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ANATOMICAL MAPPING OF THE FORAMEN OVALE: A GUIDE FOR SAFE SURGICAL NAVIGATION.

Anatomy

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ABSTRACT

Aims - Skull base surgeries have always been a challenge to neurosurgeons and otorhinolaryngologists owing to the critical anatomy of skull base. A step ahead of traditional surgeries, the introduction of endoscopic approaches has made it possible to access the target area with better exposure and visibility of anatomical structures. Endoscopic surgeries also have the advantage of early recovery and lesser discomfort to the patients in the postoperative period. Endonasal approach is a preferred approach to Foramen ovale, an important foramen for neurosurgeons. This study was conducted to describe topographic anatomy of the foramen ovale and identify the optimal surgical landmarks for safe surgical navigation to it. **Material and Methods** - The study was conducted on 50 dry human skulls, available in Department of Anatomy in our Institute. The important anatomical landmarks critical to the endonasal approach to foramen ovale were selected in the study. The distance of foramen ovale from anterior nasal spine, posterior wall of maxilla, anterior border and base of lateral pterygoid plate, median plane and carotid canal was measured on both sides on the extracranial side of base of skull. The data was statistically analyzed. **Results-** In the present study the mean distance of foramen ovale (FO) from anterior nasal spine, posterior wall of maxilla, anterior border and base of lateral pterygoid plate, median plane and carotid canal was 72.16 +/- 3.67 mm, 19.14 +/- 3.02mm, 15.94 +/- 2.32mm, 2.37 +/- 1.92 mm , 21.07 +/- 1.48mm and 12.53 +/- 2.08mm respectively. The difference in measurements of various metric parameters on both sides was not significant. **Conclusion-** The findings of this research apply to neurosurgical practices in the infratemporal area, particularly for surgeons performing endoscopic surgeries, aiming to improve patient outcomes.

KEYWORDS

anterior nasal spine; base of skull; carotid canal, lateral pterygoid plate; mandibular nerve; infratemporal fossa

INTRODUCTION

Foramen ovale is located in the greater wing of sphenoid bone, anterior to Foramen lacerum, anteromedial to the foramen spinosum and posterolateral to the foramen rotundum in the middle cranial fossa [1-2]. The foramen ovale is a critical anatomical landmark with significant implications for various medical interventions, including: minimally invasive procedures like percutaneous trigeminal rhizotomy, diagnostic techniques such as fine needle aspiration biopsy and advanced neurological testing like electroencephalographic (EEG) analysis, which utilizes the foramen ovale as a conduit for placing electrodes to record brain activity, microvascular decompression and stereotactic radiosurgery[3]. The foramen ovale's strategic location makes it a key landmark for surgeries in infratemporal fossa for neurosurgeons and otorhinolaryngologists [4]. Multiple surgical approaches to Foramen Ovale (FO) have been described, which are often technically difficult. The endoscopic approaches include- the endonasal approach, transcranial keyhole approach, lateral sublabial approach. The endoscopic endonasal transmaxillary transpterygoid approach offers a significant advantage: This surgical approach uses a natural opening, foramen ovale, to reach the target area, reducing the need for osteotomy and minimizing brain manipulation, making it a more precise and less invasive approach [5]. The literature is scanty in terms of studies conducted on Indian skulls, hence this study was undertaken.

Aims And Objective

The aim of this study was to delineate the surgical landmarks and measure their distance from Foramen ovale (FO) for a safe surgical access via minimally invasive endoscopic approach. The study provides anatomical data relevant to Indian skulls, which can aid in improving the precision of surgical techniques involving the foramen ovale or infratemporal fossa in this population.

MATERIAL AND METHOD

The study was conducted as an observational study on 50 dry, adult human skulls of Indian origin, available in department of anatomy of our institute. In the present study the minimum distance of medial margin of foramen ovale (FO) from the following anatomical landmarks of surgical significance was measured with a vernier calliper (precision of 0.01mm) on the extracranial side of the base of skull [5] . (figure 1-4)-

1. anterior nasal spine
2. posterior wall of maxilla
3. Anterior border of lateral pterygoid plate
4. base of lateral pterygoid plate
5. Carotid Canal
6. **Median sagittal plane-** The median sagittal plane was marked as a line extending from the schindylesis between the ala of vomer and sphenoidal rostrum to the basion.

