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Anatomical dimensions and variances of the foramen ovale in adult human skulls

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The researchers have stated that all local and international guidelines were followed during the use of cadaveric donors in their anatomical study.

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Abstract

Background/Aim: The foramen ovale (FO) is very important in neurosurgical approaches; however, studies and developments in the literature report that no definite consensus about the cannulation of the FO is available. Therefore, more morphometric information concerning the FO is needed in addition to the previously defined morphological and morphometric features. The aim of this study was to compare the features of the foramen ovale stated in the literature and to analyze the topographic relationship between the FO and the anatomical structures around it to determine its precise location.

Methods: The study included 70 sides from 35 dry skulls of unknown age and gender. Skulls with any deformity or pathology that would affect the measurements were not included in the study. All skulls were placed in the horizontal plane with the external occipital protuberance facing posteriorly, the piriform aperture facing anteriorly, and the skull base pointing upwards at a 90° angle after which it was photographed vertically with the length scale. A Nikon D5300 Digital Camera was used for the photography, and digital image processing software (Image J) was used for foramen ovale measurements. In addition, the shape of the foramen ovale was classified as oval, almond, D-shaped, slit-shaped, round, and irregular. SPSS 21.0 was used for the statistical analysis.

Results: The mean anteroposterior diameter length of the FO was 6.144 mm, and the transverse diameter length was 2.885 mm. When the distribution of the shape of the FO was examined, oval and almond shapes were most common shapes (34.29%). In addition, round (12.85%), D-shaped (10%), and slit-shaped (8.57%) were obtained. According to Pearson's correlation analysis, the highest correlation was between the distance from the carotid canal to the foramen ovale and the shortest distance from the foramen ovale to the midline (FO-CC and the FO-ML, respectively; r = 0.427).

Conclusion: The morphology of the FO is important in terms of surgical and interventional approaches. In the literature, no significant differences between the right and left sides for the foramen ovale were found in contrast to our study. When the FO shape percentages were examined in most previous studies, it was seen that most of them were oval. In this study, the ratios of oval and almond shapes were the same. Morphometric measurements can give different results in every race due to the structure of the bones, which may vary according to the population. We think that presenting data on the Turkish population in this study will set an example for conducting future studies.

Keywords: Foramen ovale, Cranial base, Morphometry, Anatomy

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Introduction

The foramen ovale (FO) is located on the infratemporal surface of the greater wing of the sphenoid bone and is very important for the middle cranial fossa. It is located posterolaterally to the foramen rotundum (FR) and anteromedially to the foramen spinosum (FS), lateral to the foramen lacerum (FL) [1]. The FO connects the middle cranial fossa to the infra-temporal fossa and the mandibular nerve (a mandibular division of the trigeminal nerve), the lesser petrosal nerve (a branch of the glossopharyngeal nerve), and accessory meningeal branch of the maxillary artery. Also, the venous plexus passing through the FO connects the pterygoid venous plexus in the infratemporal fossa and the cavernous sinus [2].

In the literature, although the morphology of the FO is mostly described as oval, it is quite diverse in terms of morphological and morphometric features compared to other foramina (Khan). In addition to its oval shape, "almond", "D-shape", elongated oval", "oval", "round", semicircular, "slit", with irregular borders, bordered by bony spurs, spines, and tubercles are also used to describe it, and it has also been expressed in very different terms, such as "pear" and "truly oval" [3].

The importance of the skull base foramina, which contains information about various neoplastic processes and trigeminal neuralgia related to the FO, has been emphasized in the literature [4].

The variation in number and morphometric and morphological features of the foramina located in the skull base are clinically in the view of delicate neurovascular structures [5]. Also, the variations, location, and anatomical features are important for clinicians, surgeons, anatomists, forensic scientists, and anthropologists [6]. The precise location in addition to morphological and morphometric features of the FO are of vital significance during certain diagnostic procedures, such as the cannulation of the foramen, microvascular decompression by percutaneous trigeminal rhizotomy, electroencephalographic analysis, and percutaneous biopsy of cavernous sinus tumors in addition to in the prevention of trigeminal nerve injuries during clinical approaches [7]. The FO is very important in neurosurgical approaches; however, despite the studies and developments reported in the literature, no definite consensus about the cannulation of the FO is available. Therefore, more morphometric information is needed in addition to its previously defined morphological and morphometric features [8].

The aim of this study was to compare the features of the FO stated in the literature and to analyze the topographic relationship between the FO and the anatomical structures around it to determine its precise location.

