

## Anatomical Variations of Foramen Spinosum in Adult Human Skulls of Jharkhand Population

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### **Abstract:**

**Background:** The foramen spinosum is described as lying in the greater wing of sphenoid, posterolateral to foramen ovale, perforating the base of the spine of sphenoid. The middle meningeal vessels and the meningeal branch of mandibular nerve enters the middle cranial fossa through this foramen.

**Aim:** The aim is to conduct a morphological and morphometric study of foramen spinosum of the base of adult human skull.

**Materials and methods:** A prospective observational study was carried out over a period of six months from 1/5/18 to 30/11/18 on 30 human adult skulls obtained from the department of Anatomy, RIMS, Ranchi. Fully intact, dried, adult human skulls were included in the study. Damaged and pathologically malformed skulls were excluded from the study. Absence of foramen spinosum, variations in its shape, size, location and any bony septations of foramen spinosum were observed. Maximum length and width of foramen spinosum were measured using digital Vernier calipers. The difference between right and left side were analysed statistically using student t- test.

**Results:** Absence of foramen spinosum was found on the left side in two skulls (3.33%); incomplete margin of foramen were seen in two skulls; prevalence of shapes observed were round (53.33%), oval (40%) and irregular (6.66%); size varied with a range from <1mm to a maximum of 3.6mm in diameter with a mean  $\pm$  SD of anteroposterior and mediolateral on the right side  $2.05 \pm 1.09$ mm and  $1.33 \pm 0.9$ mm, on the left side  $2.05 \pm 0.6$ mm and  $1.67 \pm 0.53$ mm, which clearly showed no significant difference between right and left side ( $p > 0.05$ ); posterior location of foramen spinosum in relation to foramen ovale was seen in two skulls and duplication of foramen was found in two skulls.

**Conclusion:** These morphological variations may be of clinical significance to neurosurgeons during surgery in this region.

**Key words:** Foramen spinosum, anatomic variations, middle meningeal vessels

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Date of Submission: 11-04-2019

Date of acceptance: 26-04-2019

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### **I. Introduction**

Foramen spinosum is an important foramen located in the base of skull in the greater wing of sphenoid bone, lying posterolateral to foramen ovale, usually round in shape and transmits middle meningeal vessels and meningeal branch of mandibular nerve from infratemporal to the middle cranial fossa.<sup>1</sup> Developmentally, the perfect ring shaped formation of foramen spinosum has been observed by 8<sup>th</sup> month after birth and the latest by 7 years after birth; ossification of greater wing being cartilaginous.<sup>2</sup> Variations in its shape, size so small (less than a pinhole) that it was difficult to imagine vessels and nerve to traverse through it and its complete absence in one intrigued us to conduct this study and also the fact that very little information seemed available in Jharkhand population. It being an important landmark in microsurgery of the middle cranial fossa, this study was planned to find out the difference in variations reported by authors from other geographical areas, particularly different regions of India.

### **II. Materials and Methods**

A prospective observational study was carried out over a period of six months from 1/5/18 to 30/11/18 on 30 adult human skulls obtained from the department of Anatomy, RIMS, Ranchi. Included in the study were dried, fully intact, adult human skulls. Damaged and pathologically malformed skulls were excluded from the study. Morphological features were observed both from the cranial and infratemporal aspect of greater wing of sphenoid. Each foramen spinosum was observed for the following –

1. Presence or absence of foramen spinosum
2. Variation in size
3. Variation in shape

4. Variation in location
5. Duplication of foramen
6. Partial ossification of foramen spinosum

The specimen of variant morphology were photographed. Measurements of anteroposterior and transverse diameters of foramen spinosum of both the sides were done from the basal side with the help of digital Vernier calipers. The metric data of the right and left sides were tabulated and analyzed statistically using student t-test. The level of significant difference was taken to be  $P < 0.05$ .

### III. Results

#### (1) Presence or absence of foramen spinosum-

Foramen spinosum was present bilaterally in 28 skulls. It was found to be absent in two skulls, both on the left sides. In one of these, foramen spinosum was partially ossified on right side while in the other, it was fully formed. [Fig. 1 and 2]



**Fig 1:** Base of skull showing absence of foramen spinosum on the left side and partially formed foramen spinosum on right side



