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Parietal foramen: incidence and topography

Running title: Anatomical study of the parietal foramen

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ABSTRACT

The parietal foramen (PF) is a small inconsistent aperture located at the border of the middle $\frac{1}{3}$ and posterior $\frac{1}{3}$ of the parietal bone near the sagittal suture and is considered an emissary foramen. Cranial emissary foramina are of utmost importance due to the structures that traverse the foramen. Variations in these foramina are common. Knowledge of the PF is important when performing neurosurgical procedures as the emissary vessels are at risk. The present study used 100 dry adult calvaria to determine the frequency of PF, the diameter of the PF, as well as topography of the PF (using the sagittal suture as an anatomical landmark). A total of 32% of calvaria had PF present bilaterally; whilst 35% of calvaria had unilateral PF. The study also reports 5% calvaria in which PF were present on the sagittal suture. The mean diameter recorded was 1.55mm [0.74 - 3.08mm], and the mean distance between the lateral margin of the PF and the sagittal suture was 9.02mm [4.44 - 18.20mm]. Knowledge of the incidence and topography of the PF may aid neurosurgeons in creating and adjusting techniques and procedures in order to mitigate the risk of injury to emissary veins and other structures emerging from the PF.

Key words: parietal foramen, emissary foramen, osteology, incidence, topography, diameter, sagittal suture

INTRODUCTION

The parietal foramen (PF) is a small inconsistent opening located near the sagittal suture in the posterior part of the parietal bone [13]. This area is described as the obelion due to the representation of the Greek symbol obelos (∞) which depicts the PF on either side of the sagittal suture [7, 8].

When present, the PF transmits an emissary vein and is therefore considered one of the emissary foramina of the cranium [7]. Emissary veins drain the neurocranium as well as cephalic structures, and the parietal emissary veins connect the scalp veins with the superior sagittal sinus [8, 14]. Emissary foramina also share an important relationship with the diploic veins of the skull, which may act as a pathway for the spread of infections from the extracranial veins to the intracranial sinuses [16].

No satisfactory explanation regarding the function of the PF has been reported, besides the transmission of vessels; therefore, the function of the PF remains unclear and under investigation [1, 14]. Due to advancements in radiological techniques, information pertaining to skull foraminal size and symmetry have become increasingly important in the diagnosis of pathological conditions surrounding these foramina [2, 16].

Knowledge of the PF is imperative to neurosurgical perspectives since the emissary veins may be ruptured during surgery [14, 16]. Bleeding from emissary veins may then result in the formation of a postoperative epidural hematoma [12].

The aim of the study was to investigate the anatomy of the PF with the objective of recording incidence, diameter, and topography of the PF in relation to the sagittal suture.

MATERIALS AND METHODS

A total of one hundred adult calvaria were obtained from the Department of Clinical Anatomy, University of KwaZulu-Natal, South Africa. These calvaria were analysed to record the incidence and diameter of the PF. Furthermore, the distance of the PF from the sagittal suture was taken as a horizontal line from the midpoint of the sagittal suture to the

lateral margin of the PF. Institutional ethical clearance was obtained from the Biomedical Research Ethics Committee (BE124/19).

A digital calliper (Linear Tools 2012, 0-150mm, LIN 86500963) was employed to take measurements; these measurements were taken three times to ensure accuracy.

Exclusion Criteria: Calvaria in which the parietal bone was damaged, and the distance of the foramina could not be recorded due to faint sagittal suture were excluded from the study.

Inclusion Criteria: Calvaria without damage to the parietal bone and visible sagittal sutures were included in the study.

RESULTS

Incidence

The PF was found to be present in 68% of calvaria (Table I) and 32% of calvaria displayed a bilateral presence of the PF. A total of 35% of calvaria had PF present unilaterally (Right: 17%, Left 18%). The present study also reports 5% of calvaria which had PF present on the sagittal suture (Table II).

Topography

The distance between the midpoint of the sagittal suture and the lateral margin of the PF, in the present study, was found to range between 4.44 - 18.20mm, with a mean distance of 9.02mm (Table III).

Diameter

The present study recorded a mean diameter of 1.55mm, with a range of 0.74-3.08mm (Table IV).

DISCUSSION

The PF are generally found bilaterally at the junction of the middle $\frac{1}{3}$ and posterior $\frac{1}{3}$ of the parietal bone near the sagittal suture [7, 14, 19]. Margins of the PF are sharply defined enabling the radiologist to differentiate between these foramina and other burr holes, caused by neurosurgical procedures, which are larger in size than that of the PF [14, 16].

