e-ISSN: 0975-1556, p-ISSN:2820-2643

Available online on www.ijpcr.com

International Journal of Pharmaceutical and Clinical Research 2022; 14(8); 209-215

Original Research Article

Anatomical Characteristics of Foramen Ovale and Foramen Spinosum in Dry Human Skulls

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Received: 15-06-2022 / Revised: 20-07-2022 / Accepted: 05-08-2022
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Conflict of interest: Nil

Abstract

Introduction: Cranial base holding important foramina through which various important neurovascular structures transmits from extra cranial to intracranial region. The anatomical knowledge of these foramina plays a vital role in surgeries to cranial base. This study was designed to assess the morphology and morphometry of foramen ovale and foramen spinosum in the dry human skull of Deccan plateau region.

Material and Methods: A total of forty-four adult human dry skulls of unknown gender were evaluated for morphological parameters like shape, incidence of foramen of Vesalius, presence or absence of foramina and morphometric parameters such as anteroposterior (AP) and medio-lateral (ML) diameter of foramen ovale and foramen spinosum were measured.

Results: Oval shaped FO (56.81% right & 52.27% left) and round shaped FS (65.9% right & 61.36% left) on both sides were recorded. The AP diameter was 8.09 mm on right and 7.57mm on left and ML diameter was 5.54mm and 5.81mm for FO. The AP diameter was 2.74mm on right and 2.61mm on left and ML diameter was 1.64mm and 2.04mm for FS. The mean difference of morphometric parameters was statistically significant ($p<0.05$).

Discussion and Conclusion: The comprehensive knowledge on anatomy and developmental variations of foramen ovale and foramen spinosum has great importance in surgical interventions at the base of skull, and sex determination in medico legal procedures.

Keywords: Foramen Ovale, Foramen Spinosum, Cranial Base, Morphometry, Variations

Background

Foramen ovale (FO) and foramen spinosum (FS) are main openings on the infratemporal aspect of alisphenoid. Recognition of foramen with structures passing through it can help to determine the normal and abnormal anatomy [1,2]. Knowing the variation in size, number, and dimension is not only useful to understand the complex

regional neurovascular anatomy but also to distinguish the abnormal structures [3].

Foramen ovale claimed important for various invasive neurosurgical procedures like the microvascular decompression by trigeminal rhizotomy for the management of trigeminal neuralgia and the percutaneous biopsy of cavernous sinus tumours. Intracranial approach through foramen ovale is also used as diagnostic procedures such as electroencephalographic analysis of the seizure for patients undergoing selective amygdalo-hippocampectomy [4]. Anatomical knowledge of the foramen spinosum is important from surgical point of view [5,6].

In addition to surgical importance, anatomical knowledge of FO and FS of skull has been of interest for forensic specialist and neuroanatomists [7]. The bones of cranial base are protected by its anatomical position and surrounding soft tissue [8]. In emergency mass disasters, and explosion, these important landmarks help for sex determination [9]. In this regard, the present study was designed to assess the morphology and morphometry of foramen ovale and foramen spinosum along with incidence of foramen Vesalius in the dry human skull of Deccan plateau region.

Material and Methods

A total of forty-four adult human dry skulls of unknown gender were measured in the Department of Anatomy, Arundhathi Institute of Medical Sciences, Malkajgiri, Hyderabad. Adult dry skulls with erupted third molar tooth, well-marked cranial sutures were included. Bones with congenital malformations, showing wear and tear, missed foramen ovale, foramen spinosum, damages and abnormalities were excluded. The morphological parameters like shape, incidence of foramen of Vesalius, presence or absence of foramina were recorded. The morphometric parameters such as anteroposterior and medio-lateral diameter were measured by using standard vernier sliding calipers.

Quantitative variables were represented by Mean±SD and qualitative variables were represented by frequency and percentages. Mean differences was analyzed by using independent "t" test. $P<0.005$ was considered as statistically significant.

