Original Article

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Anatomy Section

Morphometric Variations of the Foramen Lacerum in Dry Skulls and its Clinical Significance: A Cross-sectional Study

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ABSTRACT

Introduction: The foramen lacerum is located in the middle cranial fossa and transmits a number of nerves and blood vessels. Occlusion can result in the compression of the neurovascular bundle, and the foramen has been reported to be involved in the spread of tumours into the cranium.

Aim: The aims of the present study was to describe the morphology of the foramen lacerum and to compare the anatomical parameters on the left and right sides of the skull. Also, the significance of the anatomical parameters in male versus female skulls and right side versus left side of the skull where studied.

Materials and Methods: This cross-sectional study was conducted in May and June 2023 using 62 dry skulls (124 foramen lacerum) available in the Department of Anatomy at Gautam Buddha Chikitsa Mahavidyalay, a tertiary care teaching institute in Dehradun, Uttarakhand, India. The anatomical parameters, including the Anteroposterior (AP) and transverse diameters, were recorded using a calibrated digital Vernier caliper. The shape of the foramen was also observed. The mean and standard deviation of the recorded parameters were obtained.

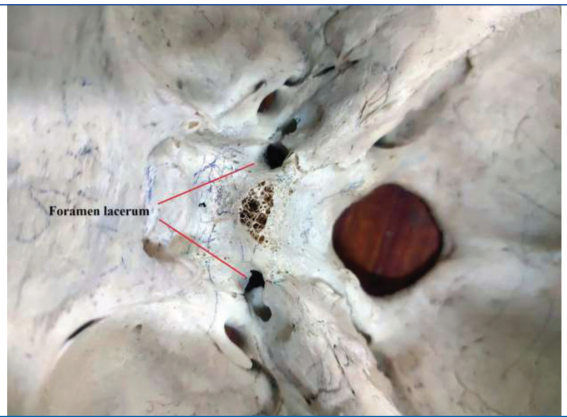
Results: Out of the 62 skulls, 41 were males and 21 were females, resulting in a male-to-female ratio of 1.8:1. The mean AP diameter on the Right Side (RT) and Left Side (LT) in males was 6.26 mm and 6.24 mm, respectively, while in females, the mean diameter was 4.97 mm (RT) and 5.4 mm (LT). The mean transverse diameter recorded in the present study was 6.14 mm (RT) and 6.2 mm (LT) in males, while in females, this measurement was 5.88 mm on both sides. The most common shape of the foramen lacerum observed in the study was bilaterally round, in both males and females.

Conclusion: There are morphological differences in the AP diameter between male and female skulls, with males having a larger AP diameter on their right side and females having larger AP diameter on their right side. The overall size of the foramen lacerum was smaller in the present study, indicating a higher likelihood of neurovascular bundle compression with age. The recent advances in skull base surgery warrant further and larger studies on this neglected yet important foramen to gather more data on its morphometric variations in different geographical regions.

Keywords: Anatomy, Middle cranial fossa, Nasopharynx

INTRODUCTION

The foramen lacerum is a triangular-shaped foramen [Table/Fig-1] located at the junction of three bones: the pterygoid process and greater wing of the sphenoid bone form its anterior border, the apex of the petrous part of the temporal bone forms its posterolateral border, and the basilar part of the occipital bone forms its posteromedial border [1].



[Table/Fig-1]: Middle cranial fossa showing foramina in relation to the foramen lacerum.

The foramen lacerum serves as a passage for several nerves and blood vessels, including the emissary vein, ascending pharyngeal artery, internal carotid artery along with the sympathetic plexus, and the greater petrosal nerve [2]. It is closely associated with the pterygoid canal, whose posterior orifice is located in the lower part of the foramen lacerum on its anterior wall. The sympathetic plexus around the internal carotid artery forms the deep petrosal nerve, which combines with the greater petrosal nerve to form the nerve of the pterygoid canal [3].

The foramen lacerum has been documented as a conduit for the intracranial spread of various malignant tumours, such as nasopharyngeal carcinoma, adenoid cystic carcinoma, juvenile angiofibroma, malignant melanoma, and lymphoma [4]. In the case of nasopharyngeal carcinoma, the incidence rates of tumour spread involving the foramen lacerum range from 47.8% [5,6] to as high as 53.2% [7]. Additionally, besides serving as a channel for tumour spread, the foramen lacerum has also been associated with the spread of infection to the intracranial space, and reports of cavernous sinus thrombosis involving the foramen lacerum are well documented [8].

There is a lack of evidence regarding the morphometric variations of the foramen lacerum in the existing literature [9,10]. Consequently, a study was conducted at a tertiary care teaching centre of a Medical University in North India with the following aims and objectives: (i) to describe the morphology of the foramen lacerum; (ii) to compare the anatomical parameters related to the foramen lacerum on the left and right sides of the skull; and (iii) to study the significance of the anatomical parameters in male versus female skulls and the right side vs. the left side of the skull.