Calvaria are formed by intramembranous ossification with the parietal bone forming via two ossification centres, located on either side of the midline, which eventually fuse [1, 19]. The formation of the PF, occurring initially as a single defect, is due to the prolonged ossification of the posterior parietal region of the skull leading to a 'v-shaped' notch known as the third fontanelle, or pars obelica [1, 7]. Thus, the defect persists as a small or oval foramen and the formation of the unilateral or bilateral foramina occurs as the third fontanelle closes [1, 14].

The identification of emissary foramina, such as the PF, is imperative for the understanding of regional vessels and to distinguish between these foramina and variant anatomy [14]. The present study recorded the incidence of PF in 68% of cases which concurs with the literature reviewed, which recorded a weighted mean incidence of 58.5% (Table I). Makandar et al. [10] stated that the incidence of the PF is a standard phenomenon - this statement concurs with the high incidence found in the present study.

This study reports a 32% occurrence of bilateral PF which is similar to the findings of Debbarma et al. [6] (30%); however, this finding is lower than those of Murlimanju et al. [14] (55.2%) and Gangmei et al. [7] (62.5%) (Figure 1A, Table II). The weighted mean incidence of bilateral PF in the literature is 41.2% (Table II).

A review of the literature revealed a weighted mean incidence of unilateral PF as 29.9% (Table II). This finding correlates with that of the present study which recorded unilateral PF in 35% (right: 17%, left: 18%) of cases (Figure 1B, Table II). The finding of the present study correlates closely with that of Berge and Bergman [2] (30%) and Murlimanju et al. [14] (32.7%) which were conducted in American and Indian populations, respectively (Table II).

PF located on the sagittal suture have been termed median PF [7]. The present study revealed a 5% incidence of the median PF (Table II), of which 1% had only the median foramen present (Figure 2A), 2% had the median foramen present along with a unilateral PF

(Figure 2B), and 2% had the median foramen present with bilateral PF (Figure 2C). This type of foramen was reported by Keskil et al. [9] (5%) and Mann et al. [11] (0.7%) which were conducted in Turkish and Japanese populations, respectively (Table II). The weighted mean incidence of the median PF in the literature is 3.4% (Table II).

Determining the topography of the foramen in relation to the sagittal suture is clinically important for neurosurgical techniques due to the risk of rupture of emissary veins during surgical procedures [14, 16]. The present study has a similar range, 4.44 - 18.20mm, of the location of the PF from the sagittal suture when compared to previous studies such as Yoshioko et al. [20] and Murlimanju et al. [14] which reported ranges of 3.00 - 12.00mm and 0.50 - 15.00mm, respectively (Table III). However, the mean distance reported by the present study, 9.02mm, was found to be higher in comparison to previous studies such as Halagatti and Sagar [8] and Shantharam and Manjunath [16] who reported mean distances of 6.60mm and 7.34mm, respectively (Table III).

Information on skull foraminal size is imperative due to radiological advancements by use of magnetic resonance imaging and computed tomography to make diagnoses of pathological conditions [2, 16]. With respect to diameter, the range of 0.74 - 3.08mm, recorded in the present study is similar to that of studies conducted by Yoshioko et al. [20] (0.40 - 4.30mm) and Shantharam et al. [16] (0.86 - 5.57mm), respectively; however, this range was greater than that of Mann et al. [11] (1.80 - 2.00mm) (Table IV). The mean diameter reported by present study, 1.55mm, was found to be lower than that of Yoshioko et al. [20] (1.80mm), yet higher than studies conducted by Berge and Bergman [2] (0.67mm) and Singh and Raibagkar [17] (0.91mm) (Table IV).

Shantharam and Manjunath [16] stated that perhaps differences in studies conducted by Yoshioko et al. [20] and Boyd [4] were due to racial differences. Furthermore, Berry and Berry [3], in a study of variations of the human cranium, stated that the frequency of any particular variant is consistent in any given race. Thus, a need for population specific data of the anatomical parameters of the PF has been highlighted; therefore, the present study aimed to partially fill this gap since a thorough review of the literature has revealed the paucity of data regarding the PF within a South African population.