Results

Table 1: Morphological parameters of foramen ovale and foramen spinosum

Morphologic parameters	Right side		Left side	
	Number	Percentage	Number	Percentage
Foramen ovale				
Oval	25	56.81%	23	52.27%
Round	08	18.18%	08	18.18%
Almond shape	08	18.18%	10	22.72%
Slit	02	4.54%	02	4.54%
Triangular	01	2.28%	01	2.28%
Foramen spinosum				
Round	29	65.90%	27	61.36%
Oval	07	15.90%	09	20.45%
Irregular	03	6.81%	03	6.81%
Pinhole	02	4.54%	02	4.54%
Absent	03	6.81%	03	6.81%
Incidence of foramen of Vesalius				

Unilateral	05	11.36%	03	6.81%
Bilateral	02	4.54%	02	4.54%

Table 2: Incidence of additional bony structures related to Foramen ovale

Bony structures	Right side		Left side	
	Number	Percentage	Number	Percentage
Foramen ovale				
Spine	03	6.81%	05	11.36%
Bony plate	05	11.36%	05	11.36%
Tubercle	05	11.36%	06	13.63%
No bony structures	31	81.82%	28	63.64%

Table 3: Relationship between spine of sphenoid and foramen spinosum

Relation	Right		Left	
	Number	Percentage	Number	Percentage
Lateral	03	6.82%	05	11.36%
Medial	06	13.63%	06	13.63%
Antero-medial	35	79.54%	33	75%

Table 4: Morphometric parameters of foramen ovale and foramen spinosum

Morphologic parameters	Right side			Left side			t-value	p value
	Min	Max	Mean±SD	Min	Max	Mean±SD		
Foramen ovale								
Anteroposterior diameter (Length)	4.98	11.2	8.09±2.02	5.03	10.12	7.57±1.24	1.310	0.346
Mediolateral diameter (Width)	3.41	7.73	5.54±0.86	3.94	7.68	5.81±1.18	1.764	0.025
Foramen spinosum								
Anteroposterior diameter	1.26	4.22	2.74±0.66	1.14	4.08	2.61±0.82	1.744	0.0302
Mediolateral diameter	0.84	2.44	1.64±0.79	0.89	3.20	2.04±0.85	2.680	0.0154

*Min-Minimum, Max-Maximum.

Discussion

The anatomical knowledge of foramen ovale has important role in various surgical procedures for middle cranial fossa and helps to assess the skull base symmetries [10,11].

The foramen ovale is an important landmark for diagnostic procedures, such as electroencephalographic analysis of the seizure for patients undergoing selective amygdalo-hippocampectomy, microvascular decompression by percutaneous trigeminal rhizotomy for trigeminal neuralgia and percutaneous biopsy of cavernous sinus tumors [11,12]. The anatomical variations of skull foramens are of great importance for anthropologists, forensic scientists and neuroanatomists [13]. The present study was designed to assess the morphology and morphometry of foramen ovale and foramen spinosum along with incidence of foramen Vesalius in the dry human skull of Deccan plateau region.

Foramen ovale (FO)

A study by Prakash KG *et al.,* found common appearance of FO were oval shape (64.5% right & 56.4% left), followed by almond shape (25.8% right & 30.6% left) and round shape (8% on both sides) [14]. A study by Shruthi BN *et al*., found common shape of FO was oval in 79.2%, almond in 18.28% and round in 2.5% skulls [15]. A study by Vaishali SK *et al*., reported oval shape (66.07%) as common, followed by almond (14.28%), round (10.72%) and D shape (7.15%) [16]. Poornima B *et al*., reported that majority FO were oval shaped followed by almond, round and slit shape [17]. A study by Aparna VPK *et al*., reported that majority FO were oval shaped (58%) followed by almond (21%), round (13%) and slit shaped (8%) [18]. Berjina Farooq *et al*., reported that majority FO were oval shaped, followed by almond, round and slit shaped [19]. The findings of present study was similar to the above findings where oval shaped foramen ovale was common on both sides (56.81% on right sided and 52.27% on left side), followed by almond shape (18.18% right & 22.72% left) and round shape (18.18% right & 18.18% left).