MATERIALS AND METHODS

The present cross-sectional study was conducted in the Department of Anatomy at Gautam Buddha Chikitsa Mahavidyalay, a tertiary

care teaching institute in Dehradun, Uttarakhand, India, in May and June 2023. Ethics clearance was obtained from the Institute Ethics Committee with the reference number GBCM/IEC/2023/06-08.

Sixty-two dry skulls available in the Department of Anatomy were collected and then analysed for suitability to be included in the study. Only dry skulls that were ossified, intact, and showed no obvious defects or deformities were included. Damaged skulls in which the base of the skull was not intact, making the study of the foramen lacerum challenging, were excluded.

Briefly, dry skulls that met the inclusion and exclusion criteria in the study were segregated and assigned a unique identification number. Based on morphological features, the gender of each skull was identified, and their morphometric parameters were measured using a well-calibrated digital Vernier caliper [Table/Fig-2] and a magnifying glass if necessary. The parameters studied included the AP diameter and the transverse diameter on both the right and left sides of the skull. Additionally, the shape of the foramen lacerum was observed and recorded as round, oval, quadrangular, triangular, irregular, or lacerated. If both sides had the same shape, it was categorised as bilateral; otherwise, the shape on the right and left sides was recorded separately if different.

[Table/Fig-2]: Measurement of the foramen lacerum using digital Vernier calliper through the middle cranial fossa approach.

The collected data was entered into Microsoft Excel (Microsoft Corp., USA). The mean and standard deviation of the recorded parameters were obtained.

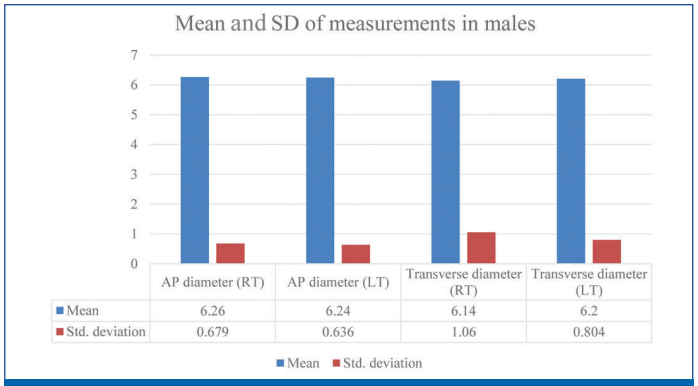
RESULTS

A total of 62 skulls were included in the study, and the bilateral foramen lacerum was studied for each skull, resulting in a total of 124 foramen lacerum studied. Out of the 62 skulls, 41 were male and 21 were female, resulting in a male-to-female ratio of 1.8:1 in the study.

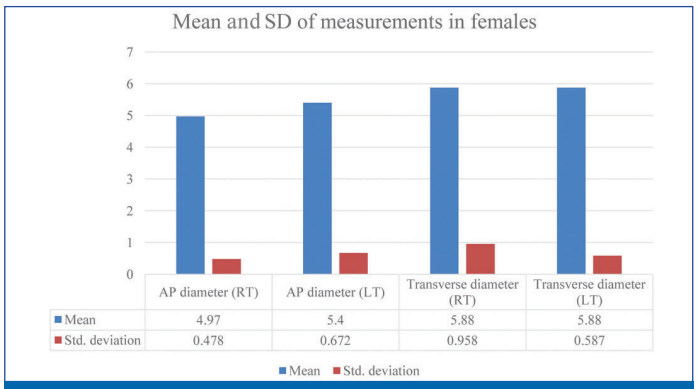
The measurements of the AP and transverse diameter of the foramen lacerum were recorded for both males [Table/Fig-3] and females [Table/Fig-4] on the right and left sides. In males, the mean AP diameter on the right side was 6.26 mm (range 5.2-7.71 mm), while the same diameter on the left side was 6.24 mm (4.14-7.43 mm). The mean transverse diameter was also comparable, with 6.14 mm (4.14-7.43 mm) on the right side and 6.20 mm (4.48-7.81 mm) on the left side. In females, the mean AP diameter was 4.97 mm (4.12-5.61 mm) on the right side and 5.40 mm (4.5-6.68 mm) on the left side, with a mean transverse diameter of 5.88 mm (4.62-7.9 mm) on the right side and 5.88 mm (5.08 mm-7.42 mm) on the left side.

The mean AP and transverse diameter were larger in males compared to females. Additionally, the mean diameter was slightly larger on the left side compared to the right side in both males and females, except for the mean AP diameter in males, which was higher on the right side.

The majority of males (n=58; 70.7%) as well as, females (n=22; 52.4%) had symmetrical foramen lacerum on both sides, which

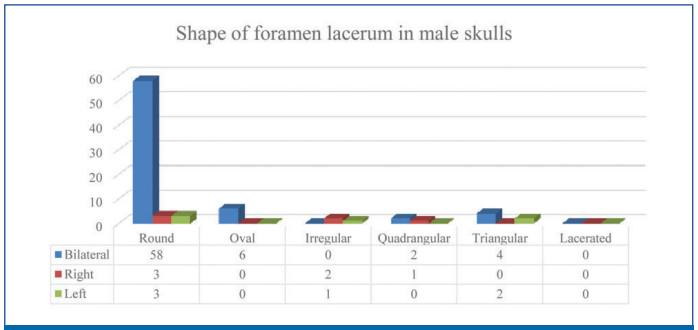


[Table/Fig-3]: Measurements of foramen lacerum in male skulls.

