ONLINE FIRST

ISSN: 0015-5659

e-ISSN: 1644-3284

Anatomical observation and significance of the parietal foramen in Chinese adults

Authors: D. Liu, H. Yang, Jua. Wu, J-H Li, Y-K Li

DOI: 10.5603/FM.a2021.0106

Article type: Original article

Submitted: 2021-09-19

Accepted: 2021-10-03

Published online: 2021-10-21

Anatomical observation and significance of the parietal foramen in Chinese adults

D. Liu[1, 2#], H. Yang[1#], J. Wu[2#], J.-H. Li[1], Y.-K. Li[1]

[1]School of Traditional Chinese Medicine, Southern Medical University, Guangzhou, Guangdong, P.R. China
[2]Department of Rehabilitation Medicine, the third affiliated Hospital, Southern Medical University, Guangzhou, Guangdong, P.R. China

Address for correspondence: Yi-Kai Li, School of Traditional Chinese Medicine, Southern Medical University, No. 1838, North of Guangzhou Great Road, BaiYun District, Guangzhou, Guangdong Province, 510515, China, e-mail: ortho@fimmu.com
[#]*These authors contributed equally to this work. Dan Liu is the first author, Han Yang and Juan Wu are the co-first.*

Abstract

Background: This study aimed to investigate the incidence, number, diameter, and relative location of the parietal foramen (PF), as well as communication of intracranial and extracranial orifices and their direction, and sagittal suture morphology and length.

Materials and methods: A total of 280 dry Chinese adult skull specimens from the Department of Anatomy, Southern Medical University, were observed and measured. The occurrence rate and quantity of the PF near the sagittal suture were recorded. The aperture of the PF, the vertical distance between PF and sagittal suture, and the linear distance between PF and lambda were measured using a vernier calliper. The length of the sagittal suture was measured by a flexible ruler, the direction and communication of intracranial and extracranial orifices were detected using a probe.

Results: The total incidence of the PF was 82.86%, slightly more on the right side than on the left side. The single foramen type was the most. The mean diameter of the PF on the left and right sides were 1.02±0.72 mm and 1.07±0.67 mm, respectively, and the diameter of the PF on the sagittal suture was 1.77±0.44 mm. The mean vertical distance between the PF and

the sagittal suture was 5.90±2.78 mm and 5.85±2.75 mm on the left and right sides, respectively. The shape of the sagittal suture in the PF area was primarily dentate shaped, with an average arc length of χ = 124.36±7.76 mm, of which the majority were completely healed type. The intracranial and extracranial communication was 39.97%, and the majority of the PF were anteromedial direction.

Conclusions: The current study provided an anatomical basis for imaging diagnosis and neurosurgery by investigating the incidence, diameter, and relative location of the PF and intracranial and extracranial communication and direction.

Key words: anatomy, skull, parietal foramen, sagittal suture, lambda, parietal emissary vein

INTRODUCTION

The parietal foramen (PF) is a small inconsistent diameter located at the border of the middle 1/3 and posterior 1/3 of the parietal bone near the sagittal suture. It is usually considered an emissary foramen [1]. The edge of the PF is clear, with meningeal branches of the occipital artery, venules and nerves passing through [2]. PF has some important functions, such as communicating intracranial and extracranial transmitting blood vessels, nerves, and regulating intracranial pressure and body temperature, while it remains unclear whether the PF has other functions [6,7]. The anatomical knowledge of the PF is essential for neurosurgery because surgical manoeuvres may rupture the guiding vein and thus lead to bleeding. Moreover, intracranial navigation through the PF for vascular disease (e.g., dural arteriovenous fistulas) is becoming mainstream research [3, 4].

The existing literature has shown that the incidence, number, diameter, shape, relative location of the PF, and intracranial and extracranial communication and direction are not constant [1, 5]. There are few studies investigating this topic on the Asian race to date, especially Chinese. The current study aimed to observe and provide a large number of anatomical data related to the PF in Chinese adults; to review the frequency and diameter of the PF in different ethnic groups; and to provide an anatomical reference for clinical, scientific research and teaching of modern medicine.

