417789, date: 03.01.2025). In this study, cranial CT images were obtained using a 128-slice multi-detector CT scanner with a slice thickness of 0.625 mm. The study's data came from re-examining the digital patient archives, to find images of 313 patients who had CT evaluations in our hospital between January and December 2024 for various reasons.

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Since the study was conducted retrospectively, no additional informed consent was required beyond what was initially obtained.

Following a review of the image archives, 62 patients with image artifacts or trauma in the occipital bone region were excluded from the study, and a total of 251 patients without trauma and with good image quality and positioning were included.

The patients were children aged 0-18. In this descriptive study, patients were divided into age groups: 0-1 years, 2-4 years, 5-8 years, 9-13 years, and 14-17 years. The study comprised 251 patients.

A Vernier Caliper was used to measure the FM's anteroposterior and transverse transverse diameters (TD) with an accuracy of 0.1 mm (Figure 1). The distance in the mid-sagittal plane between the opisthion (posterior border) and the basion (anterior border) is known as the anteroposterior diameter (APD) of the FM. The maximum distance along the transverse plane is known as the TD.

### Statistical Analysis

Statistical analysis of the measurements was performed. Data were analyzed using the Statistical Package for the Social Sciences (IBM SPSS 22.0, IBM Corporation®, Armonk, NY, USA) software (IBM SPSS Inc.). Values with p<0.05 were considered statistically significant.

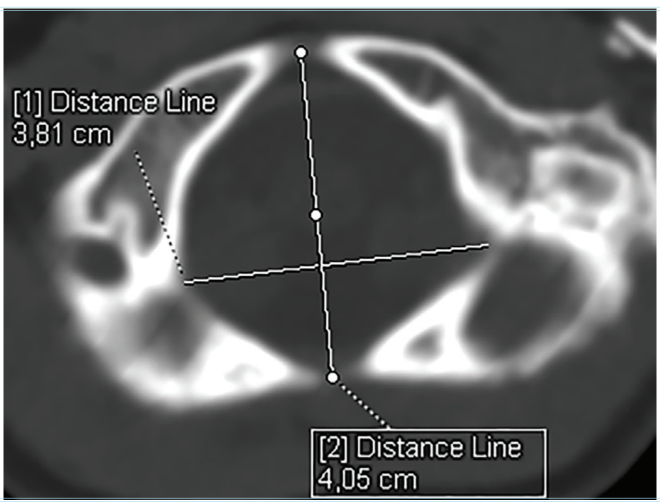


**Figure 1.** The widest transverse and longest sagittal length measurements of the axial plane foramen magnum were taken. The yellow arrow indicates the measurement of the longest sagittal diameter, while the blue arrow indicates the measurement of the widest transverse diameter

## Results

The study included 251 children, 156 boys (62.2%) and 95 girls (37.8%). The youngest age included in the study was 2 months, and the oldest age was 17 years. The median age of children was 7.

The lowest sagittal diameter (SD) measurement value is 26, and the highest is 44. The lowest and highest SD values in girls were found to be 26 and 44, respectively, while in boys they were found to be 19 and 37. The mean SD of all children was 36 and the mean TD was 29.

In FM measurements, the sagittal dimension is greater than TD in all ages.

There was no discernible gender difference in any of the SD, TD measurement values between girls and boys.

Tables 1 and 2 display the general measurements and specific SD, TD values along with their values in boys and girls.

Compared to the other groups, all measurements made at ages 0-1 years and 2-4 years were noticeably lower. Measurements taken at ages 5-8 and 9-13, as well as 14-17, showed related results. At every age, there were no appreciable variations in SD and TD measurements between boys and girls.

Age and SD and TD values had a substantial positive connection (p<0.05). Table 3 provides a summary of the results.

## Discussion

Morphometric research in anthropology aids in determining anthropometric variations among populations, such as ethnicity, gender, age, and genetic factors, that may influence bone size and shape. Additionally it can differentiate between a pathogenic situation and typical variations.[1] For many abnormalities, it is essential to ascertain the size of FM and how it changes with age.[5] In addition, knowing the size of the FM is important in diagnosing diseases such as FM meningioma, and in planning intracranial surgery.[6]

Adult measurements from imaging and dry skull investigations serve as the foundation for most FM evaluations.[7]

**Table 1. The min. and max. values SD and TD values are shown**

| | Min. (mm) | Max. (mm) | Median |
|---|---|---|---|
| SD | 26 | 44 | 36 |
| TD | 19 | 37 | 29 |

SD: Sagittal diameter, TD: Transverse diameter, Min.: Minimum, Max.: Maximum

**Table 2. The results obtained for the sagittal and transverse dimensions of foramen magnum for the study group by sex**

| | Sex | Min. (mm) | Max. (mm) | Median |
|---|---|---|---|---|
| SD | Girl | 27 | 41 | 34 |
| | Boy | 26 | 44 | 36 |
| TD | Girl | 20 | 35 | 29 |
| | Boy | 19 | 37 | 30 |

