Anatomic Variations In Foramen Ovale and Foramen Spinosum

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Abstract
An anatomical study was conducted to observe the shapes of foramen ovale and foramen spinosum with their anatomical variants. The foramen ovale being one of the important foramina in the middle cranial fossa, is present in the superior surface of greater wing of sphenoid bone. Foramen spinosum is located posterolateral to foramen ovale. We studied seventeen human skulls and three sphenoid bones (i.e. total 40 foramen ovale and 40 foramen spinosum were studied, since foramen of right as well as left sides were taken for study). They were obtained from the Post graduate Department of Anatomy, Government Medical College, Jammu. Posterior part of the greater wing of sphenoid was observed for visualising the foramen ovale and foramen spinosum. Oval, round, almond and slit like foramen ovale were found. The maximum number was that of oval shaped foramina followed by almond, round and slit like foramen. Moreover, bony outgrowths in the form of spines were observed in two foramen ovale, and in the form of bony plate was seen in one foramen ovale. Furthermore, confluent foramen ovale and spinosum was seen on left side in one skull and on right side in another skull. Double foramen spinosum was seen in one skull on right side. Absence of foramen spinosum was observed in one of the skulls on right side. Foramen ovale is of surgical importance in percutaneous trigeminal rhizotomy in trigeminal neuralgias. For surgical procedures in the middle cranial fossa, the knowledge about the variations of these foramina should be taken into account. This data will add to the knowledge of clinicians as well as anatomists.

Keywords
Foramen Ovale, Foramen Spinosum, Skull, Trigeminal Neuralgia, Anatomical Variation

Introduction
The foramen ovale being one of the important foramina in the middle cranial fossa, is present in the superior surface of greater wing of sphenoid bone. It opens into the infratemporal fossa (1). It gives passage to important structures i.e. mandibular nerve, the accessory meningeal artery, the lesser petrosal nerve and the emissary vein (2). It is one of the foramen of importance which is present between the intracranial and extracranial structures. Venous part of foramen ovale may be separated from other structures of the foramen by means of a bony spur. These spurs are located anteriorly and medially (3).

It is usually oval in shape but its shape shows variations when compared to rest of the foramina in the skull. It is of great significance to neurosurgeons as transcutaneous approach to skull base is possible via it in cases of trigeminal neuralgias (4,5). A careful observation of these foramina will be helpful in the diagnosis of the lesions present in the nasopharynx and middle cranial fossa. Neuroma of the fifth cranial nerve can lead to enlargement of the foramen ovale (6). Moreover, bony outgrowths in the form of spurs, can compress the passing mandibular nerve and henceforth could lead to dysfunction of the muscles supplied by it (7).

Foramen spinosum being a circular foramen, is present in the greater wing of the sphenoid, posterolateral to foramen ovale. It is present at root of spine of sphenoid. It gives passage to middle meningeal artery (8,9,10). In 0.4% of cases, foramen spinosum may be absent and in that case the middle meningeal artery arises from ophthalmic...
artery. Moreover, foramen spinosum can be duplicated in some cases (11).

**Material and Methods**

The study was conducted on seventeen human skulls and three sphenoid bones (i.e. in total on the 40 foramen ovale and 40 foramen spinosum) obtained from the Post graduate Department of Anatomy, Government Medical College, Jammu. Posterior part of the greater wing of sphenoid was observed for visualising the foramen ovale and foramen spinosum. Their patency was checked by means of bristle. Skulls used for study were not damaged or broken. For each skull, general features and anatomical variations of the foramen ovale and spinosum were carefully noted. Bony spur in the form of spine, tubercle or bony plate, in any foramen ovale was noticed.

**Results**

The study was conducted on a total of 40 sides in 17 dry adult human skulls and three sphenoid bones. On visualizing the foramen ovale, it was seen that 28 foramina out of 40 foramina had an oval shaped foramen (Fig 1) (Table 1), 7 foramina showed almond shaped foramen (Fig 2) (Table 1), 4 foramina showed round shaped foramen (Fig 3) (Table 1) and 1 foramina showed slit shaped foramen (Fig 4) (Table 1). Incidences of oval, almond, round and slit shaped foramen were 70%, 18%, 10% and 2% respectively. Out of 40 sides, 2 foramina showed the presence of bony spine (Fig 5) (Table 2), 1 foramina showed the presence of bony plate (Fig 6) (Table 2) and foramen with a tubercle was seen in none. Incidence of spine and bony plate were 5% and 3% respectively.

Confluency of foramen ovale and spinosum (Fig 7) was seen in two skulls, in one, on the right side and in other, on the left side. Moreover, double/duplicated foramen spinosum (Fig 8) was seen on right side in one skull and absence of foramen spinosum (Fig 9) was also seen on the right side in one of the skulls.