MATERIALS AND METHODS

Materials and instruments

A total of 280 dry Chinese adult skull specimens from the Department of Anatomy, Southern Medical University, were observed and measured after excluding skull damage, lesions, malformations, and intracranial foreign body filling. All the specimens were treated by corrosion, cleaning and drying. The structures were complete, and the external conditions of the skull, such as the PF and sagittal suture, were clearly identified. The sex of the specimens was known, but no age identification was made.

Methods

The incidence and number of the PF were observed by visual inspection, and the diameter of the PF, the vertical distance between the PF and the sagittal suture, and the linear distance between the PF and the herringbone were measured using a digital vernier calliper with an accuracy of 0.01 mm (Wuxi Kaibaoding Tools Co., Ltd., China). The length of the sagittal suture (the arch from the bregma (b) to the lambda (l)) was measured using a flexible ruler. The direction and communication of intracranial and extracranial orifices were detected using a probe with a diameter of 0.5 mm.

All the above items were measured three times independently by two researchers. Both researchers had more than two years of experience in anatomical measurements and were trained before the measurement to reduce systematic errors. After the measurement, the digital image acquisition (D610 camera, Nikon) and image processing (Photoshop 2020, Illustrator 2020, Adobe) were performed.

All methods in the current study complied with the Declaration of Helsinki. The study was approved by the Chinese Ethics Committee of Registering Clinical Trials (Reference No. ChiECRCT20210191).

Statistical analysis

Using IBM SPSS Statistics for Windows 26.0 to analyse statistics. The values are expressed as an mean ± SD ($\bar{x} \pm s$). Using the Kolmogorov Smirnov test to assess the normality of the data. using the Paired-sample t-test or Wilcoxon signed-rank test to assess Bilateral asymmetry, and an independent-sample t-test or Mann-Whitney U test was used to assess gender dimorphism. For all the analyses, $P < 0.05$ was considered to indicate statistical significance.

RESULTS

The incidence of the PF

Of the 280 skulls measured, 161 were males, and 119 were females, with a male-to-female ratio of 1.35:1. The overall incidence of PF was 82.86% (232/280). Among the PF, the incidence of the left PF was 63.21% (177/280), the incidence of the right PF was 66.07%, and the incidence of simultaneous incidence was 48.93% (137/280). Additionally, the incidence of the PF on the sagittal suture was 2.5% (7/280) (Figure 1). These incidences of the PF were compared with findings of previous studies (Table 1).

The diameter of the PF

The diameters of the PF on the left and right sides were 1.02±0.72 mm and 1.07±0.67 mm, respectively, and the diameter of the PF on the sagittal suture was 1.77±0.44 mm. The diameters of the PF in males and females were 1.05±0.71 mm and 1.07±0.69 mm, respectively, and there was no statistically significant difference in the diameter of the PF in sides and sex ($P>0.05$) (Table 2).

The relative location of the PF

The vertical distance between the PF and the sagittal suture was 6.12±2.62 mm and 5.96±2.60 mm on the left and right sides, respectively. The vertical distance between the PF and the sagittal suture was not statistically different in sides and sex ($P>0.05$).

The linear distance between the PF and the lambda was 35.33±6.36 mm and 34.27±5.84 mm on the left and right sides, respectively; 34.90±6.50 mm and 34.40±5.98 mm in males and females, respectively. The distance between the PF to the lambda was not statistically different in sex ($P>0.05$) but was slightly longer on the left side than on the right side ($P<0.001$) (Table 3).