SD: Sagittal diameter, TD: Transverse diameter, Min.: Minimum, Max.: Maximum

**Table 3. Changes in SD and TD values with age and gender**

| Age | | | SD | | | TD | | |
|---|---|---|---|---|---|---|---|---|
| | Sex | N | Min. | Max. | Median | Min. | Max. | Median |
| 0-1 | Girl | 18 | 27 | 39 | 32 | 20 | 34 | 24.5 |
| | Boy | 32 | 26 | 38 | 32 | 19 | 29 | 26 |
| 2-4 | Girl | 19 | 31 | 37 | 34 | 24 | 34 | 28 |
| | Boy | 34 | 30 | 39 | 36 | 24 | 33 | 28 |
| 5-8 | Girl | 21 | 35 | 40 | 37 | 27 | 33 | 30 |
| | Boy | 30 | 32 | 44 | 37 | 26 | 37 | 30 |
| 9-13 | Girl | 13 | 34 | 39 | 37 | 27 | 34 | 30 |
| | Boy | 30 | 33 | 42 | 38 | 26 | 36 | 31 |
| 14-17 | Girl | 24 | 34 | 42 | 37 | 27 | 35 | 30 |
| | Boy | 30 | 34 | 42 | 39 | 29 | 37 | 32 |

SD: Sagittal diameter, TD: Transverse diameter, Min.: Minimum, Max.: Maximum

More et al.[7] analyzed age groups and compared children in the 0-9 and 10-19 age groups using CT scans. In the 0-9 age group, the mean APD was 36.00 (SD 6.93) mm, and the mean TD was 27.85 (SD 0.64) mm. In the 10-19 age group, both dimensions were 35.70 (SD 3.38) mm and 29.45 (SD 2.86) mm. In our study, the mean SD was 34.6 and the mean TD was 27.6 in the 0-8 age group. In the 9-18 age group, the mean SD was 37.75 and the mean TD was 30.75.

Our study's mean FM SD and TD values compare to those found in adult research. Our findings were consistent with research by Ulcay et al.[8] in a Turkish population, where the mean SD was 35.81 mm and the TD was 28.14 mm.

The mean values of FM APD and TD presented in our study were similar to those reported by Ganapathy et al.[9] in their study of the Indian adult population. In their study, the mean SD value was 3.49±0.23, and the mean TD value was 2.98±0.25.

As in the studies conducted by Natsis et al.[10] on the Greek adult population, the study conducted by Osunwoke et al.[11] on the skulls of the African adult population also showed results close to ours.

In certain instances, the mean values we found in children were greater or less than the FM dimensions of adults.[6,7,12,13] The sample size, measuring technique, or racial disparities could all be to blame for the discrepancies in the reported data.

The mean values for girls and boys in the children's study by More et al.[7] were 35.15 (SD 3.76) mm and 36.09 (SD 4.64) mm, respectively. Girls had a mean TD of 28.53 (SD 3.25) mm, whereas boys had a mean TD of 29.6 (SD 3.49) mm. Our results and those obtained were comparable. Although the results are similar, the two studies show minor differences, which are likely due to population differences and the use of different age ranges.

Given the statistically significant results, the findings are compatible with Shepur et al.[12] claim that FM achieves its maximum size in early childhood.

As a result, in this study investigating changes in FM morphology with age and sex, no difference was observed in SD and TD measurements between girls and boys, while a positive correlation was found with age.

### Study Limitations

Our study has some limitations. First, this study is retrospective, so a comprehensive data review and detailed history were not possible. Second, our small sample size limits statistical analysis and reduces the power of our results. Third, images containing artifacts could not be included in the study because data measurement was not possible.

## Conclusion

The morphology and size measurement of the FM have been extensively studied in the literature, although the pediatric age group has received relatively little attention.

As a result, in this study investigating changes in FM morphology with age and gender, no difference was observed in SD and TD measurements between girls and boys, while a positive correlation was found with age.

### Ethics

**Ethics Committee Approval:** This study was approved by the Non-Interventional Clinical Research Ethics Committee of Erzincan Binali Yıldırım University (decision no: 417789, date: 03.01.2025).

**Informed Consent:** Since the study was conducted retrospectively, no additional informed consent was required beyond what was initially obtained.

### Footnotes

### Authorship Contributions

Surgical and Medical Practices: E.B., M.S., Concept: Ö.Ç.A., Design: Ö.Ç.A., M.S., Data Collection or Processing: E.B., Analysis or Interpretation: Ö.Ç.A., Literature Search: E.B., M.S., Writing: E.B.

**Conflict of Interest:** No conflict of interest was declared by the authors.

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