**Discussion**

The sphenoid bone has two type of ossification centres i.e. the intramembranous and endochondral ossification centres which form body, lesser wings and greater wings (7). Foramen ovale shows variations in shape and size throughout natural life. In the 7th fetal month, the earliest formation of ring shaped foramen ovale was observed and latest it was observed at 3 years after birth (12). Foramen ovale is of significance in various invasive and diagnostic procedures. In cases going for amygdalohippocampectomy, the electroencephalographic analysis is done by placing electrodes at the foramen ovale. It provides good neurophysiological information (13). Percutaneous biopsy of cavernous sinus tumours can be successfully achieved through foramen ovale which definitely is of significance before making any move for open surgical procedures (14). Nasopharyngeal carcinoma spreads intracranially and usually spreads via foramen ovale (15). Anatomical variations of foramen ovale are of importance in operative treatment of trigeminal neuralgia which is performed through the opening of foramen ovale. Moreover, any stenosis or bony plate leads to reduced patency and difficulty in approaching for surgical procedures through this route (16,17).

Yanagi reported that foramen ovale in majority cases was found to be oval in shape and furthermore they were irregular in shape in comparison to the other foramina present in the sphenoid bone (12). In our study also, the majority of the foramen ovale were oval in shape (Table 1). There are some developmental reasons for the variations in the shape of foramen ovale (18). Tubbs et al., in their work revealed that pterygosphenoid ligament of Civinini and pterygoalar ligament of Hyrtl ligaments lead to division of foramen ovale into two compartments. These ligaments could make transcutaneous needle placement into the foramen ovale very difficult (19). Ray et al., observed in their study on anatomic variations of foramen ovale that a spine was present on the margin of the foramen ovale.

**Table 1. Variations in Appearance of Foramen Ovale**

<table>
<thead>
<tr>
<th>Shape</th>
<th>Right (n=20)</th>
<th>Left(n=20)</th>
<th>Total(n=40)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oval</td>
<td>17</td>
<td>11</td>
<td>28</td>
</tr>
<tr>
<td>Almond</td>
<td>3</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Round</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Slit shaped</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

**Table 2. Bony Outgrowths Seen in Foramen Ovale**

<table>
<thead>
<tr>
<th>Bony outgrowths</th>
<th>Right(n=20)</th>
<th>Left(n=20)</th>
<th>Total(n=40)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spine</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Tubercle</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bony plate</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
It was seen in 3 cases (3). In our study, we also appreciated two bony spines on the margins of foramen ovale in two different skulls and both were present on left side (Table 2) (Fig 5) Moreover, 1 bony plate was also seen on foramen ovale in our study (Table 2) (Fig 6).

Studies on the morphology of foramina of greater wings of sphenoid have revealed variations in the foramen spinosum. The foramen spinosum may be absent, when the meningeal artery arises from ophthalmic artery instead of arising from maxillary artery or in circumstances, when meningeal artery enters the cranial cavity through foramen ovale (20). Ginsberg et al., also observed that the foramen spinosum may be absent when middle meningeal artery follows an aberrant pathway (21). Berge and Bergman conveyed that the foramen spinosum was found to be unilateral in (1%) skulls or (0.5%) of foramina which were examined had no evidence of assimilation with foramen ovale (22). Lindblom observed that the foramen spinosum was small and was not present in 0.4% cases. It was observed by him in his roentgenographic study of the vascular channels of the skull (23). In the present study, foramen spinosum was absent in one skull and that too on the right side (Fig 9).

Lindblom and Sondheimer also reported a variant in which double foramen spinosum were found on the same side of the skull. A bony bar was a partition which lead to the duplication of foramen spinosum which can be because of division of middle meningeal vessels before
entering the foramen spinosum (23,24). Our study also revealed a skull with double foramen spinosum on the same side of the skull i.e. the right side. They were separated from each other by a thin bony margin (Fig 8). Osunwoke et al., made thorough study on 87 dried human skulls from the southern Nigerian population and they noticed that all skull had foramen. They were not able to find any skull with absence of foramen spinosum (25).

**Conclusion**

The present study was conducted to provide information regarding the foramen ovale and foramen spinosum as the knowledge about these foramina is still scarce. Some foramen ovale present with tubercles or bony plates. The mandibular nerve passes through the foramen ovale and it is via this foramen that trigeminal rhizotomy is done. So, the patency of the foramen ovale is very important for this procedure. In case of stenosis of foramen ovale as is seen in foramen with tubercles, the surgeries procedures are difficult. For surgical procedures in the middle cranial fossa, the knowledge about the variations of these foramina should be taken into account and the present data will suffice for that purpose. Refined surgical techniques in microsurgery are available for which the foramen spinosus acts as an identifiable landmark. So, the knowledge about the anatomical features of foramen spinosum along with its variations will enlighten the minds and will be fruitful. For medical practitioners this data will be of significance in dealing the cases of trigeminal neuralgia and will aid in diagnosing various vascular lesions in cranial cavity. This data will add to the knowledge of clinicians as well as anatomists.

**References**

13. Wieser HG and Siegel AM. Analysis of foramen ovale and foramen spinosum in cranial cavity. This data will add to the knowledge of clinicians as well as anatomists.