The shape distribution, length and degree of healing of the extracranial sagittal suture

The configuration of the human cranial suture is similar to a fingerprint, which varies from each other, and the morphology of the cranial suture is complex and highly specific [12]. The shape of the extracranial sagittal suture in the interparietal foramen area could be divided into six types:.straight suture in 3 cases (1.04%); dentate suture in 222 cases (79.27%); the corrugated suture in 44 cases (15.54%); the secondary corrugated suture in 4 cases (1.55%);healed suture in 4 cases (1.55%); the secondary healed suture in 4 cases (1.55%) (Figure 2). The arc length of the sagittal suture was between 100 mm and 141 mm

(χ=124.36±7.76 mm) (Table 4). 66.22% of the extracranial sagittal sutures were completely healed, 31.08% were partially healed, and 2.70% were completely unhealed.

The intracranial and extracranial communication of the PF

Of the 280 skulls measured, a total of 98 skulls with 178 PF had intracranial and extracranial communication. Among these PF, the communication rate of the PF on the left and right sides was 17.18% (48 cases) and 22.09% (63 cases), respectively. The incidence of the PF communication on both sides was 6.75 (20 cases), and the PF communication on the sagittal suture was 2.45% (7 cases). The PF communication was 19.64% (55 cases) in males and 15.36% (43 cases) in females. Intracranial and extracranial communication of the PF was not statistically different in sides and sex (P>0.05).

The 178 single-hole PF were classified according to their directions [15]: 39.70% antero-medial direction (46), 17.65% anterior direction (21), 13.24% antero-lateral direction (15), 13.24% antero-superior direction (15), 11.76% antero-inferior direction (14), 2.94% medio-superior direction (3), and 1.47% medio-inferior direction (2).

DISCUSSION

The PF is usually located on both sides of the middle 1/3 and posterior 1/3 of the sagittal suture [1]. The frequency, number, diameter, shape, location of the PF, intracranial and extracranial communication and direction are not constant. Studying the PF is, therefore, important not only for understanding the complex regional neurovascular anatomy but also for distinguishing between normal and potentially abnormal structures [16].

The overall incidence of the PF measured in the current study was 82.86%, which was different from other populations(Table 1), which may be due to ethnic differences, and this trend was also reported by Makandar et al. [17]. With the development of imaging technology, the diameter of the PF can be scanned by MRI and CT to diagnose some diseases, so it is of considerable significance for research on the diameter of the PF. The diameter of the PF in Chinese adults measured in this study was larger than that in the study by Yoshioko et al. [14] but smaller than that in the study by Berry and Singh et al. [11, 18], and the diameter was not statistically different in sides and sex (P>0.05). The distance between the PF and the sagittal suture can affect the complexity of the sagittal suture, and the mean distance was 5.90±2.78 mm on the left side and 5.85±2.75 mm on the right side, which was smaller than 6.7 mm reported by Murlimanju BV et al[1]. Investigating the specificity of

cranial sutures, especially extracranial sagittal sutures, may provide a new way of identifying individual biological information for criminal investigation, forensics and other fields.

The PF is a characteristic of humans, which is less frequent in lower animals and absent in some species [12]. Normal PF usually transmits venules connecting the occipital vein and superior sagittal sinus, anastomosis and nerves between the middle meningeal artery and occipital artery [16]. Reis CV studied 40 parietal regions in 20 adult bodies and observed that each foramen transmitted an anastomotic vessel between the middle meningeal artery and the extracranial artery, with the superficial temporal artery anastomosing to the superficial occipital artery in 55% of cases and the middle meningeal artery anastomosing the pericranial arteriole in the remaining cases (45%) [3]. The emissary vein (EV) in the PF crosses the skull with varying degrees of inclination, while presenting a highly consistent course on the sagittal plane [16].