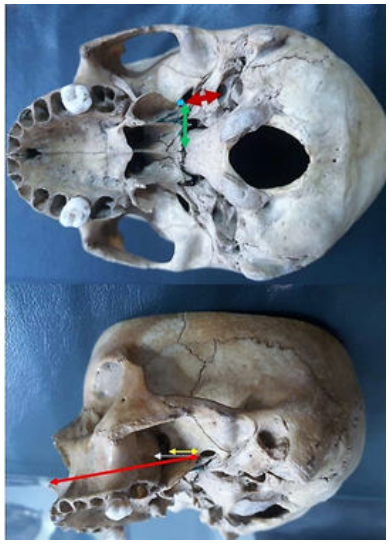

Figure 1. Top- Base of skull showing marking of distance between medial end of foramen ovale and base of lateral pterygoid plate (blue

line) , midsagittal plane **(green line) and carotid canal (red line)**

Bottom- Lateral view of skull showing marking of distance between medial end of foramen ovale and anterior nasal spine (red line), Posterior wall of maxillary bone (white line) , anterior wall of Lateral pterygoid plate (yellow line)

Figure 2. Distance between foramen ovale and anterior nasal spine

Figure 3. Distance between foramen ovale and anterior border of Lateral Pterygoid Plate

Figure 4 . Distance between foramen ovale and midsagittal plane

Inclusion Criteria- All the adult skulls with intact base and undamaged foramen ovale and other landmarks were included in the study.

Exclusion Criteria- Skulls with broken or damaged skull base were excluded from the study.

The data was statistically analyzed using the paired t test for any significant difference between the both sides.

RESULTS

In the study the mean distance of FO (n=100) from anterior nasal spine was 72.16 +/- 3.67 mm. The mean distance of FO (n=100) from posterior wall of maxilla was 19.14 +/- 3.02mm. From the anterior border of lateral pterygoid plate study the mean distance of FO was 15.94 +/- 2.32mm and from the base of lateral pterygoid plate it was 2.37 +/- 1.92mm. The carotid canal was at the mean distance of 12.53 +/- 2.08 mm from the foramen ovale. The foramen ovale was at the mean distance of 21.07 +/- 1.48mm from the mid sagittal plane. There was no significant difference between the dimension on both sides p>.05.The range and the measurements on both sides are recorded in **Table 1**.

Table 1- Distance between foramen ovale and bony landmarks of surgical significance (in mm) on both sides .

S.N	Distance between Foramen Ovale and the bony landmark	Range (n=100)	Mean +/- S.D (Right) (n= 50)	Mean +/- S.D (Left) (n=50)	Overall Mean +/- S.D (n= 100
1	Anterior Nasal spine	63.09 – 83.00	72.48 +/- 4.15	71.84+/- 3.18	**72.16 +/- 3.67**
2	Posterior Maxillary wall	12.87 – 25.68	18.86 +/- 3.17	19.43 +/- 2.88	**19.14 +/- 3.02**
3	Ant. border of Lateral Pterygoid Plate	10.12- 21.85	15.88 +/- 2.34	15.99 +/- 2.31	**15.94 +/- 2.32**
4	Base of lateral Pterygoid plate	0.00 – 8.92	2.23 +/- 1.74	2.51 +/- 2.1	**2.37 +/- 1.92**
5	Carotid Canal	8.47 – 19.81	12.43 +/- 1.85	12.63 +/- 2.31	**12.53 +/- 2.08**
6	Median sagittal plane	17.50 – 24.62	21.09 +/- 1.5	21.04 +/- 1.46	**21.07 +/- 1.48**
			(p>0.05).		

DISCUSSION

With the advent of technology in medical sciences, endoscopic surgeries provide a minimally invasive approach that offers better visualization and access to skull base structures, while minimizing tissue disruption. By leveraging endoscopic technology, surgeons can perform procedures with reduced trauma to the patient, leading to potential benefits of faster healing, reduced pain, and shorter recovery times[5]. The topographic relationship of targeted lesion to the critical structures while exploring through the surgical corridor is a detrimental factor while considering the endoscopic approaches. The associated possible complications in the endoscopic surgeries depends more on the neurovascular structures along the surgical corridor to the targeted lesion [6].

