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Analysis of foramen ovale with special emphasis on pterygoalar bar and pterygoalar foramen

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The foramen ovale is of great surgical and diagnostic importance in procedures like percutaneous trigeminal rhizotomy for trigeminal neuralgia, transfacial fine needle aspiration technique in perineural spread of tumour, and electroencephalographic analysis. This study presents the anatomic variations in dimensions, appearance, number of foramen ovale (FO), and presence of pterygoalar bar and pterygoalar foramen.

For the present study ninety dry adult human skulls were utilised. Anteroposterior (length) and transverse (width) diameters of FO were measured, and the presence of pterygoalar bar and foramen were observed.

The most common shape of FO observed was like a figure 'D'. The ranges of anteroposterior diameter of the right and left FO were 8.5–4.5 mm and 10–3 mm, respectively. The mean length of the right FO was 6.60 mm while that of the left FO was 6.26 mm. The ranges of transverse diameter (width) of both right and left foramen were 2.5–6 mm and 2–5 mm, respectively. The mean transverse diameter of the right FO was 3.70 mm and that of left was 3.34 mm. Bony spur in FO was seen in 6.66% of cases. A complete pterygoalar bar and foramen were observed in seven cases unilaterally, and in one case it was bilateral.

Anteroposterior and transverse diameters of right FO were greater than left. Anatomical understanding, including the size, shape of FO, and presence of pterygoalar bar, has immense surgical and diagnostic importance. (Folia Morphol 2011; 70, 3: 149–153)

Key words: skull, foramen ovale, pterygoalar bar, pterygoalar foramen, and bony spur

INTRODUCTION

Foramen ovale (FO) is a fairly large oval aperture lying posterolateral to the foramen rotundum, which opens into the infra-temporal fossa. It transmits the sensory part of the mandibular nerve along with the motor root of the trigeminal nerve, accessory meningeal artery, lesser petrosal nerve, emissary veins, and sometimes the anterior trunk of the middle meningeal sinus [3].

The FO is situated at the transition zone between intracranial and extracranial structures. Therefore, it is used in various surgical as well as diagnostic procedures [13]. Knowledge of anatomical variations in the appearance and number of FO is of immense surgical importance in various procedures such as percutaneous trigeminal rhizotomy and biopsy of cavernous sinus tumour, and in the event of anaesthesia of the mandibular nerve [13, 15].

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The pterygoalar bar and the pterygoalar foramen are rarely described in anatomical literature, and even papers on morphological variants and books of gross anatomy do not always mention these structures [15]. The term pterygoalar bar applies to bony formations which result from ossification of the ligament that lies between the lateral pterygoid plate and the greater wing of the sphenoid bone in the outer aspect of the skull. It runs close to the FO [16]. Occasionally the FO may be covered by a bony lamina or bridge, which results from ossification of a ligament that lies between the lateral pterygoid process and the spine of the sphenoid [5]. De Froe and Wagenaar [4] were the first to recognize radiographically the pterygoalar bar. The pterygoalar bar and related foramina are normally present in lower animals and persist in 8% of Hawaiian human skulls [10]. A wide pterygospinous bar exists in all skulls of herbivores, rodentia, carnivores, and mature monkeys [7].

From a clinical standpoint, ossified ligaments have become very critical whenever considering block anaesthesia for the mandibular nerve. These variations can mean serious implications to any surgical intervention in the region and may lead to a false differential diagnosis for any said neurological condition [14].

The anatomical site of entrapment is the partially or completely ossified pterygospinous ligament. Lingual nerve entrapment can lead to hypoesthesia or anaesthesia and loss of taste in the anterior 2/3 of the tongue, anaesthesia of the lingual gums, and pain related to speech articulation disorders. Dentists should therefore be aware of the possible signs of neurovascular compression in regions where the lingual nerve is distributed [9].