Variations of skull foramina are important for their disease associations and surgical implications [12, 17]. Therefore, due to the high incidence of the PF as reported by the

present study, and since the emissary veins of the cranium will be encountered by the neurosurgeon, knowledge of the anatomy of the emissary PF is imperative.

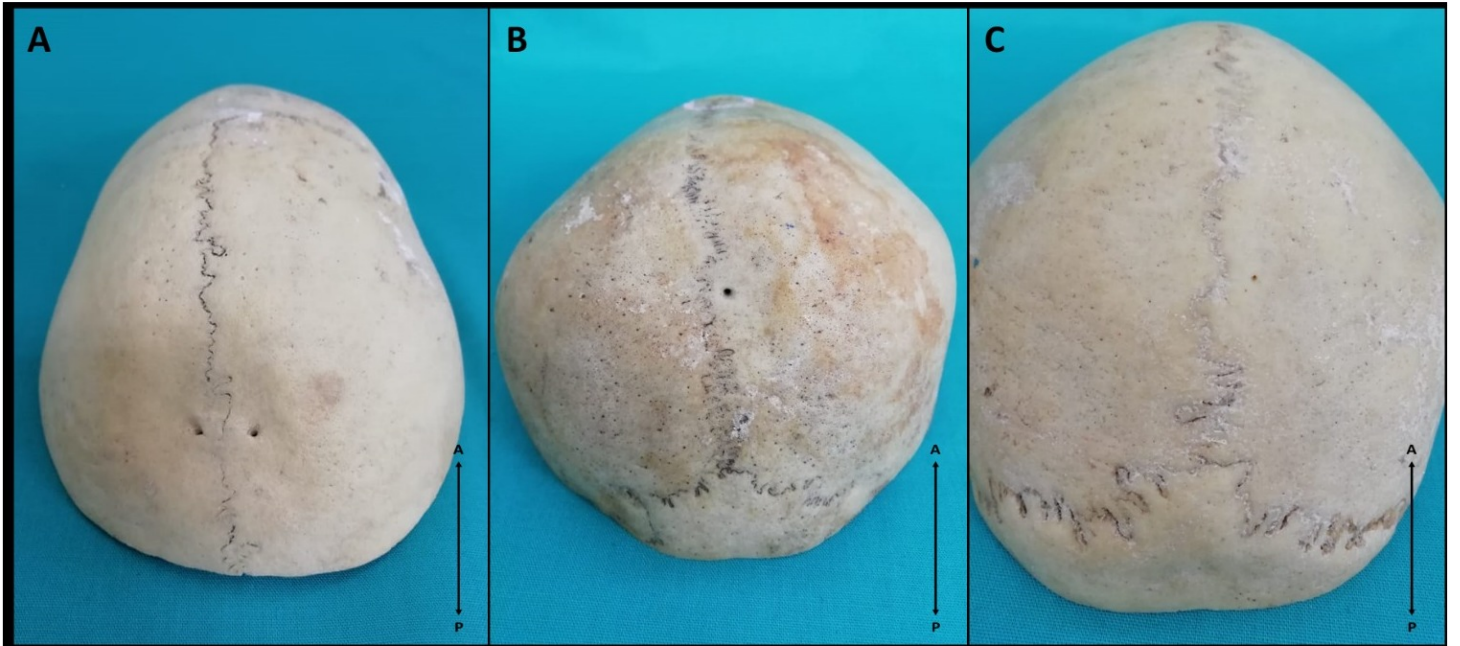
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Figure 1. Calvaria depicting incidence of PF. A: PF present bilaterally, B: PF present unilaterally, C: PF absent bilaterally.

Figure 2. Calvaria depicting presence of median PF. A: Median PF, B: Median PF with unilateral PF, C: Median PF with bilateral PF.



