

Anatomical Variations of Foramen Rotundum and Its Clinical Significance in Gujarat Region - A Cross Sectional Study

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Citation: Dr. Purohit B, Dr. Rajguru J, Dr. Shah S, Dr. Shah V (2024), Anatomical Variations of Foramen Rotundum and Its Clinical Significance in Gujarat Region – A Cross Sectional Study, Educational Administration: Theory and Practice, 30(1), 1877 - 1883.

Doi: 10.53555/kuey.v30i1.6697

ARTICLE INFO

ABSTRACT

Introduction: Foramen rotundum is present in the greater sphenoidal wing just below and behind medial end of superior orbital fissure. It leads forwards into pterygopalatine fossa and transmits maxillary division of trigeminal nerve.

Aim: The present study is aimed to study the anatomy and variations of foramen rotundum in dried adult human skulls of Gujarat region.

Material and Methods: A cross sectional study was carried out in total 153 dry adult human skulls and 20 intact dry sphenoid bones obtained from various medical colleges of Gujarat region. Appropriate statistical analysis was done by SPSS software version 14. p value less than 0.05 was considered statistically significant.

Results: All 153 skulls and 20 sphenoid bones showed the bilateral presence of foramen rotundum. The mean maximum dimension (breadth along transverse axis of the foramen) of the foramen was 2.74 ± 0.90 mm on right side and 2.70 ± 0.82 mm on left side. The shape of the foramen was found to be circular in all the skulls studied. Foramen rotundum was found duplicated in two skulls (0.01%). Accessory foramina adjacent to the foramen rotundum were seen in two skulls and in one intact sphenoid bone on right side (0.017%).

Conclusion: This study is helpful to neurosurgeons because a sound knowledge regarding anatomy and variations of the foramen rotundum is prerequisite in endonasal surgeries for the treatment of trigeminal neuralgia and carcinoma of nasopharyngeal region and brain.

Key words: Foramen rotundum, Maxillary nerve, Endonasal surgery, Trigeminal neuralgia.

Introduction:

Foramen rotundum is a rounded opening situated at the anterior and medial part of the sphenoid bone. It transmits the maxillary nerve which arises from the anterior convexity of trigeminal ganglion between ophthalmic and mandibular divisions of the trigeminal nerve. It is a medium-sized branch compared to the smaller ophthalmic nerve and the larger mandibular nerve. It courses forward within the lateral wall of the cavernous sinus along with the oculomotor nerve, trochlear nerve, and ophthalmic division of the trigeminal nerve. It then leaves the middle cranial fossa through foramen rotundum and enters the superior part of the pterygopalatine fossa. [1,2]

The maxillary nerve is pure sensory nerve and carries pain, temperature, touch, pressure from the skin, teeth, gums, cheek, mucosa related to maxilla and the skin from the side of nose. In cases of trigeminal neuralgia, when this nerve is often implicated, maxillary nerve block is usually approached through foramen rotundum. However, there are many researches suggesting failure of the maxillary nerve block through this route. [3,4] This

foramen is located nearer to nasopharynx. Hence, it can be encroached by the nasopharyngeal carcinoma and other brain tumours.^[5] This is the reason why the precise knowledge of surgical anatomy of foramen rotundum has much importance to neurosurgeons prior to endonasal surgeries or other kinds of neurosurgery involving this foramen.

Material and Methods:

A cross sectional observation study was carried out in total 153 dry adult human skulls and 20 intact sphenoid bones collected from various medical colleges of Gujarat region from March 2012 to April 2016. The permission from institutional ethics committee was taken before the beginning of the study (Number-HMPCMCE/HREC/UG/PG/15/Session-2/18, HM Patel Centre for Medical Care & Education, Karamsad dated on 30/06/2012.

Sample size calculation: According to a study by Berlis et al.^[6] mean breadth of foramen rotundum was found to be 3.29 ± 0.63 mm. Therefore, considering standard deviation of 0.63 for the mean breadth of foramen rotundum, with 5% α error and at 95% confidence level, the sample size obtained was 56. However, we included 153 intact dry skulls and 20 sphenoid bones to enhance the precision of estimates, leading to narrower margin of the error.

Exclusion criteria: The skulls having crack or fracture lines in the region of middle cranial fossa.

Parameters studied:

The presence, absence or presence of multiple foramina on the both sides of middle cranial cavity,

The shape of foramen,

Measurement of the foramen along the maximum dimension (breadth) with the help of digital vernier calliper and geometric compass (Fig. 1 and fig. 2),

The measurement from foramen rotundum to middle clinoid process on both sides (Fig. 3).

Statistical tests applied:

Student's t-test in SPSS software, version 14.