MATERIAL AND METHODS

For the present study ninety dry adult human skulls of unknown sex were utilised. Anteroposterior and transverse diameters of FO were measured by a pair of dividers and then transferred to a meter rule for the reading to be taken. Various shapes of FO were observed and the presence of bony spur was also recorded.

The presence of pterygoalar bar and pterygoalar foramen were observed, and the laterality (unilateral/bilateral) of the bar and foramen was reported. The variations in morphology of the foramina were noted and photographed with a high-resolution digital camera. The paucity of studies related to the above stated landmarks led us to undertake this project on the skulls available in western part of India.

Table 1. Different shapes of foramen ovale with percentages

Shape	Percentage
D shape	46.16%
Oval	29.87%
Rounded	12.52%
Elongated	10.41%
Slit	1.04%

RESULTS

Of the various shapes of FO, the most commonly observed was 'D' shaped. Other shapes observed were oval, rounded, elongated, and slit shape; their percentages are listed in Table 1 (Fig. 1). FO was found in every skull on both sides. In one skull a double FO was observed unilaterally on the right side (Fig. 2A). The dimensions of FO were measured and the findings charted in a tabular form. Table 2 presents the mean anteroposterior and transverse diameter and range on the right and left sides. Bony spur in FO was seen in 4 cases unilaterally and 2 cases bilaterally (6.66%) (Fig. 2B). A total of 7 (7.77%) skulls revealed the presence of complete pterygoalar bar and the pterygoalar foramen, out of which 6 were unilateral and only one case (1.10%) was bilateral (Fig. 3).

DISCUSSION

Various Workers in this field have described the different shapes of FO and its parameters. Berlis et al. [1] demonstrated the shapes of FO to be oval in 56.7% of cases, elongated oval in 31.7%, and semicircular in 11.7%. Ray et al. [13] observed oval shapes in 43 sides, almond shapes in 24 sides, rounded in 2 sides, and slit-like in 1. Reymond et al. [12] studied 100 skulls and observed the shape as flattened oval. Literature reveals that the most commonly observed shape of the FO is oval. In the present study we observed the maximum number to be 'D' shaped (46.16%), which is not mentioned elsewhere.

Ray et al. [13] reported the mean length of FO to be 7.46 mm on the right side and 7.01 mm on the left side. The mean width on the right side was 3.21 mm and on left side it was 3.29 mm. They quoted a Japanese study showing an average maximal length of FO as 7.48 mm and average minimal length as 4.17 mm and a German study that showed the length as 7.2 mm and the width as 3.7 mm in adult skulls.