Materials and methods

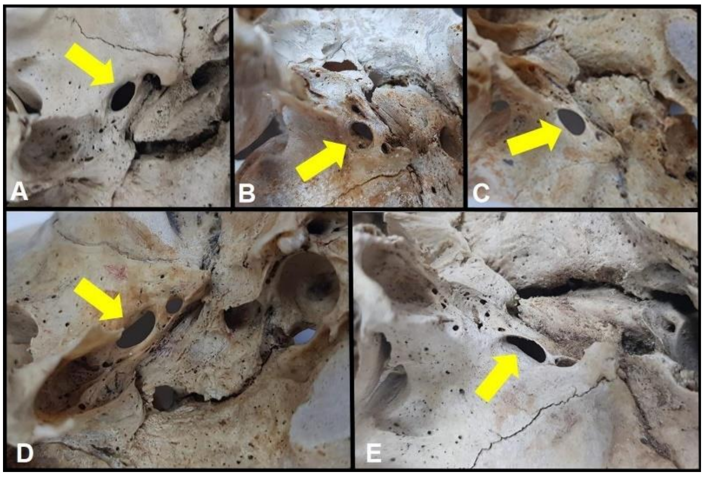
The study included 70 sides of 35 dry skulls of unknown age and gender, which belonged to the Anatomy Laboratory of Çukurova University Faculty of Medicine. The authors declare that the study was conducted in accordance with the 1964 Declaration of Helsinki. The study did not include human/animal experimentation. Skulls used in this study are used as student course material in the Laboratory of the Department of Anatomy. Skulls with any deformities or pathologies that would affect the measurements were not included in the study. All skulls were placed in the horizontal plane with the external occipital protuberance facing posteriorly, the piriform aperture facing anteriorly, and the skull base pointing upwards at a 90º angle after which the skulls were photographed vertically using the length scale. A Nikon D5300 Digital Camera was used for photography, and digital image processing software (Image J) was used for FO measurements. Measurements made on the skulls are shown in Figure 1, and their definitions are given in Table 1. In addition, the shapes of the FO were classified as oval, almond, D-shaped, slit-shaped, round, and irregular (Figure 2).

Table 1: Definitions of measurements made on the skull

Measurements	Definitions
APFO	Anteroposterior diameter of foramen ovale
TFO	Transverse diameter of foramen ovale
FO-ML	The shortest distance between foramen ovale and midline
FO-FS	The shortest distance between foramen ovale and foramen spinosum
FO-CC	The shortest distance from the carotid canal to the foramen ovale
FO-FL	The shortest distance from the foramen lacerum to the foramen ovale
FO-TRZ	The shortest distance from the foramen ovale to the tubercle of root of zygoma

Figure 1: Morphometric measurements made on the skulls; 1 = APFO, 2 = TFO, 3 = FO-ML, 4 = FO-FS, 5 = FO-CC, 6 = FO-FL, 7 = FO-TRZ.

Figure 2: The shapes of the foramen ovale (FO): A = Oval, B = Round, C = Almond, D = D-Shaped, E = Slit Shaped



All measurements were made by a single investigator and intraclass correlation coefficients ([ICC] with 95% confidence intervals [CI]) were used for reliability testing. When the interobserver reliability was examined for all measurements, the ICC value was found to be between 0.91 and 0.95, and the interobserver reliability of all measurements was excellent.

Statistical Analysis

The suitability of the data for consideration as a normal distribution was evaluated with the Kolmogorov–Smirnov test and graphical examinations. The descriptive analysis was performed to obtain means, standard deviations, and ranges (minimum and maximum values). A paired sample t-test was used for the right and left side data comparison that showed normal distribution. The relationship between quantitative variables was analyzed by correlation analysis, and the Pearson's correlation coefficient was used to determine the level of relationship. The SPSS (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.) program was used for statistical analysis. Statistical significance was accepted as $P < 0.05$.

Results

Descriptive statistics of the FO are shown in Table 2. The mean anteroposterior diameter length of the FO (APFO) was 6.144 mm, and the transverse diameter length (TFO) was 2.885 mm. When the distribution of the shape of the FO was examined, it was found that oval and almond shapes were most common (34.29%). In addition, round 12.85%, D-Shaped 10%, and slit-shaped 8.57% were reported (Table 3).

