Anatomical Observation of Different Shapes of Foramen Magnum and Its Clinical Implications: A Study in Dry Adult Human Skulls of Indian Population


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ABSTRACT

Background: Understanding of thoroughly explained anatomical basis is must for various surgical approaches at the craniovertebral junction. High mortality and morbidity are anticipated during the surgical procedures when undertaken without in depth anatomical knowledge. With so much clinical importance in this area, our study will present a thorough understanding in terms of skull.

Objectives: The aim of the present study is to evaluate the various shapes of foramen magnum in dry adult human skulls of Indian population and to find out their clinical correlation.

Materials and methods: 347 dried adult human skull base obtained from the Department of Anatomy, Geetanjali Medical College and Hospital, Udaipur, Rajasthan and other medical colleges were used in the present study. All the dry adult human skulls were observed from outer side at their base by naked eyes to determine the shape of foramen magnum. It was classified into one of the following shapes: - Oval, round, tetragonal, egg shaped, hexagonal, pentagonal and irregular.

Results: The shape of the foramen magnum in dry skulls were oval in 44.95%, round in 30.84%, hexagonal in 9.23%, irregular in 6.63%, pentagonal in 5.19%, tetragonal in 1.73 %, and egg shaped in 1.44%.

Conclusion: Inferences of the present study in the form of variations in the shapes of foramen magnum will be useful to the neurosurgeons, radiologists, orthopedics, anthropologists, forensic experts as well as anatomists. Further these data can be used as an anatomical reference for the researchers.

KEY WORDS: Human Skull, Shape, Foramen Magnum.

INTRODUCTION

The English word “skull” is derived from “skulle” which means head [1]. Familiarity of the detailed knowledge of the morphological variations in the foramina of skull base as well as their morphometrical values are vital to...
perform safe radical surgical procedures as well as interventional diagnostic procedures [2]. Vital structures passing through the foramen magnum are affected by the variations in shape of foramen magnum. Irregular shape of foramen magnum is featured by the formative cranial anomalies [3]. Occipital bone anterior to the foramen magnum develops from the basioccipital portion, posterior to the foramen magnum develops from supraoccipital portion and lateral to the foramen magnum develops from exoccipital portion of the chondrocranium. Development of a particular shape of the foramen magnum is explained on the basis of the embryologic data. It may be caused by ossification of primordial cranial residues, which join the endochondral ossification points in different locations, resulting in various shapes [4]. Irregular shape of foramen magnum is accentuated by the developmental anomalies of the bone and soft tissues at the craniovertebral junction [5]. Due to high chances of morbidity and mortality during various surgical procedures at the skull base, this area is having higher clinical importance. The present study was done to evaluate the various shapes of foramen magnum in dry adult human skulls of Indian population and to find out their clinical correlation.

MATERIALS AND METHODS

Present study was conducted on 347 dried adult human skull base obtained from the Department of Anatomy, Geetanjali Medical College and Hospital, Udaipur, Rajasthan and other medical colleges (GSVM medical college, Kanpur, Uttar Pradesh and King George’s medical university, Lucknow, Uttar Pradesh) after taking necessary institutional ethical approval, during the year 2015 to 2018. Fractures or damaged skulls, skulls with congenital malformations or deformities or having previous trauma were excluded from the study. Fully ossified adult skulls were included in the present study. All the dry adult human skulls were observed from outer side at their base by naked eyes to determine the shape of foramen magnum. The shapes of foramen magnum were classified into one of the following: Oval, round, tetragonal, egg shaped, hexagonal, pentagonal and irregular. The findings of the present study were tabulated and graphed by using Microsoft Office Excel 2019.

RESULTS

Photograph 1: Posterior part of base skull showing ‘oval shape’ of FM.

Photograph 2: Posterior part of base skull showing ‘round shape’ of FM.

Photograph 3: Posterior part of base skull showing ‘hexagonal shape’ of FM.

Photograph 4: Posterior part of base skull showing ‘irregular shape’ of FM.
Posterior part of base skull showing ‘pentagonal shape’ of FM.