The results were considered significant when p-value was ≤ 0.05 .

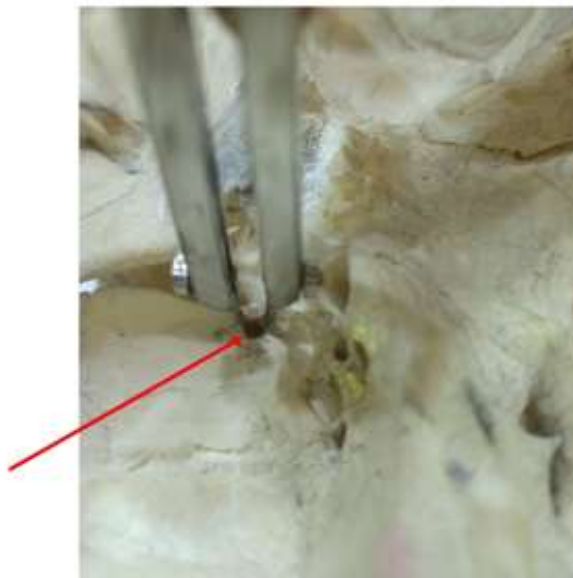


Fig. 1- Shows measurement of maximum diameter (breadth) of foramen rotundum



Fig. 2 Shows the measurement of foramen rotundum with the help of vernier calliper. s



Fig. 3- Shows measurement of distance from foramen rotundum to the tip of middle clinoid process.

Results:

Table-1 shows comparison between the mean maximum diameters of right and left sided foramen rotundum and the mean distance from the foramen rotundum to middle clinoid process. Here, the p-value is ≥ 0.05 . Hence, there is no statistically significant bilateral difference.

Table-1- Maximum dimension of foramen rotundum and the distance(mm)		
Foramen/Distance(mm)	Right side	Left side
Maximum dimension or breadth (FR)*	2.74±0.90	2.70±0.82
Distance from FR to middle clinoid process	13.07±1.988	12.91±1.879

FR*= Foramen rotundum

The shape of the foramen was circular in all skulls observed. Duplication of this foramen was observed in two skulls (incidence 0.01%), out of which it was duplicated unilaterally in one skull with its maximum dimension of 1.78 mm on right side [Fig.4]. Bilateral duplication was observed in one skull [Fig.5] with their maximum dimension(breadth) 2.46 mm on right side and 2.54 mm on left side. Accessory foramina around the foramen rotundum were observed in two skulls and one sphenoid bone on right side (total incidence 0.017%). Fig. 6 shows an accessory foramen rotundum with maximum dimension of 0.99 mm in one skull on right side, located lateral to the main foramen. Two accessory foramina (each having maximum dimension 0.28 mm)

which were situated lateral to main foramen on right side of skull are shown in Fig.7. Another accessory foramen was found in a single intact sphenoid bone on right side, which was located anteromedial to the main foramen with maximum dimension of 1.47 mm [Fig.8].



Fig. 4- Shows unilateral duplication of foramen rotundum

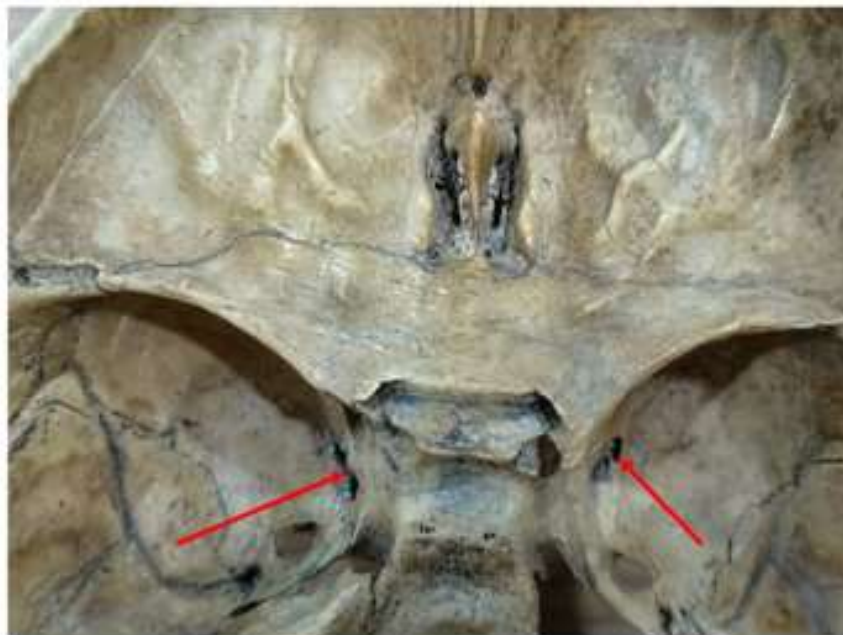


Fig. 5- Shows bilateral duplication of foramen rotundum



Fig. 6- Shows Accessory foramen rotundum on right side of the skull



Fig. 7 – Shows Accessory foramina around(lateral to) foramen rotundum



Fig. 8- Shows Accessory foramen rotundum on right side of intact sphenoid bone

Discussion:

Sphenoid bone is an irregular unpaired bone at the base of the skull, consisting of a body and three pairs of processes; named greater wing, lesser wing and pterygoid processes. It is developed from both intramembranous and endochondral ossification by fusion of pre-sphenoid and post-sphenoid centres. The sphenoid bone openings appear around and after the 8th gestational week. Here, the skull base ossification occurs in the vicinity of pre-existing neurovascular bundle, i.e. vessels and cranial nerves.^[7]

Foramen rotundum is a constant opening in the floor of middle cranial fossa located at medial end of superior orbital fissure. It allows the passage of the maxillary division of the trigeminal nerve from the cavernous sinus to the pterygopalatine fossa. ^[1,2] The foramen rotundum is oval in shape during embryonic life. It becomes ring-shaped by 4th month of embryonic life and finally acquires round shape after birth. The foramen rotundum is found to be in convergence with the superior orbital fissure during embryogenesis. However, it can be recognized as a distinct orifice from the superior orbital fissure by the 12th week of embryonic life. ^[8-10]

The shape of foramen was found to be circular in present study, which is in sync with the findings of many researchers and authors. ^[2,11,12,13] The shape of foramen rotundum was found semicircular and was bipartite in one skull out of fifty studied by Kumar A et al. ^[14] Pavlovic M et al. ^[15] showed that this foramen was rather oval in shape in 75% of skulls. In the rest of skulls, shape was found almost round.

The incidence of double foramen rotundum in present study was 0.01% (2 out of 173). Accessory foramen/foramina around foramen round were found in two skulls and one intact sphenoid bone (total incidence 0.017%). Aggarwal B et al. ^[13] observed the presence of accessory foramen nearer to foramen rotundum leading into the pterygopalatine fossa, in 12 out of 34 sides (35%) of skull studied. Prasath SR et al. ^[16] found that the incidence of the accessory bony canal was 21.87% (14 out of 32 skulls).

Bertelli et al. ^[17] exhibited the branching of foramen rotundum (in 1.06% of individuals on right side of skull), which was connecting orbit and middle cranial fossa.

Rusu et al. ^[18] and Sepahdari AR et al. ^[19] demonstrated an anatomical case showing the maxillary nerve duplication along with double foramen rotundum.

In present study, the maximum dimension(breadth) of foramen rotundum was 2.74±0.90 mm on right side and 2.70±0.82 mm on left side, which was nearer to values in a study performed by Kumar et al ^[14]. The comparison of the dimensions of this foramen with various researchers is shown in Table-2.

Name of the researcher	Right side	Left side
Unver DN et al. ^[20] (2014)	4.48±1.15	4.36±0.66
Kumar A et al. ^[14] (2016)	2.9 ±1.04	3.29 ±0.8
Pavlovic M et al. ^[15] (2021)	3.14 ± 0.77	3.44 ± 0.65
Hinaz ZF et al. ^[21] (2022)	3.2744±0.03	3.3249±0.4
Edouard A et al. ^[5] (2022)	3.15±0.55	3.15±0.79
Bhattarai R et al. ^[22] (2023)	2.41±0.49	
Present study (2024)	2.74±0.90	2.70±0.82

Conclusion:

The base of skull houses many constant and inconstant foramina. Foramen rotundum, foramen ovale and foramen spinosum are constant foramina on the sphenoid bone which transmit the various branches of trigeminal nerve. This nerve is usually involved in cases of trigeminal neuralgia.^[23] There is a significant association between the morphometric and morphological variations of foramen rotundum and trigeminal neuralgia.^[24]

In our study, we found the breadth (maximum dimension) of foramen rotundum 2.74±0.90 mm on right side and 2.70±0.82 mm on left side. The incidence of the same foramen was 0.01% (2 out of 150 skulls). The incidence of accessory foramina around the foramen rotundum in intact skulls and intact sphenoid bones was 0.017%.

Limitation of study: This study is focused on dry adult bones only. Further study can be carried out on living patients with the help the imaging techniques and collaborated with the findings observed in this osteological study of Gujarat region.

Conflict of interest- None

Source of funding- None

Acknowledgements: I acknowledge Dr. Ukti Desai (Tutor, Govt. Medical College, Vadodara) for supporting my project work.

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