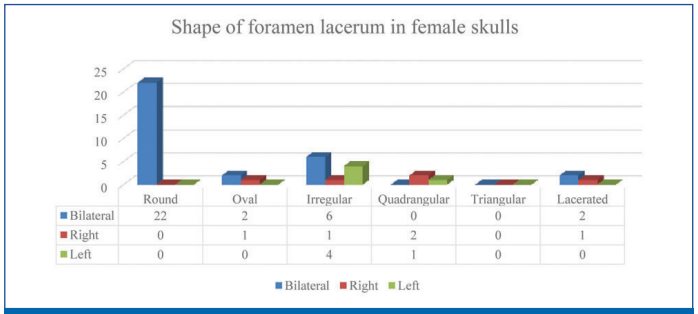


[Table/Fig-4]: Measurements of foramen lacerum in female skulls.

were round in shape [Table/Fig-5,6]. Other shapes observed in males included oval, triangular, quadrangular, and irregular. None of the male skulls had a lacerated foramen lacerum. In females, all shapes were found, except for triangular.



[Table/Fig-5]: Shape of foramen lacerum in male skulls.



[Table/Fig-6]: Shape of foramen lacerum in female skulls.

DISCUSSION

The present study was conducted at a tertiary care centre in North India to investigate the morphometric variations in the foramen lacerum in North Indian skulls. There is a lack of such data as only a few studies have been conducted on the foramen lacerum to date [9,10]. Nevertheless, it is an important anatomical structure as it is considered to be a conduit for carcinomas into the cranium, both benign and malignant [11]. Moreover, it lies at the intersection of the sagittal and coronal planes but has not been widely utilised in intracranial surgeries until recently [12,13].

The size of the foramen lacerum in the present study was found to be smaller than in other geographical regions [9,10], except for the transverse diameter, which was larger than the reported size in a previous study from India [10]. The mean AP diameter on the right side was larger than on the left side in males, whereas in females, the mean AP diameter was larger on the left side compared to the right side. This observation contrasts with a study conducted by Abd EL Naeem A, where there was no difference in the mean AP diameter between the right and left sides [9]. However, the study did not differentiate the morphometric variations by gender, so differences between males and females could not be determined. Another study from India reported a larger mean AP diameter on the left side compared to the right side in Type-I and Type-II skulls, while Type-III skulls had comparable mean diameters on both sides [10].

The mean transverse diameter of the foramen lacerum was slightly larger on the left side compared to the right side in males, while it was similar on both sides in females. This was in contrast with the previous studies from Egypt and India, in which the transverse diameter was larger on the right side [9,10].

The overall mean AP diameter in the present study is smaller than in the Egyptian and previous Indian studies, which could be attributed to racial and geographical differences as observed by Singh R and Kumar R in their study from Eastern Uttar Pradesh [10]. The mean transverse diameter is similar to the study from Egypt, but the previous study from India reported a smaller transverse diameter of 4 mm (RT) and 3 mm (LT). Given the high prevalence of foramen lacerum associated with tumour spread to the intracranial space, the increasing incidence of cancer, and the recent advances in skull base surgeries and middle cranial fossa approaches, more studies should be conducted to analyse the morphometric variations in the foramen lacerum in different geographical regions, genders, and races [10]. Additionally, the association of tumour spread needs to be studied in relation to the size and shape of the foramen, for which imaging-based clinical studies can be useful.

The foramen lacerum can be obliterated by the ossification of fibrocartilaginous tissue. This, combined with variation in the size of the foramen, can result in compression of the neurovascular bundle passing through the foramen, namely the deep petrosal nerve, the greater petrosal nerve, and the vidian nerve [10]. A variety of neurectomy and/or decompression procedures may be required in such cases to provide clinical relief to the patient [2,14-16]. Understanding the morphometric variations in the anatomy of the foramen lacerum can greatly improve the outcomes of such surgeries.

Limitation(s)

A few limitations of the study should be considered before applying the data clinically. Minor variations in the morphology of the foramen lacerum could have occurred during the processing of the dry bones for retrieval from the cadavers. While this should not affect the comparison of morphometric variations with other studies based on dry bones assessment, it is important to keep this in mind before applying the findings clinically. Additionally, although there is a body donation programme in the Institute and cadavers are generally sourced from the local region, some skulls could have been obtained from cadavers of individuals with ethnic origins in other geographical regions, and tracing or identifying the donors was beyond the scope of this research.

CONCLUSION(S)

Male skulls in the present study had a larger AP diameter on their right side, whereas female skulls had a larger AP diameter on their left side. Discussion compared the data with the two previous studies done from Egypt and Eastern Uttar Pradesh, leading to a higher incidence of related clinical problems. Furthermore, the observation of this foramen being a conduit for metastasis of tumours into the middle cranial fossa highlights the need for further, larger clinical studies based on imaging to gather more data on this neglected and understudied foramen from various geographical regions.

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