Other functions of the PF (except allowing vessels to pass through) remain unknown and under ongoing investigation. In the study by Tsutsumi S et al., it was found that 75% of the emissary vein (EV) passed through the PF as a single channel, EV could function as a blood supply vessel under pathological conditions; for example, EV could play a role in supplying dural vessels in the case of maxillary sinus dural arteriovenous fistulas, and EV could be found play a role in supplying blood in MRI of patients with parasagittal meningiomas [16]. The EV drain intracranial and extracranial blood flow, and these veins are not valvular and play a key role in controlling intracranial pressure and body temperature, particularly when the head position and Valsalva manoeuvre changes during daily physical activity [19]. Body GI et al. also proposed that the skull roof osteomyelitis, meningitis, and brain abscess may be complications due to perforating vein infection between the diploe, meninges, and meningeal veins, and then concluded that scalp injury and disease would be reduced by half without the EV [12]. Additionally, Chapot R et al. reported firstly several cases of dural fistula treated by transcranial puncture of the PF and the mastoid foramen. The arterial anastomosis in the dural fistula was enlarged and supplied to the vessels of the PF and mastoid foramen, and the intracranial segment of the supply artery was traversed along a straight line[20]. The PF or mastoid foramen, therefore, could be directly punctured and entered into the straight segment of the supply artery, and propylene glue could inject to embolise the fistula [20].

There are scarce studies on the role of nerves in the PF to date. Lacković Z et al. found that there may be a direct bidirectional innervation between the trigeminal nerve in the parietal foramen and the epidural system through the experiment of botulinum toxin in the treatment of migraine in mice [21].

Enlarged parietal foramina (EPF) is a rare defect in parietal bone development resulting from intramembranous osteogenesis abnormalities, and they are not homologous to normal PF and have a different development basis [22-24]. It was first described in 1707 but not appreciated by scholars until the 1940s [15]. During the development of a normal foetus, intramembranous osteogenesis occurs in the squamous portion of the frontal, parietal, and temporal bones, which are usually ossified during the fifth month of gestation. When there is insufficient ossification around the parietal notch, they form giant permanent holes [15]. The diameter has been reported to be up to 2.0 cm [25], and the incidence is not well understood. Tubbs RS reported its incidence to be about 1 in 15,000 to 1 in 25,000, and transmission by autosomal dominant inheritance [26]. The EPF is associated with Saethre-Chotzen syndrome [25] and the deletion of chromosome 11 [23]. The EPF is now thought to result from mutations in the homeobox genes ALX4 (located on chromosome 11) and MSX2 (located on chromosome 5) [27-29]. Therefore, Durão C et al. proposed that decreased identity information could be clarified by forensic identification based on rare anatomical variations of the PF [30]. In addition, studies have found that pathological processes of some diseases may change the diameter and shape of the skull foramina, which may be associated with cranial malformation, cleft lip and palate, craniofacial dysplasia, broad thumb syndrome, hypoplasia of the skull and clavicle, and syndrome consisting of the hypoplastic syndrome [31, 32], ocular inflammation, hyperglycaemia, obesity, mental retardation and epilepsy [26]. The treatment of the EPF is usually conservative; traditional Chinese medical massage and acupuncture can change intracranial and extracranial, and diploic vascular blood flow, but whether the treatment could change the diameter of the PF remains unclear. However, persistent cranioschisis may require surgical closure [15]. In the current study, the EPF was not observed.

Limitations and expectations

This study had some limitations, e.g., no geographical and age analysis and identification. Also, the relevant data of the PF were measured and analysed manually in this study, and advanced instruments and equipment such as computer analysis were not used. For future research, modern instruments and equipment can be used to carry out more in-depth and precise research on clinical anatomy to obtain more anatomical information conducive to basis and clinical medicine.

CONCLUSIONS

This study measured the incidence, diameter, and location of the PF in Chinese adults, and found the differences compared with other ethnic groups. These findings also provided us with a scientific basis for imaging diagnosis and treatment associated with the PF.

Acknowledgements

We are grateful to the Human Anatomy Laboratory of the Southern Medical University, which provided materials that were essential to carry out the study.

Ethical approval

All methods in the study were carried out in accordance with the Helsinki guidelines and declaration. Ethical approval for this study was obtained from the Chinese Ethics Committee of Registering Clinical Trials (Reference number: ChiECRCT20210191).

Conflict of interest: None declared.

REFERENCES

[1] Murlimanju BV, Saralaya VV, Somesh MS, et al. Morphology and topography of the parietal emissary foramina in South Indians: an anatomical study. Anat Cell Biol. 2015; 48(4): 292-298, doi: 10.5115/acb.2015.48.4.292, PMID: 26770881.