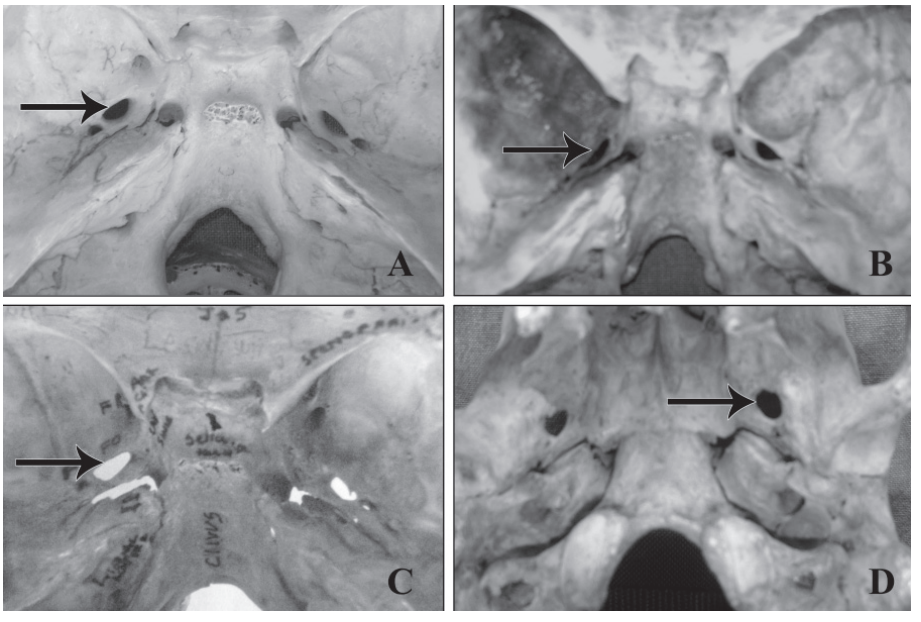

Figure 2. Different shapes of foramen ovale; **A.** "D" shape foramen ovale indicated by arrow; **B.** Slit shaped; **C.** Oval shape; **D.** Round foramen ovale.

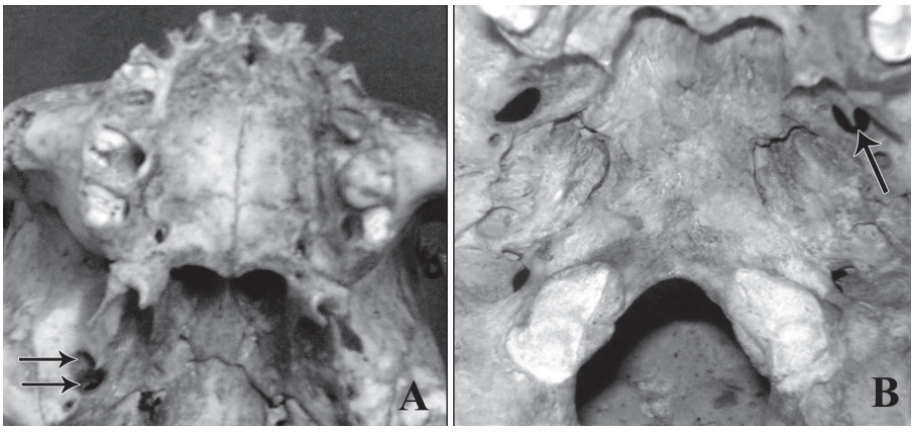

Figure 2. A. Two foramen ovale unilaterally on right side indicated by arrows; **B.** Bony spur unilaterally on left side indicated by arrow.

Table 2. Dimensions of foramen ovale

Foramen ovale [mm]	A-P diameter		Transverse diameter	
	Mean (SD)	Range	Mean (SD)	Range
Right side	6.60 (1.06)	8.5–4.5	3.70 (0.81)	6–2.5
Left side	6.26 (1.23)	10–3	3.34 (0.77)	5–2

Osunwoke et al. [8] revealed the range of length of FO to be 5.0–9.5 mm and range of width to be 2.0–5.0 mm. The mean length of right FO was 7.01 and left FO was 6.89 mm. The range of width of both right and left FO was 2.0–5.0 mm. The mean width of right FO was 3.37 mm while that of left side was 3.33 mm.

Bony spur has been described by certain workers. Ray et al. [13] observed the spur on 3 sides out of 35 skulls. Reymond et al. [12] described in 9 cases that FO was divided into 2–3 separate compartments. According to Berlis et al. [1] the FO was divided in 12.55% of cases by an osseous bridge and in 0.8% of cases it was completely double.