Table 2: Descriptive statistics of measurements of the foramen ovale in mm

Measurements	Mean (SD)	Minimum	Maximum	SEM
APFO	6.144 (0.913)	4.327	7.981	0.109
TFO	2.885 (0.565)	1.440	4.559	0.067
FO-ML	19.147 (1.887)	15.214	23.713	0.225
FO-FS	2.471 (0.803)	1.086	4.305	0.095
FO-CC	10.757 (1.992)	7.248	16.507	0.238
FO-FL	6.260 (1.307)	3.793	9.514	0.156
FO-TRZ	26.688 (2.170)	23.376	32.892	0.259

n = 70, SD: Standard deviation, SEM: Standard Error of Mean

Table 3: Distribution according to the shape of the foramen ovale

Shape	Right (n=35)	Left (n = 35)	Total (n = 70)
Oval	14 (40%)	10 (28.57%)	24 (34.29%)
Round	4 (11.43%)	5 (14.28%)	9 (12.85%)
3333Almond	11 (31.43%)	13 (37.14%)	24 (34.29%)
D-Shaped	3 (8.57%)	4 (11.43%)	7 (10%)
Slit Shaped	3 (8.57%)	3 (8.57%)	6 (8.57%)

The comparison between the measurements of the side difference (right and left side) of FO in the skull is shown in Table 4. When the measurements were examined, = a statistically significant difference between the right and left sides only in the anteroposterior diameter of the FO (APFO) measurement (6.292 versus 5.995 mm; $P = 0.004$) was shown, while no right and left side differences in terms of other measurements were found ($P > 0.05$).

Table 4: Differences between the right and left sides of the foramen ovale (mm)

Measurements	Right (n = 35) Mean (SD)	Left (n = 35) Mean (SD)	Mean difference	SEM	T value	*P*-value
APFO	6.292 (0.150)	5.995 (0.157)	0.297	0.096	3.076	0.004*
TFO	2.942 (0.097)	2.828 (0.094)	0.113	0.101	1.129	0.267
FO-ML	19.356 (0.324)	18.939 (0.315)	0.416	0.252	1.650	0.108
FO-FS	2.375 (0.132)	2.565 (0.138)	−0.190	0.112	−1.703	0.098
FO-CC	10.599 (0.350)	10.914 (0.325)	−0.314	0.155	−2.025	0.051
FO-FL	6.191 (0.229)	6.328 (0.214)	−0.136	0.111	−1.234	0.226
FO-TRZ	26.763 (0.361)	26.612 (0.377)	0.151	0.207	0.733	0.469

SD: Standard deviation, SEM: Standard Error of Mean

The correlation between the measurements of the FO is shown in Table 5. While a statistically significant positive correlation between APFO measurement and TFO, the distance from the carotid canal to the foramen ovale (FO-CC), and the foramen ovale to the tubercle of root of zyoma)FO-TRZ) measurements, a statistically significant negative correlation was found in terms of the shortest distance between the foramen ovale and formen spinosum (FO-FS) measurement (r = 0.390, r = 0.334, r = 0.253, and r = 0.292, respectively). In addition, a statistically significant and positive correlation was obtained between TFO measurement and the shortest distance from the foramen ovale to the midline (FO-ML), FO-CC, and FO-TRZ measurements (r = 0.242, r = 0.315, and r = 0.331, respectively). In addition, a statistically significant and positive correlation was found between FO-ML and FO-CC, FO-FS and FO-FL, FO-CC, and FO-TRZ, and FO-FL and FO-TRZ (r = 0.427, r = 0.394, r = 0.383, and r = 0.346, respectively).

The comparison of the length and width measurements of the FO and the distribution data of the shapes obtained in our study with the studies in the literature is shown in Table 6.

Discussion

This study provides information about the shape of the FO and its relationship with the other cranial base structures in the Turkish population. The FO plays an important role because it connects the intracranial and extracranial structures of the skull. Therefore, it is widely used in various surgical interventions and diagnostic procedures [9]. For this reason, the relationship of the FO with the neighboring structures in the region is important.