[2] Mann RW. Enlarged parietal foramina and craniosynostosis in an American Indian child. AJR Am J Roentgenol. 1990; 154(3): 658, doi: 10.2214/ajr.154.3.2106245, PMID: 2106245.

[3] Reis CV, Deshmukh V, Zabramski JM, et al. Anatomy of the mastoid emissary vein and venous system of the posterior neck region: neurosurgical implications. Neurosurgery. 2007; 61(5 Suppl 2): 193-200; discussion 200-201, doi: 10.1227/01.neu.0000303217.53607.d9, PMID: 18091233.

[4] Murlimanju BV, Reddy G, Prabhu LV, et al. Foramen of Vesalius: Prevalence, Morphology, Embryological Basis and Clinical Implications. 2015 ,

[5] Sharma NA, Garud RS. Morphometric evaluation and a report on the aberrations of the foramina in the intermediate region of the human cranial base: A study of an Indian population. European Journal of Anatomy. 2011; 15(3): 140-149,

[6] de Souza Ferreira MR, Galvão A, de Queiroz Lima P, et al. The parietal foramen anatomy: studies using dry skulls, cadaver and in vivo MRI. Surg Radiol Anat. 2021; 43(7): 1159-1168, doi: 10.1007/s00276-020-02650-0, PMID: 33399919.

[7] Louis RG, Loukas M, Wartmann CT, et al. Clinical anatomy of the mastoid and occipital emissary veins in a large series[J]. Surg Radiol Anat, 2009,31(2):139-144.doi:10.1007/s00276-008-04 23-5.

[8] Mann RW, Manabe J, Byrd JE. Relationship of the Parietal Foramen and Complexity of the Human Sagittal Suture. International Journal of Morphology. 2009; 27(2), doi: 10.4067/S0717-95022009000200040,

[9] Gangmei G. Variations of parietal foramen in dried adult human skulls ,2018.

[10] Keskil S, Gözil R, Calgüner E. Common surgical pitfalls in the skull. Surg Neurol. 2003; 59(3): 228-231; discussion 231, doi: 10.1016/s0090-3019(02)01038-8, PMID: 12681561.

[11] Carolineberry A, Berry RJ. Epigenetic variation in the human cranium. J Anat. 1967; 101(Pt 2): 361-379, PMID: 4227311.

[12] Boyd GI. The Emissary Foramina of the Cranium in Man and the Anthropoids. J Anat. 1930; 65(Pt 1): 108-121, PMID: 17104299.

[13] Wysocki J, Reymond J, Skarzyński H, et al. The size of selected human skull foramina in relation to skull capacity. Folia Morphol (Warsz). 2006; 65(4): 301-308, PMID: 17171609.

