INTRODUCTION

The foramen magnum is the largest foramen in the skull.\(^1\) It is a wide opening in the posterior cranial fossa connecting the cranial cavity with the vertebral canal. It allows the passage of vital structures of brain through it.\(^2\) It is oval in shape, wider behind and the largest diameter is antero-posterior. It contains lower end of medulla oblongata, meninges, cerebro-spinal fluid, vertebral arteries and veins, and spinal accessory nerve.\(^3\)

The dimensions of the foramen magnum are clinically important because of the above mentioned various surgical procedures at the skull base, this area is having higher clinical importance. The morphometric analysis of foramen magnum and its variations is important not only for anatomists but also to the anesthetist, neurosurgeons, orthopedicians and radiologist. It has also has important clinical implications in the prognosis and treatment of various neurological pathologies like Arnold Chiari syndrome, and posterior cranial fossa lesions.\(^4\) Thus, understanding of the variations in its normal anatomy is essential for accurate diagnosis and treatment of same. Hence, the present study was done to determine and analyse the morphological types and diameters of the foramen magnum in adult skull of Indian population.

MATERIALS AND METHODS

Study Population: A total of 30 dry adult human skulls of unknown age and sex were collected from Department of Anatomy Zoram Medical College...
Falkawn over a period of six months from January 2023 to June 2023. The study was approved by the Institute Ethics Committee.

**Inclusion Criteria**
Fully ossified, dried, macerated and thoroughly cleaned skull

**Exclusion Criteria**
Deformed and damaged bones related with foramen magnum

**Methodology:** Various morphometric measurements like anterio-posterior diameter and transverse diameter of foramen magnum were taken using the Digital Vernier sliding caliper which is accurate to 0.01 millimeter. The mean and standard deviation of the foramen magnum in various dimensions were calculated.

**Antero-posterior Diameter (APD):** Measured from the end of anterior border (basion) to the end of posterior border (opisthion) of foramen magnum.

**Transverse Diameter (TD):** Measured from the point of maximum concavity on the right margin to the maximum concavity on left margin of foramen magnum.

**Foramen Magnum Index (FMI):** was calculated by dividing the transverse diameter by AP diameter and multiplied by hundred.

**Area of the Foramen Magnum:** It is surface area of the foramen magnum calculated by the following formula.[8]

\[
\text{AREA} (A) = \frac{1}{4} \pi \times w \times h
\]

\[
\pi = \frac{22}{7}, \text{mathematical constant.}
\]

The above parameters were recorded as an average of two observations which were measured independently by two different people. The mean and standard deviation for each parameter was calculated and expressed as mean ± standard deviation.

In addition the shapes of the foramen magnum were also noted and classified as oval, round, tetragonal, hexagonal, pentagonal and pear shaped.

**Statistical Analysis:** The qualitative data were expressed in proportion and percentages and the quantitative data expressed as mean and standard deviations. The difference in proportion was analyzed by using chi square test. Significance levels for tests were determined as 95% (P< 0.05).

**RESULTS**

The various parameters related to the foramen magnum were measured and demonstrated in this study.

In this study various shapes of foramen magnum were observed. The most common shape was oval in 22 (37.2%) skulls; followed by round shape in 12 (20.3%), tetragonal shape was 10(16.9%), skulls and hexagonal in 06 (10.1%) skulls, hexagonal was 5 (8.4%). Round shaped FM was present in 16 (13.3%) skulls, pentagonal FM in 16 (13.3%) and pear shaped was present in 8 (6.6%) skulls. [Table 1]

In this study the anteroposterior diameter of the foramen magnum was in a range of 27.30–37.20 mm with a mean of 32.25 ± 2.55 mm, and the transverse diameter of the foramen magnum was in a range of 23.11–32.78 mm with a mean of 27.94±2.10 mm. The mean surface area of the foramen magnum was 712.51±110.65 mm², range being from 486.74 mm² to 880.28 mm². The mean foramen magnum index was found to be 83.99±6.75. [Table 2]