In the literature, there are studies on the structure and topography of the foramen ovale conducted on different races. In a study conducted in the Japanese population by Yagani, the mean length and width of the FO were 7.48 and 4.17 mm, respectively, from 220 adult skulls [10]. In another study conducted in Nepal with 35 skulls, the mean length of the FO was reported as 7.46 (1.41) mm, and the mean width of the FO was 3.21 (1.02) mm on the right side. On the left side, the mean length and width were 7.01 (1.41) and 3.29 (0.85) mm, respectively [11]. Also, according to Lang et al.'s study conducted in New York, the mean length of FO was 7.2 mm. It was 6.9 mm on the right side and 6.8 mm on the left. The mean width of the FO in adult skulls was 3.7 mm [12]. In Somesh's study, the maximum widths of FO were 7.5 and 8.0 mm on right and left sides, respectively, and the minimum width was 3.0 mm on the right and left sides. The mean width was 5.128 (0.827) mm on the right side and 5.244 (0.950) mm on the left side, and no side differences were found [13]. In these studies, no statistically significant differences between the right and left sides were noted although millimetric differences were detected. In our study, the mean maximum length of the FO was 6.29 mm on the right side and 5.99 mm on the left side. The mean width of the FO was 2.94 mm and 2.83 mm for the right and left sides, respectively.

Table 5: Comparison between the present and previous studies

	Authors	Doğan et al. [4] 2014	Karthikeyan et al. [5] 2017	Patil et al. [7] 2013	Daimi et al. [9] 2011	Das et al. [14] 2019	Ajrish George & Thenmozhi [15] 2019	Ravinthar [16] 2015	Srikantaiah & Shetty [17] 2019	Sridhar et al. [18] 2014	Present study
Shape (%)	Others	-	-	-	-	-	-	-	-	28.3%	-
	Slit shaped	-	-	-	-	-	-	-	-	6.7%	8.57%
	D-shaped	-	-	-	-	3.94%	-	-	-	-	10%
	Round	-	-	-	-	21.05%	-	-	-	6.7%	12.85%
	Almond	-	-	-	-	21.05%	-	-	-	10%	34.29%
	Oval	-	-	-	-	53.94%	-	-	-	48.3%	34.29%
TFO (Mean [SD])	Right	4.32 (1.41)	3.99 (1.80)	5.0 (0.42)	70 (0.81)	3.49 (0.54)	3.56 (0.73)	3.56 (0.73)	6.0 (1.7)	4.46 (0.83)	2.94 (0.10)
	Left	4.06 (0.66)	4.6 (1.40)	4.70 (0.91)	3.34 (0.77)	3.73 (0.83)	4.28 (0.83)	4.28 (0.83)	5.6 (1.4)	4.40 (0.94)	2.83 (0.10)
APFO (Mean [SD])	Right	7.18 (1.78)	7.45 (1.10)	7.0 (2.17)	6.60 (1.06)	7.17 (1.31)	6.77 (1.65)	6.77 (1.65)	7.45 (3.1)	7.17 (1.46)	6.29 (0.15)
	Left	7.29 (0.94)	7.61 (1.15)	6.8 (1.40)	6.26 (1.23)	7.26 (1.91)	5.74 (1.79)	5.74 (1.79)	6.8 (1.5)	7.41 (1.67)	5.99 (0.16)

In a study by Ray et al. [11] in which the authors used 70 sides from 35 adult skulls, 43 (22R, 21L) were typically oval shaped, 24 (11R, 13L) were almond shape, two (1R, 1L) were round, and one side resembled a slit-like shape. In Somesh's study [13] with 82 adult dry skulls, 56.70% (48R, 45L) had an oval shape, 28.65% (24R, 23L) had an almond shape, 10.97% (8R, 10L) had round shape, and 3.65% (2R, 4L) were irregular. In our study using the same number of skulls, the oval (14R, 10L) and almond shaped (11R, 13L) skulls had the same number out of 70 sides. Seven out of 70 sides (3R, 4L) were D-shaped, and six (3R, 3L) were slit-shaped. The mean FO values reported in other studies are shown in Table 5 [4, 5, 7, 9, 14–18].

Burdan et al. [19] stated that the mean maximum length of the FO was 6.070 mm for males and 5.793 mm for females on the right side. On the left side, they reported values of 5.913 mm for males and 5.817 mm for females. The mean width of the FO was 3.477 mm on the right side and 3.650 mm on the left side for the males. In females, the mean width of the FO was 3.050 mm on the right side and 3.200 mm on the left side in the Polish population. They also stated that that no side differences were found.

In the study of Akcay et al. [20] on 40 Anatolian dry skulls, the average length of the FO on the right side was 7.09 (1.07) mm and 7.06 (1.01) mm on the left side. The mean width was 4.16 (0.79) mm on the right side and 4.15 (0.5) mm on the left side. Out of 80 skulls, 70.0% (28R, 28L) had an oval shape, 18.75% (7R, 8L) had an almond shape, 5% (2R, 2L) had a round shape, and 6.25% (3R, 2L) were split-shaped. The distance between the posterior point of the CC and the FO was 18.89 (2.03) mm on the right and 18.82 (1.74) mm on the left side. Özalp et al. [21] claimed that the mean distance between the FO and the CC was 12.57 (1.56) mm in skulls and 12.45 (1.34) mm on computed tomography (CT) images. In our study, the distance between the FO and the CC was 10.599 (0.350) mm on the right side and 10.914 (0.325) mm on the left side.