In view of the described steps for the endoscopic endonasal transmaxillary transpterygoid approach to the infratemporal fossa the various anatomical parameters were selected in the present study[7].

In the present study there was no significant difference between the measurements taken on both sides as also described by the other researchers [5] .Therefore mean value of various parameters was calculated in total 100 cases which included both sides in 50 skulls.

In the present study the mean distance of FO from anterior nasal spine in 100 cases was 72.16 +/- 3.67 mm while in another study conducted on High-resolution computed tomography it was 78.5 ± 5.9 mm [8]. The small difference might be due to difference in method used in measurement and possibly due to difference in the race studied.

The mean distance between foramen ovale and posterior maxillary wall was 19.14 +/- 3.02mm, while no such past reference could be found but in one study[9] the distance between posterior wall of Maxillary Sinus and foramen rotundum was 10 mm +/- 0.71mm and distance between Foramen rotundum and FO was 9.09mm in another study[10] .

The mean distance between foramen ovale and Ant. border of Lat. Pterygoid Plate was 15.94 +/- 2.32mm as also observed in another study to be 17.14 +/-1.72 mm in males , 16.8 +/- 1.70mm in females [11] . The distance between foramen ovale and Base of lat. Pterygoid plate was 2.37 +/- 1.92mm as [1,5] also described the foramen ovale to be present at the base of the lateral pterygoid plate. Therefore **t**he importance of the lateral pterygoid plate in locating the foramen ovale was obvious as also described by other researchers [5]. Measuring the distance from the foramen ovale to the lateral pterygoid plate helps surgeons drill safely in the area without damaging the muscle, reducing pain and trismus after surgery.

The mean distance between foramen ovale and median sagittal plane was 21.07 +/- 1.48mm in our study which is comparable to other studies with Mean distance as 22.13mm on right side 21.71mm on left side [12] and 25.83±1.26mm on right side and 25.08±1.31mm on left side [13] .The data is useful if bilateral surgery is to be done.

The mean distance between foramen ovale and Carotid Canal was

12.53 +/- 2.08 mm similar to the observation of 10mm [14] . The foramen ovale is located anterior to the internal carotid artery's (ICA) anterior genu, making it a high-risk area for injury during drilling. The ICA has a vulnerable segment that runs medially to the mandibular nerve, which requires careful navigation. This segment is short, deep, and poorly defined, increasing the risk of damage[14]. Additionally, the more proximal, horizontal portion of the ICA lies behind the mandibular nerve, in a bony canal in the petrous part of the temporal bone. However, any injury to the ICA can lead to severe bleeding, making it essential to exercise extreme caution when operating in this region[15]. Other researchers have also mentioned that the lateral pterygoid plate, foramen ovale and mandibular nerve as important anatomical landmarks for exposing the parapharyngeal segment of the internal carotid artery through a combined endoscopic transnasal and transmaxillary approach for a better view of the upper PPS and middle skull base, allowing for effective bimanual techniques and bleeding control. [16]. Thus the endoscopic endonasal transmaxillary transpterygoid approach can be a preferred route to the middle cranial fossa, cavernous sinus, infratemporal fossa and Meckel's cave[17-20].

CONCLUSION

The Surgical interventions on the foramen ovale or infratemporal fossa require an accurate knowledge of the surgical anatomy. In the study the mean distance of FO from anterior nasal spine, posterior wall of maxilla, anterior border and base of lateral pterygoid plate, median plane and carotid canal was 72.16 +/- 3.67 mm, 19.14 +/- 3.02mm, 15.94 +/- 2.32mm, 2.37 +/- 1.92 mm , 21.07 +/- 1.48mm and 12.53 +/- 2.08mm. The data of this study is helpful to neurosugeons and otolaryngologists in various endoscopic and conventional surgical approach to foramen ovale and other surgeries in infratemporal region with better view and minimal risks and complications.

Conflict of interest – No
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