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<tr>
<th>Table 1: Shapes of foramen magnum.</th>
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<td>Shape</td>
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<tr>
<td>Oval</td>
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<td>Round</td>
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<th>Table 2: Dimensions of foramen magnum.</th>
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<tr>
<td>Parameter</td>
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<tr>
<td>Anteroposterior diameter (APDfm) (mm)</td>
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<tr>
<td>Transverse diameter (TDfm) (mm)</td>
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<tr>
<td>Foramen magnum area (Afm) (mm²)</td>
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<td>Foramen magnum index (Ifm)</td>
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<th>Table 3: Mean dimensions of foramen magnum according to shape.</th>
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<tr>
<td>Parameter</td>
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<tr>
<td>Mean Anteroposterior diameter</td>
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<td>Mean Transverse diameter</td>
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<td>Mean Foramen magnum area</td>
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574
DISCUSSION

Foramen magnum is morphologically variable osteological feature in the skull which has undergone evolutionary changes.[9]

In this study we found that the most common shape of foramen magnum was oval shape in 22 (37.2%) skulls; followed by round shape in 12 (20.3%), tetragonal shape was 10(16.9%), skulls and hexagonal in 06 (10.1%) skulls, pentagonal was 5 (8.4%) and the least was pear shaped in 8 (6.6%) skulls. [Table 1] Our findings are accordance with Vinutha SP et al,[1] who also reported the most common shape of foramen magnum was oval shape in 36.5% skulls. Many other researchers Nagwani M et al,[10] Kumar A et al,[11] Singh R and Kumar R,[12] also observed oval as most common type. However Chethan P et al,[13] found round shape was the most common. In another study Aragao JA et al,[14] reported pear shape was the most common foramen magnum while Sindel M et al,[15] reported tetragonal shape as a common shape of foramen magnum. The difference in shapes of the foramen magnum from various reports indicates racial variability among the morphology. These variations might have been attributed by the factors such as sexual dimorphism,[16] types of population.[13] Therefore the variation in the foramen magnum shape should be taken into consideration during clinical and radiological diagnostic procedures and the surgical approach.[13]

In this study we found that the mean anteroposterior diameter of the foramen magnum was in 32.25 ± 2.55 mm and the mean transverse diameter was 27.94±2.10 mm. our findings are consistent with Muthukumar N et al,[18] who observed that the average anteroposterior length of the foramen magnum was 33.3 mm and the transverse diameter was 27.9 mm. In another study Sampada PK et al,[19] reported anteroposterior diameter of foramen magnum was 34.84±2.32 mm and an average transverse diameter of 29.39±1.73 mm. In a study done on 71 skulls of Uttar Pradesh the mean anteroposterior diameter of foramen magnum was 34.09± 2.23 mm and transverse diameter was 28.22 ± 2.19 mm.[20] However Philipp Gruber,[21] in his study on skulls from Western Europe found that the mean anteroposterior diameter of foramen magnum was 36.6 mm and the mean transverse diameter was 31.1 mm which was higher value than our study. In present study we also found that the mean surface area of the foramen magnum was712.51±110.65 mm2, range being from 486.74 mm2 to 880.28 mm2 which is similar with the study conducted by Singh D et al.[22] who observed 728.12±112.98 mm2. In another study conducted by Praveen T and Singh P,[23] reported the mean area of foramen magnum was 792.61±91.01 mm2. However Shika et al,[24] and Rohinin devi et al,[25] reported that the mean area of the foramen magnum was 970.57 mm2 and 820.53 mm2 which were higher than present study. The variations observed in various studies may be due to the ethnic group involved and size of study sample.

In this study we found that the mean foramen magnum index was found to be 83.99±6.75 which is consistent with the study conducted by Archana Singh et al7 who also reported 83.91±6.43. Various study conducted by Chaturvedi RP et al., and Howale DS et al. reported the average value of foramen magnum index as 83.81 and 84.85±4.77 respectively, which was concordance with present study.[26,27] The shape of the foramen magnum is morphologically variable. Variations in foramen magnum shape should be taken into consideration during radiological diagnostic procedures and surgical approaches to the region. This is also important for deciding that how much bone must be removed.[28] In early fetal development, foramen magnum is one of the centres of ossification and because of evolutionary changes its shapes are variable.[9,18] The irregular shape of the FM may be due to developmental anomalies related to bones and soft tissues at the craniovertebral junction.

CONCLUSION

The analysis of various shapes of foramen magnum is utmost important. This study will become a useful guide for the surgeons, radiologists, orthopedics, anthropologists as well as forensic experts. The present study enhances the knowledge about various shapes of foramen magnum at the base of skulls in Indian populations.

REFERENCES

27. Howar DS, Bathija D, Pandit DP. Correlation between cranial index and foramen magnum index in human dried skulls. GJRA. 2014;3(1):3-6