Posterior part of base skull showing ‘tetragonal shape’ of FM.

Posterior part of base skull showing ‘egg shaped’ of FM.

Table 1: Showing the frequency and percentages of various shapes of foramen magnum in the present study.

<table>
<thead>
<tr>
<th>Sr No</th>
<th>Shapes of foramen magnum</th>
<th>Number of specimen (Out of total 347)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Oval</td>
<td>156</td>
<td>44.95</td>
</tr>
<tr>
<td>2</td>
<td>Round</td>
<td>107</td>
<td>30.84</td>
</tr>
<tr>
<td>3</td>
<td>Hexagonal</td>
<td>32</td>
<td>9.22</td>
</tr>
<tr>
<td>4</td>
<td>Irregular</td>
<td>23</td>
<td>6.63</td>
</tr>
<tr>
<td>5</td>
<td>Pentagonal</td>
<td>18</td>
<td>5.19</td>
</tr>
<tr>
<td>6</td>
<td>Tetragonal</td>
<td>6</td>
<td>1.73</td>
</tr>
<tr>
<td>7</td>
<td>Egg shaped</td>
<td>5</td>
<td>1.44</td>
</tr>
</tbody>
</table>

As shown in Table 1 and graph 1, various shapes of foramen magnum in 347 dry adult human skulls in the present study were as follows:

The most common shape of foramen magnum was oval in 156 out of 347 skulls (44.95%) (Photograph 1). The least common shape of foramen magnum was egg shaped in 5 out of 347 skulls (1.44%) (Photograph 7). The round shape of foramen magnum was observed in 107 out of 347 skulls (30.84%) (Photograph 2). The hexagonal shape of foramen magnum was observed in 32 out of 347 skulls (9.22%) (Photograph 3). The irregular shape of foramen magnum was observed in 23 out of 347 skulls (6.63%) (Photograph 4). The pentagonal shape of foramen magnum was observed in 18 out of 347 skulls (5.19%) (Photograph 5). The tetragonal shape of foramen magnum was observed in 6 out of 347 skulls (1.73 %) (Photograph 6).

DISCUSSION

The foramen magnum is the largest foramen of the skull, which is located in the most inferior portion of the cranial fossa and it is a part of the occipital bone [6]. Several anatomical parameters such as shape, size and orientation of the foramen magnum should be taken into consideration during surgery involving the posterior and lateral craniovertebral junctions. The quantitative data may be useful in planning the degree of bone work required for optimum exposure of the surgical field and minimization of the risks of morbidity [4].

In the present study, the most common shape of FM in Indian population was oval (156 out

In the present study, round shape foramen magnum was found in 30.84% cases (107 out of 347 skulls). The value of this study was almost similar to the values of studies done by Riyaz ZH et al[13](2015) in 29.50% and Chandekar KS et al[24](2017) in 30.43 % cases; lower than the findings of Muthukumar N et al[25](2005) in 54% and Ajay R et al[26] (2015) in 35% cases; higher than the findings of Chethan P et al[5](2012) in 22.6%, Radhika PM et al[27] (2014) in 20%, Ganapathy A et al[28](2014) in 9%, Gopalakrishana K et al[29] (2015) in 25%, Saini K[8](2015) in 19%, Bhaskar R et al[11] (2017) in 16%, Veeramani R et al[15] (2018) in 20%, Aragão JA et al[19] (2014) in 22.5%, Sharma DK et al[22] in 22.67% and Sharma A et al[23] in 15.7% cases (Table 1 & 2). This difference may be due to population variation.
In the present study, hexagonal shape of foramen magnum was in 9.22% cases (32 out of 347 skulls). The finding of the present study is almost similar to the studies done by Ganapathy A et al[28] (2014) in 9%, Riyaz ZH et al[13] (2015) in 8.19%, Sharma Set al[30](2015) in 8%, Ajay Ret al[26](2015) in 10%, Aragão JA et al[19](2014) in 9.1%, Revankar S et al[21] in 10% and Kumar A et al[16] (2015) in 8% cases; lower than the finding of Krishna K et al[10](2016) in 11.8%, Fathima F et al[31](2016) in 21%, Veeramani R et al[15](2018) in 21%, Ilhan P et al[20] (2017) in 21%, Sharma DK et al[22] in 16% and Sharma A et al[23] in 45.1% cases; higher than the finding of Pires LA et al[17](2016) in 1.29% cases. (Table 1 & 2)

These differences could be due to interobserver variation.