Table 5: Comparison of mean values of foramen ovale between present study and previous studies

Author	AP diameter (Length)		ML diameter (Width)	
	Right	Left	Right	Left
Karishma R *et al* (2015) [10]	6.77	5.74	3.56	4.28
Ahmed *et al* (2015) [20]	5.25	4.84	4.87	5.18
Shruthi BN *et al* (2017) [15]	9.1	9.5	4.1	3.9
Poornima B *et al* (2017) [17]	6.5	6.4	3.54	3.5
Zahra HB *et al* (2017) [21]	7.04	7.18	4.15	3.99
Rao *et al* (2017) [22]	7.24	7.11	3.75	3.75
Sankaran *et al* (2018) [23]	7.45	7.61	3.99	4.6
Prakash KG *et al* (2019) [14]	7.74	7.60	5.18	5.4
Vidya CS *et al* (2019) [24]	7.45	6.8	6	5.6
Das S *et al* (2019) [25]	7.17	7.26	3.49	3.73
Vaishali SK *et al* (2020) [16]	7.52	7.19	4.18	4.28
Aparna VPK *et al* (2020) [18]	7.5	6.625	5.79	5.34
Boduc E *et al* (2021) [26]	7.05	6.83	3.30	3.30
Present study (2022)	8.09	7.57	5.54	5.81

The mean anteroposterior diameter of foramen ovale was less than the study by Shruthi BN *et al*., and higher than the remaining studies. The comparison of mean medio-lateral diameter was higher than all studies (Table 5).

Foramen spinosum (FS)

A study by Camellia Chanda *et al*., observed broadly round shape (53.3%), followed by oval (40%) and irregular shape (6.66%) [27]. Aparna VPK *et al*., noticed that 71% foramina were round shape, followed by oval (23%), pin hole (4%) and irregular shape (2%) (18). Shaik Hussain Saheb *et al*., found that majority FS were round shaped (58%) followed by oval shape (38%) and irregular shape (4%) [28]. Sophia MM *et al*., reported broadly round shape (52.5%) followed by oval shape (30%), irregular (12.5%) and pinhole shape (2.5%) foramen spinosum [29]. Misganaw GW *et al*.,

reported that majority foramen spinosum were round shaped (50%) followed by oval (32.81%), pinhole (10.94%) and irregular shape (6.25%) [30]. The current study findings were similar to the above findings where common appearances of FS were round shape (65.9% right & 61.36% left), followed by oval (15.90% right & 20.45% left), irregular (6.81% on both sides) and pinhole shape (4.54% on both sides). In 6.81% skulls, foramen spinosum was absent bilaterally (Table 1).

Table 6: Comparison of mean levels of foramen spinosum between present study and previous studies

Author	AP diameter (Length)		ML diameter (Width)	
	Right	Left	Right	Left
Sophia MM *et al* (2015) [29]	2.37	2.32	2.32	1.73
Camellia Chanda *et al* (2019) [27]	2.05	2.05	1.33	1.67
Aparna VPK *et al* (2020) [18]	3.04	2.87	1.79	1.66
Misganaw GW *et al* (2021) [30]	3.72	3.37	3.3	2.97
Present study (2022)	2.74	2.61	1.64	2.04

The mean values of anteroposterior diameter and medio-lateral diameter was consistent with findings of previous studies (Table 6).

Incidence of foramen of Vesalius

A study by Binita BR *et al*., reported unilateral distribution of foramen Vesalius in 35.56% skulls and bilateral incidence in 32.23% skulls [31]. Nirmala *et al*., reported that unilateral distribution in 23.3% and bilateral distribution in 26.67% [32]. A study by Gupta *et al*., found unilateral incidence in 20% skulls and bilateral incidence in 14% skulls [33]. Chaisuksunt *et al*., reported that bilateral distribution of foramen in 10.9% and unilateral distribution in 4.5% skulls [34]. Foramen Vesalius has surgical importance in the treatment of trigeminal neuralgia. Needle targeting foramen ovale can be misplaced towards foramen Vesalius causing serious intracranial bleeding [35]. A morphological study on foramen Vesalius by Milos Maletin *et al*., reported unilateral and bilateral incidence of foramen in 12.5% (02 skulls) and 87.5% (14) skulls respectively [36]. The unilateral and bilateral incidence of foramen Vesalius was consistent with the above findings where the distribution of foramen Vesalius on unilateral right side was 11.36% and left side was 6.81%. Two (4.54%) skulls has bilateral incidence.

Conclusion

The comprehensive knowledge on anatomy and developmental variations of foramen ovale and foramen spinosum has great importance in surgical interventions at the base of skull, and sex determination in medico legal procedures. The oval shaped FO and round shaped FS were common and incidence of other shapes having developmental reasons. The morphometric knowledge is essential during neurosurgical procedures such as anaesthetic administration for blocking mandibular nerve.

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