[14] Yoshioka N, Rhoton AL Jr, Abe H. Scalp to meningeal arterial anastomosis in the parietal foramen. Neurosurgery. 2006; 58(1 Suppl): ONS123-126; discussion ONS123-126, doi: 10.1227/01.NEU.0000193516.46104.27, PMID: 16543869.
[15] Griessenauer CJ, Veith P, Mortazavi MM, et al. Enlarged parietal foramina: a review of genetics, prognosis, radiology, and treatment. Childs Nerv Syst. 2013; 29(4): 543-547, doi: 10.1007/s00381-012-1982-7, PMID: 23207976.
[16] Tsutsumi S, Nonaka S, Ono H, et al. The extracranial to intracranial anastomotic channel through the parietal foramen: delineation with magnetic resonance imaging. Surg Radiol Anat. 2016; 38(4): 455-459, doi: 10.1007/s00276-015-1579-4, PMID: 26498934.
[17] Makandar UK, Kulkarni PR, Suryakar AN. Comparative Study of Incidence of Parietal Foramina in North and South Indian Human Crania. Indian Journal of Forensic Medicine & Toxicology. 2013; 7(2),
[18] Singh D, Raibagkar D. Study of variation in atypical foramina of dry human skull. NJIRM. 2011; 2(2): 1-5,
[19] Mortazavi MM, Tubbs RS, Riech S, et al. Anatomy and pathology of the cranial emissary veins: a review with surgical implications. Neurosurgery. 2012; 70(5): 1312-1318; discussion 1318-1319, doi: 10.1227/NEU.0b013e31824388f8, PMID: 22127046.
[20] Chapot R, Saint-Maurice JP, Narata AP, et al. Transcranial puncture through the parietal and mastoid foramina for the treatment of dural fistulas. Report of four cases. J Neurosurg. 2007; 106(5): 912-915, doi: 10.3171/jns.2007.106.5.912, PMID: 17542540.
[21] Lacković Z, Filipović B, Matak I, et al. Activity of botulinum toxin type A in cranial dura: implications for treatment of migraine and other headaches. Br J Pharmacol. 2016; 173(2): 279-291, doi: 10.1111/bph.13366, PMID: 26493010.
[22] O&#39, RAHILLY R, TWOHIG MJ. Foramina parietalia permagna. Am J Roentgenol Radium Ther Nucl Med. 1952; 67(4): 551-561, PMID: 14914930.
[23] Bartsch O, Wuyts W, Van Hul W, et al. Delineation of a contiguous gene syndrome with multiple exostoses, enlarged parietal foramina, craniofacial dysostosis, and mental retardation, caused by deletions in the short arm of chromosome 11. Am J Hum Genet. 1996; 58(4): 734-742, PMID: 8644736.
[24] Tubbs RS, Smyth MD, Oakes WJ. Parietal foramina are not synonymous with giant parietal foramina. Pediatr Neurosurg. 2003; 39(4): 216-217, doi: 10.1159/000072475, PMID: 12944704.
[25] Thompson EM, Baraitser M, Hayward RD. Parietal foramina in Saethre-Chotzen syndrome. J Med Genet. 1984; 21(5): 369-372, doi: 10.1136/jmg.21.5.369, PMID: 6502651.
[26] Tubbs RS, Doughty K, Oakes WJ, et al. Duane's syndrome and giant parietal foramina. Pediatr Neurol. 2004; 30(1): 75-76, doi: 10.1016/s0887-8994(03)00425-9, PMID: 14738958.
[27] Mavrogiannis LA, Taylor IB, Davies SJ, et al. Enlarged parietal foramina caused by mutations in the homeobox genes ALX4 and MSX2: from genotype to phenotype. Eur J Hum Genet. 2006; 14(2): 151-158, doi: 10.1038/sj.ejhg.5201526, PMID: 16319823.
[28] Wilkie AO, Tang Z, Elanko N, et al. Functional haploinsufficiency of the human homeobox gene MSX2 causes defects in skull ossification. Nat Genet. 2000; 24(4): 387-390, doi: 10.1038/74224, PMID: 10742103.
[29] Wuyts W, Cleiren E, Homfray T, et al. The ALX4 homeobox gene is mutated in patients with ossification defects of the skull (foramina parietalia permagna, OMIM 168500). J Med Genet. 2000; 37(12): 916-920, doi: 10.1136/jmg.37.12.916, PMID: 11106354.
[30] Durão C, Carpinteiro D, Pedrosa F, et al. Enlarged parietal foramina: a rare forensic autopsy finding. Int J Legal Med. 2016; 130(3): 855-857, doi: 10.1007/s00414-015-1239-6, PMID: 26233611.
[31] Mupparapu M, Binder RE, Duarte F. Hereditary cranium bifidum persisting as enlarged parietal foramina (Catlin marks) on cephalometric radiographs. Am J Orthod Dentofacial Orthop. 2006; 129(6): 825-828, doi: 10.1016/j.ajodo.2006.02.020, PMID: 16769502.
[32] Reddy AT, Hedlund GL, Percy AK. Enlarged parietal foramina: association with cerebral venous and cortical anomalies. Neurology. 2000; 54(5): 1175-1178, doi: 10.1212/wnl.54.5.1175, PMID: 10720293.