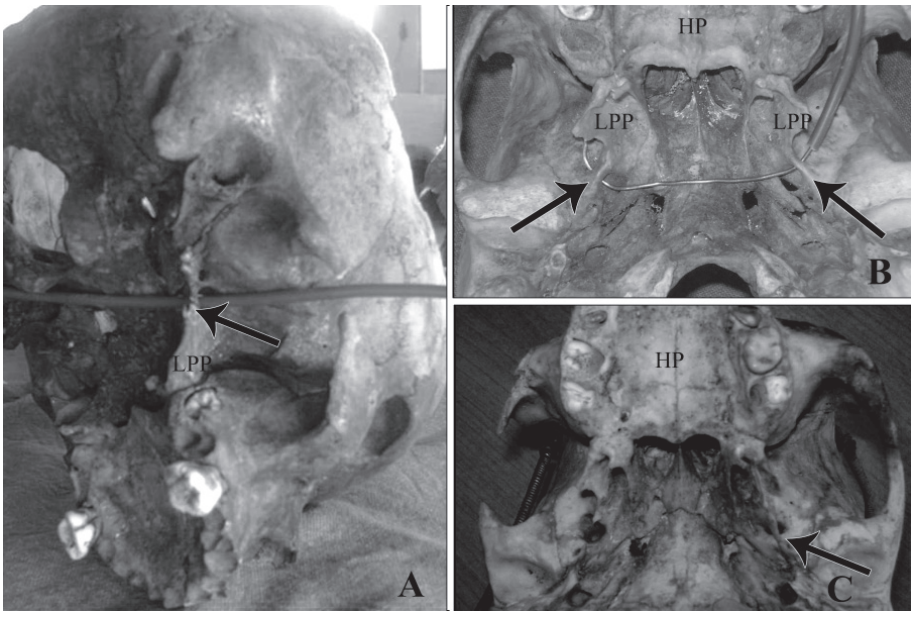

Figure 3. Pterygoalar bar and pterygoalar foramen; **A.** Unilaterally on right side pterygoalar bar indicated by arrow; probe is passing through the pterygoalar foramen; **B.** Bilateral pterygoalar bar indicated by arrow and bilateral pterygoalar foramen through which a probe passes; **C.** Unilateral pterygoalar bar and foramen on left side indicated by arrow; LPP — lateral pterygoid plate; HP — hard palate.

In the present study bony spur was found in 6.66% of cases and in one case (1.10%) a complete double foramen was found. It can be concluded that the venous segment of FO, which is separate from the other contents of FO, may be responsible for double or accessory foramen [13].

In 1951 Chouke and Hodes [2] found the pterygoalar bar in 7.05% unilaterally and in 0.89% bilaterally. Lepp and Sandner [6] reported that these osseous bridges were present in about 8–10% of the population and that the pterygoalar ligament was ossified more often than the pterygospinous ligament. Kapur et al. [5] stated that complete unilateral pterygoalar bar has been found in about 5% of Anatolian skulls with greater frequency in the African population, while the incidence of the bilateral pterygoalar bar is very low (1%). The occurrence of the pterygoalar bar and foramen may, therefore, vary from 1–10%.

Skrzat et al. [16] revealed that the pterygoalar foramen and pterygoalar bar was present in 5 cases. The pterygoalar bar was located medially or laterally to the FO and in one case it crossed the FO. The occurrence of pterygoalar bar and foramen in the present study is more or less similar to the findings of other workers in this field.

Although the prevalence of pterygoalar bar is rare its presence has significant clinical implications. In surgical interventions required for relieving the trigeminal neuralgia, the ossified ligaments can obstruct the passage of the needle into the FO, thereby disabling the anaesthetisation of the trigeminal ganglion or the mandibular nerve [16]. The presence of the ossified ligament may compress the surrounding neurovascular structures causing lingual numbness and pain associated with speech impairment [11] and could lead to a weakening of taste transmission from the taste buds located on the anterior 2/3 of the tongue unilaterally [16].

CONCLUSIONS

FO was observed to have different shapes and sizes. The most frequent was a D shape. Right side FO was larger than left side FO. Pterygoalar bar was present in 7 (7.77%) cases unilaterally and in 1 (1.10%) case it was bilateral. Pterygoalar bar is formed because of ossification of pterygospinous ligament. The presence of pterygoalar bar leads to compression of structures of FO and may cause widespread symptoms depending upon which structure is compressed, and is also a hindrance in injection of anaesthesia to the mandibular nerve and trigeminal ganglion.

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