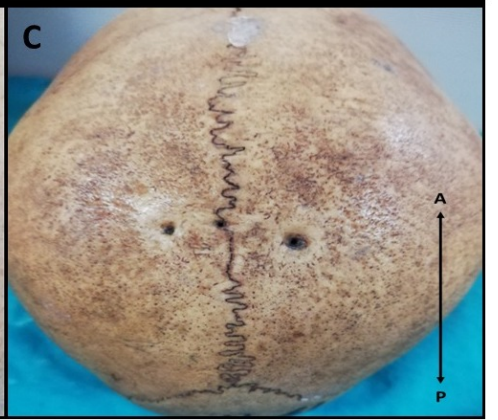
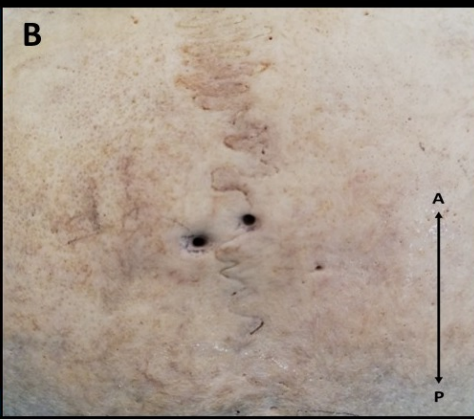
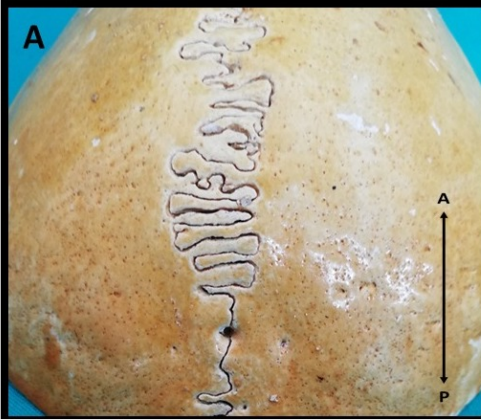


Table I: Incidence of the presence of the PF

Author (year)	Country	Sample Size (n)	Incidence (%)
Boyd (1930)	Scotland	1500	60
Berry and Berry (1967)	Egypt	250	44.2
	Nigeria	56	59.2
	Palestine (Lachish)	54	35.2
	Palestine (Modern)	18	22.2
	India	53	50
	Burma	51	50
	North America	50	62
	Peru	53	53
Keskil et al. (2003)	Turkey	200	63
Wysocki et al. (2006)	Poland	100	60
Yoshioko et al. (2006)	USA	20	50
Mann et al. (2009)	Japan	137	80.3
Debbarma et al. (2015)	India	40	43.8
Gangmei et al. (2018)	India	48	77.1
Weighted mean	-	-	58.5
Present study (2019)	South Africa	100	68

Table II: Incidence of the topographical location of the PF

Author (Year)	Country	Sample Size (n)	Present Bilaterally (%)	Present Unilaterally (%)	Present on sagittal suture (%)	Absent Bilaterally (%)
Boyd (1930)	Scotland	1500	19.9	25.9	-	39.6
Berge and Bergman (2001)	USA	100	40	30	-	20
Keskil et al. (2003)	Turkey	200	27	31	5	-
Yoshioko et al. (2006)	USA	20	40	20	5	40
Mann et al. (2009)	Japan	137	45.3	34.3	0.7	19.7
Singh and Raibagkar (2011)	India	103	51	29	-	20
Debbarma et al. (2015)	India	40	30	13.75	-	42.50
Murlimanju et al. (2015)	India	58	55.20	32.70	3.40	12.10
Gangmei et al. (2018)	India	48	62.50	29.20	-	8.30
Weighted Mean	-	-	41.2	29.9	3.4	20.5
Present study (2019)	South Africa	100	32	35	5	32

Table III: Topography of the PF from the sagittal suture

Author (Year)	Country	Sample Size	Distance from Sagittal Suture (mm)	
			Range	Mean
Yoshioko et al. (2006)	USA	20	3.00 – 12.00	8.00
Pereira et al. (2013)	Brazil	31	-	7.9
Murlimanju et al. (2015)	India	58	0.50 – 15.00	6.70
Halagatti and Sagar (2018)	India	215	-	6.60
Shantharam and Manjunath (2018)	India	78	-	7.34
Weighted Mean	-	-	-	6.9
Present Study (2019)	South Africa	100	4.44 - 18.20	9.02

Table IV: Size of the PF

Author (Year)	Country	Sample Size	Diameter (mm)	
			Range	Mean
Berge and Bergman (2001)	USA	100	-	0.67
Yoshioko et al. (2006)	USA	20	0.40 – 4.30	1.80
Collipal et al. (2009)	Chile	39	0.37- 2.65	-
Mann et al. (2009)	Japan	110	1.80 – 2.00	-
Singh and Raibagkar (2011)	India	103	-	0.91
Shantharam et al. (2018)	India	78	0.86 – 5.57	-
Weighted Mean	-	-	-	0.88
Present Study (2019)	South Africa	100	0.74 - 3.08	1.55