Table 1. Incidence of the PF (from high to low incidence)

No.	**Author (s)**	**Year**	**Population**	**Sample Size (n)**	**Incidence (%)**
1	Le Double et al.[6]	2021	Brazil	301	84.3
2	***Present study***	2021	Chinese	280	82.86
3	Mann et al.[8].	2009	Japan	137	80.3
4	Gangmei et al.[9].	2018	India	48	77.1
5	Murlimanju BV et al.[4]	2015	South Indians	116	71.5
6	Keskil et al.[10]	2003	Turkey	200	63
7	Berry and Berry[11]	1967	North America	50	62
			Nigeria	56	59.2
			Peru	53	53
			India	53	50
			Burma	51	50
			Egypt	250	44.2
			Palestine (Lachish)	54	35.2
			Palestine (Modern)	18	22.2
8	Boyd GI[12]	1930	Scotland	1500	60
9	Wysocki et al.[13]	2006	Poland	100	60
10	Yoshioko et al.[14]	2006	USA	20	50

Table 2. Diameter of the PF (mm)

Bore	**Side**		**Gender**	
Diameter	**Left**	**Right**	**Males**	**Females**
Min	0	0	0	0
Max	3.29	2.82	3.29	2.82
Mean ± SD	1.02 ± 0.72	1.07 ± 0.67	1.05 ± 0.71	1.07 ± 0.69
P	> 0.05		> 0.05	

Table 3. The vertical distance between the PF and the sagittal suture and the linear distance between the PF and the lambda (mm)

	Sagittal suture				Herringbone			
Distance	**Side**		**Gender**		**Side**		**Gender**	
	Left	**Right**	**Males**	**Females**	**Left**	**Right**	**Males**	**Females**
Min	0	0	0	0.81	12.22	17.79	12.22	20.08
Max	13.84	15.09	15.09	12.06	46.46	52.94	48.49	52.94
Mean ±	6.12±	5.96 ±	6.18±	5.98±	35.33±	34.27 ±	34.90±	34.40±
SD	2.62	2.60	2.94	2.33	6.36	5.84	6.50	5.98
P	> 0.05		> 0.05		> 0.001		> 0.05	

Table 4. Range and proportion of arc length of the sagittal suture (n=280)

Range [mm]	100–109	110–119	120–129	130–139	≥ 140
Percentage (%)	2.78%	18.05%	51.39%	26.39%	1.39%