It is seen that the present study yielded low values when compared to other studies except for the study by Burdan et al. [19]. The present study also had similar results, but it was not possible to compare them because of the lack of specific gender of the skulls. Also in the present study, a side difference in the mean maximum length of the FO was noted, and the right left side had a higher value than the right side. When the FO shape percentages were examined in most previous studies, it was seen that the shape was mostly oval. In the present study, the oval and almond shapes of the FO ratios were the same (34.29%), which we think affected the average values of the FO.

Most studies in the literature present findings regarding the maximum width and length of the FO for morphometry. In the study, the relationship of the FO with other adjacent bone structures, such as the FS, FL, and CC, were evaluated morphometrically. When we evaluated the correlation between variables, we did not encounter a variable with a high correlation coefficient. The highest correlation was between the FO-CC and the FO-ML (r = 0.427). Also, we tried to produce a formula with a regression analysis to estimate the location of the FO, but this attempt was not successful.

The bone structures differ between populations due to genetic and environmental factors, such as gender, geography, and nutrition [21]. It is worth mentioning the numbers of different shapes of the FO because of its bilateral symmetry. Most of the major brain anomalies involve asymmetrical deformities of the cranial bones; therefore, it is important to understand anatomical structure and their morphometry [20].

The morphology of the FO is important in terms of surgical and interventional approaches. The measurements made in this region and the neighboring areas and relationship of the structures with each other are especially important for surgeons, radiologists, and anatomists to understand. Morphometric measurements can yield different results in every race due to the structure of the bones, which may vary according to the population. We think that our study will set an example for ways to conduct future studies.

Limitations

The most important limitation of our study was the low number of intact skulls due to the strict inclusion criteria and the lack of age and gender data on the skulls. Further multicenter studies using these data and larger samples can be planned to investigate the Turkish population in more detail.

Conclusion

The FO is one of the major anatomical structures on the cranial base. The morphology of the skull differs between populations because of genetics and environment. Its variations, location, anatomical features, and relationship with the other important neighboring structures are important for clinicians, surgeons, anatomists, forensic scientists, and anthropologists to understand.