In the present study, irregular shape foramen magnum was found in 6.63% cases (23 out of 347 skulls) in Indian population. This value is almost similar to the study done by Singh KC et al[14] (2017) in 8%, Aragão JA et al[19](2014) in 6.4% and Sharma A et al[23] in 5.9% cases; lower than the findings of Chethan P et al[5](2012) in 15.1%, Sampama PK et al[12](2017) in 10%, Ganapathy A et al[28](2014) in 22%, Riyaz ZH et al[13](2015) in 11.47%, Veeramani R et al[15](2018) in 32%, Kumar A et al[16](2015) in 16%, Pires LA et al[17](2016) in 16.88%, Ilhan P et al[20](2017) in 22%, Revankar S et al[21] in 12.5% and Sharma DK et al[22] in 14.67% and Sharma A et al[23] in 17.6% cases. (Table 1 & 2) These higher percentages may be due to racial differences as the population in the above studies differs from population of the present study.

In the present study, pentagonal shape of foramen magnum was in 5.19% cases (18 out of 347 skulls). The finding of the present study is almost similar to the studies done by Ajay Ret al[26](2015) in 5% cases; higher than the finding of Fathima F et al[31](2016) in 4%, Chethan P et al[5](2012) in 3.8%, Radhika PM et al[27](2014) in 2%, Sampama PK et al[12](2017) in 1%, Pires LA et al[17](2016) in 1.29%, Aragão JA et al[19](2014) in 2.7%, Ilhan P et al[20](2017) in 2% and Sharma A et al[23] in 3.9% cases; lower than the finding of Radhikrishna SK et al[32](2012) in 14%, Sharma Set al[30](2015) in 8%, Devadas P et al[7](2017) in 12%, Revankar S et al[21] in 12.5% and Sharma DK et al[22] in 9.33% cases (Table 1 & 2).

In the present study, tetragonal shape of foramen magnum was in 1.73% cases (06 out of 347 skulls). The finding of the present study is lower than the findings of Radhika PM et al[27](2014) in 6%, Bhaskar R et al[11](2017) in 30%, Veeramani R et al[15](2018) in 11%, Kumar A et al[16](2015) in 6%, Aragão JA et al[19](2014) in 10.9%, Pires LA et al[17](2016) in 16.88%, Ilhan P et al[20](2017) in 24% and Revankar S et al[21] in 12.5%, Sharma DK et al[22] in 14.67% and Sharma A et al[23] in 17.6% cases. (Table 1 & 2) These higher percentages may be due to racial differences as the population in the above studies differs from population of the present study.

In the present study, egg shaped foramen magnum was in 1.44% cases (05 out of 347 skulls). The value of the present study is lower than the finding of Chethana P et al[5](2012), in 18.6%, Radhika PM et al[27](2014) in 10%, Sampama PK et al[12](2017) in 11%, Veeramani R et al[15](2018) in 12%, Natsis K et al[18](2013) in 21%, Ilhan P et al[20](2017) in 24%, Revankar S et al[21] in 12.5% and Sharma DK et al[22] in 12%. As explained earlier these higher values of egg shape of foramen magnum could be due to interobserver variation or due to classification of foramen magnum into 6 shapes only.

**CONCLUSION**

As the various surgical approaches and the radiological diagnostic procedures have their own limitations, 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. As the present study enhances the knowledge about...
various shapes of foramen magnum at the base of skulls in Indian population, the data of the present study may serve as an anatomical reference for researchers.

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