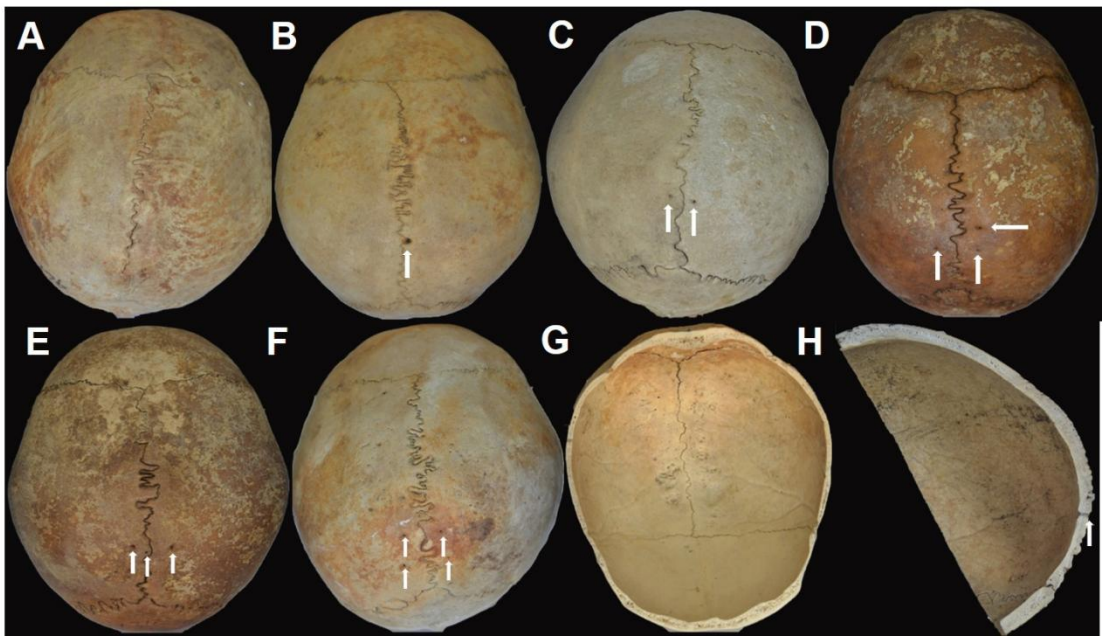

Figure1 Presence/absence of the PF; **A.** Absent; **B.** Present unilaterally (arrow); **C.** Present bilateral (arrow); **D–F.** Presence of multiple foramina (arrows); **G.** Internal view of the PF; **H.** Sagittal section in the PF.

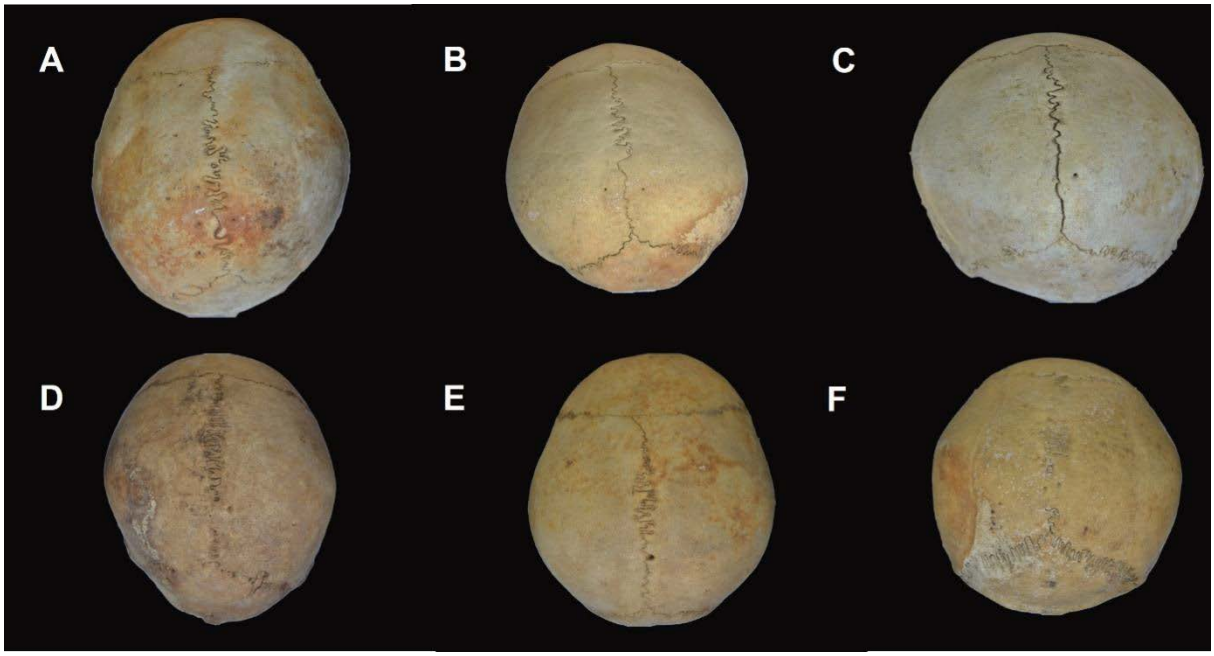

Figure 2. The shape of the extracranial sagittal suture; **A.** Dentate suture; **B.** Corrugated suture; **C.** Straight suture; **D.** Healed suture; **E.** Secondary corrugated suture; **F.** The secondary healed suture.