**Fig 2:** Base of skull showing absence of foramen spinosum on the left side

#### (2).Variation in size –

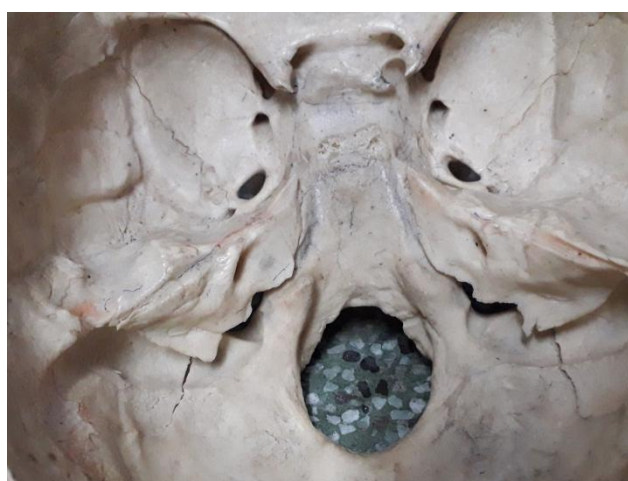
A wide variation was found in the size of foramen spinosum as shown in table 1. Morphological dimensions with anteroposterior diameter ranging from a minimum of 0.91mm to a maximum of 3.63mm; mediolateral diameter ranging from a minimum of 0.96mm to a maximum of 2.9mm. The mean value of length of foramen spinosum was  $2.05 \pm 1.09$ mm on right and  $2.05 \pm 0.60$ mm on left. The mean value of width was  $1.33 \pm 0.9$ mm on right and  $1.67 \pm 0.53$ mm on left. The difference between the length and width of the right and left sides was not statistically significant ( $p > 0.05$ ). [Fig 3 and 4]

**Table 1:** Table showing comparison of size of foramen spinosum of the right and left sides. Mean and standard deviation (SD) of anteroposterior and mediolateral diameters of the right and left foramen spinosum

Dimensions	Right side Mean $\pm$ SD (mm)	Left side Mean $\pm$ SD (mm)
AP diameter/length	2.05 $\pm$ 1.09	2.05 $\pm$ 0.60
ML diameter/width	1.33 $\pm$ 0.9	1.67 $\pm$ 0.53



**Fig 3:** Base of skull showing foramen spinosum with maximum anteroposterior diameter



**Fig 4:** Cranial aspect of base showing pinhole size of foramen spinosum bilaterally

**(3).Variation in shape –**

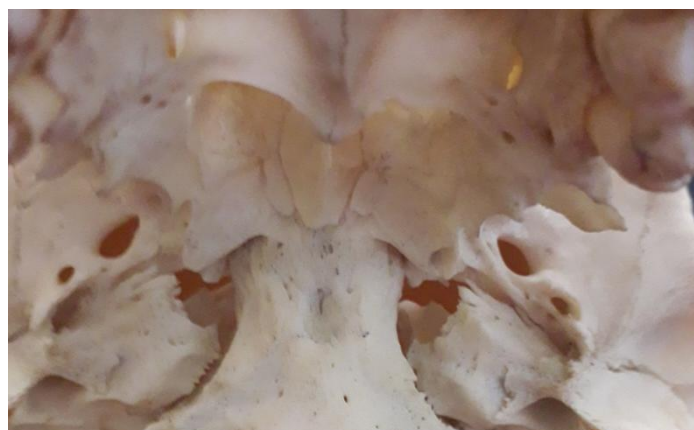
Broadly three types of shapes were observed – round, oval and irregular; prevalence described in table 2. Those foramina which had approximately equal anteroposterior and mediolateral diameter were classified in the category of round shape. Foramina whose anteroposterior diameter was more than mediolateral diameter were classified as oval shape and those which did not have a clear well defined margin were categorised as having irregular shape. Prevalence of round shape was found to be highest (53.3%) and that of irregular shape to be lowest (6.66%) in our study.[ Fig 5, 6 and 7]

**Table 2:** Table showing the prevalence of different types of shapes of foramen spinosum

Types of shapes	Prevalence (%)
Round	16 (53.3%)
Oval	12 (40%)
Irregular	2 (6.66%)



**Fig 5:** Base of skull showing **round shape** of foramen spinosum bilaterally



**Fig 6:**Base of skull showing **oval shape** of foramen spinosum bilaterally



**Fig 7:** Cranial aspect of base showing **irregular shape** of foramen spinosum bilaterally

**(4). Variation in location –**

Foramen spinosum was found located posterior to foramen ovale in two skulls and was found located at the sphenosquamosal suture in three skulls. [Fig 8 and 9]



**Fig 8:** Base of skull showing posterior location of foramen spinosum on left side



**Fig 9:** Cranial aspect of skull showing the location of foramen spinosum at the sphenosquamosal suture bilaterally

**(5).Duplication of foramen spinosum -**

Duplication of foramen spinosum was seen in two skulls on the right side.[Fig 10 and 11]