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References

1. Zdilla MJ, Hatfield SA, McLean KA, Laslo JM, Cyrus LM, Lambert HW. Orientation of the Foramen Ovale: An Anatomic Study With Neurosurgical Considerations. J Craniofac Surg. 2016 Jan;27(1):234-7. doi: 10.1097/SCS.0000000000002332. PMID: 26703059; PMCID: PMC4706813.
2. Reymond J, Charuta A, Wysocki J. The morphology and morphometry of the foramina of the greater wing of the human sphenoid bone. Folia Morphol (Warsz). 2005 Aug;64(3):188-93. PMID: 16228954.
3. Natsis K, Piagkou M, Repousi E, Tegos T, Gkioka A, Loukas M. The size of the foramen ovale regarding to the presence and absence of the emissary sphenoidal foramen: is there any relationship between them? Folia Morphol (Warsz). 2018;77(1):90-8. doi: 10.5603/FM.a2017.0068. Epub 2017 Jul 13. PMID: 28703850.
4. Doğan Ü, Fazlıoğulları N, Uysal Z, Uysal İİ, Şeker M, Karabulut AK. Anatomical examination of the foramens of the middle cranial fossa. Int J Morphol. 2014 Mar;32(1):43-8. doi: 10.4067/S0717-95022014000100008.
5. Karthikeyan G, Sankaran PK, Raghunath G, Yuvaraj M, Arathala, R. Morphometric study of various foramina in the middle cranial fossa of the human skull. Indian J Clin Anat Physiol. 2017;4(4):574-8.
6. Mishra SJ, Sushobhana S, Singh S, Singh R, Gaharwar A. Morphometric and Topographic Study of Foramen Ovale in Indian Skulls. Malays J Med Biol Res. 2018 Dec;5(2):75-84. Doi: 10.18034/mjmbr.v5i2.455.
7. Patil J, Kumar N, K G MR, Ravindra S S, S N S, Nayak B S, et al. The foramen ovale morphometry of sphenoid bone in South Indian population. J Clin Diagn Res. 2013 Dec;7(12):2668-70. doi: 10.7860/JCDR/2013/7548.3727. Epub 2013 Dec 15. PMID: 24551606; PMCID: PMC3919287.
8. Zdilla MJ, Fijalkowski KM. The Shape of the Foramen Ovale: A Visualization Aid for Cannulation Procedures. J Craniofac Surg. 2017 Mar;28(2):548-51. doi: 10.1097/SCS.0000000000003325. PMID: 28027173.
9. Daimi SR, Siddiqui AU, Gill SS. Analysis of foramen ovale with special emphasis on pterygoalar bar and pterygoalar foramen. Folia Morphol (Warsz). 2011 Aug;70(3):149-53. PMID: 21866524.
10. Yanagi S. [Developmental studies on the foramen rotundum, foramen ovale and foramen spinosum of the human sphenoid bone]. Hokkaido Igaku Zasshi. 1987 May;62(3):485-96. Japanese. PMID: 3610040.
11. Ray B, Gupta N, Ghose S. Anatomic variations of foramen ovale. Kathmandu Univ Med J (KUMJ). 2005 Jan-Mar;3(1):64-8. PMID: 16401947.
12. Lang J, Maier R, Schafhauser O. Postnatal enlargement of the foramina rotundum, ovale et spinosum and their topographical changes. Anat. Anz. 1984;156(5):351-87.
13. Lang J, Maier R, Schafhauser O. Uber die postnatale Vergrösserung der Foramina rotundum, ovale et spinosum und deren Lageveränderungen [Postnatal enlargement of the foramina rotundum, ovale et spinosum and their topographical changes]. Anat Anz. 1984;156(5):351-87. German. PMID: 6486466.
14. Somesh MS, Sridevi HB, Prabhu LV, Swamy MS, Krishnamurthy A, Murlimanju BV, et al. A morphometric study of foramen ovale. Turk Neurosurg. 2011;21(3):378-83. doi: 10.5137/1019-5149.JTN.3927-10.2. PMID: 21845575.
15. Das S, Bhattacharjee S, Pal S. A morphometric study of foramen ovale. Indian J Clin Anat Physiol. 2019;6(3):359–62. Doi: 10.18231/j.ijcap.2019.078.
16. Ajrish George S, Thenmozhi MS. The morphometric study of occurrence and variations of foramen ovale. Drug Invent Today 2019;12(1):98–100.
17. Ravinthar TK. Morphometric Study of Size and Symmetry of Foramen Ovale in Dry Skulls. J Pharm Sci Res. 2015;7(10):830-3.
18. Srikantaiah VC, Shetty H. Anthropometric Evaluation of Foramen Ovale in Adult Dry Skulls of the Mysuru-based Population. J Morphol Sci. 2019;36(01):14-6. Doi: 10.1055/s-0039-1678754.
19. Sridhar S, Jayasree N, Chidambaram S, Vetrayan V. Morphometric Observations In Foramen Ovale (Fo) And Foramen Spinosum (Fs) Of Human Sphenoid Bones In Andhra Pradesh Populaıons. J Head Neck Physicians Surg. 2014;3(1):18-28.
20. Burdan F, Umławska W, Dworzański W, Klepacz R, Szumiło J, Starosławska E, Drop A. Anatomical variances and dimensions of the superior orbital fissure and foramen ovale in adults. Folia Morphol (Warsz). 2011 Nov;70(4):263-71. PMID: 22117244.
21. Akçay E, Chatzioglu GN, Gayretli O, Gürses IA, Öztürk A. Morphometric measurements and morphology of foramen ovale in dry human skulls and its relations with neighboring osseous structures. Med Sci. 2021;10(3):1039-46. Doi: 10.5455/medscience.2021.04.149.
22. Özalp H, Beger O, Erdoğan O, Koç T, Kayan G, Hamzaoğlu V, et al. Morphometric Assessment of the Carotid Foramen for Lateral Surgical Approach. J Int Adv Otol. 2019 Aug;15(2):222-8. doi: 10.5152/iao.2019.6154. PMID: 31347511; PMCID: PMC6750789.
23. van Meurs JB, Boer CG, Lopez-Delgado L, Riancho JA. Role of Epigenomics in Bone and Cartilage Disease. J Bone Miner Res. 2019 Feb;34(2):215-30. doi: 10.1002/jbmr.3662. Epub 2019 Feb 4. PMID: 30715766.

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