**Fig 10:** Base of skull showing **duplication of foramen spinosum** on the right side



**Fig 11:** Base of skull showing **duplication of foramen spinosum** on the right side

**(6).Partial ossification of foramen spinosum –**

Foramen spinosum was found incomplete in two skulls due to its incomplete ossification. [Fig 12]



**Fig 12:** Base of skull showing **incomplete margin** of foramen spinosum on left side

#### IV. Discussion

Foramen spinosum is an important foramina in the greater wing of sphenoid bone, providing communication between the infratemporal fossa and the middle cranial fossa. Presence of this foramen has been reported by different authors in 98.5%, 99.6% and 99.2%.<sup>3,4,8</sup> In our study, we found the foramen to be present in 96.66% foramen and absent in 3.33% foramen. The absence of foramen spinosum has been stated to be a normal variation, seen upto 3% of CT study of skull base, where it is associated with abnormal development and altered course of middle meningeal artery. In such cases, the middle meningeal artery enters the cranial cavity through the foramen ovale. Absence of foramen spinosum was reported to be 0.4% by Lindblom, stating the possibility of the middle meningeal artery arising from the ophthalmic artery in such cases.<sup>4</sup>

The foramen spinosum may get divided into two by a thin/thick plate of bone creating a duplication of the foramen. This raises the possibility of the middle meningeal artery dividing early into its anterior and posterior divisions in the infratemporal fossa and thereby passing through separate compartments of a duplicated foramen spinosum.<sup>4</sup>

**Table 3:** Comparisons of various studies regarding **absence and duplication** of foramen spinosum

Authors	Number of skulls	Absence of foramen	Duplication of foramen
Anju et al <sup>10</sup>	35	2.85	2.85
Somesh et al <sup>12</sup>	82	2	-
Kulkarni et al <sup>13</sup>	100	2.5	0
Mandavi et al <sup>14</sup>	312	0.3	2.56
Khan et al <sup>16</sup>	25	2	2
Present study	30	3.3	3.3

Lang et al reported a length of 2.56mm and width ranging from 1.05 to 2.1mm in adults.<sup>3</sup> Lanaprai et al reported a diameter range of 1-4.3mm with an average of 2 mm; round or oval in shape.<sup>5</sup> Raymond et al in their study reported that the mean area of the foramen was not considerable enough to play a major role in the dynamics of blood circulation in the venous system of the head.<sup>6</sup> Desai et al found the maximum diameter to be 2.92±0.65mm and minimum diameter to be 2.12±0.45mm.<sup>7</sup>

**Table 4:** Comparisons of various studies regarding **range of anteroposterior diameters** of foramen spinosum

Authors	Maximum (mm)	Minimum (mm)
Lang et al <sup>3</sup>	2.1	1.05
Anju et al <sup>10</sup>	Male 4(right), 4.5(left) Female 4(right), 4(left)	3(right), 2(left) 3.5(right), 3(left)
Somesh et al <sup>12</sup>	5(right), 3.5(left)	2(right), 1.5(left)
Kulkarni et al <sup>13</sup>	4	2
Present study	3.63(right), 3.42(left)	0.91(right), 1.31(left)

Desai et al in their study in South Indian skulls, reported round shape in 54%, oval shape in 42% and irregular in 6% which matched with our result.<sup>7</sup>

**Table 5:** Comparisons of various studies regarding **different shapes** of foramen spinosum. Our findings closely matched with those of Desai et al.

Authors	Round	Oval	Irregular
Desai et al <sup>7</sup>	54%	42%	6%
Tewari et al <sup>9</sup>	55.56%	33.33%	3.96% ; pinhole(7.1%)
Present study	53.3%	40%	6.66%

Normally, the spine of sphenoid is located posterior and lateral to foramen spinosum. Changes in this relation may affect the course of middle meningeal vessels. Also, the spine of sphenoid is related medially to chorda tympani nerve and laterally to auriculotemporal nerve. Therefore, variation in the location of foramen spinosum may cause damage to these nerves during surgery. In our study, posterior location of foramen spinosum was found in relation to ovale and also found located at the sphenosquamosal suture.

#### V. Conclusion

The anatomical variations of foramen spinosum are related either to incomplete osteogenesis or abnormal development of the middle meningeal artery. The knowledge of these anatomical variations of foramen spinosum is of clinical significance to neurosurgeons during microsurgeries of the middle cranial fossa where the foramen spinosum acts as an identifiable landmark. It is also of help to radiologists in CT and MRI examinations.

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Camellia Chanda. "Anatomical Variations of Foramen Spinosum in Adult Human Skulls of Jharkhand Population." *IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)*, vol. 18, no. 04, 2019, pp 01-07.