DOI: 10.7860/JCDR/2026/82051.23175

Original Article

Anatomy Section

Prevalence of Posterior Condylar Canal in Adult Human Skulls of the Indian Population: A Cross-sectional Study

RADHIKA PARAMESH MUDALIAR[1], JYOTHI KRISHNARAJANAGAR CHANDRACHARI[2], ANUPAMA KODIALBAIL[3], SHAILAJA SHETTY[4]

ABSTRACT

Introduction: The Posterior Condylar Canal (PCC) is the largest emissary foramen that transmits the Posterior Condylar Vein (PCV). Emissary veins connect extracranial veins with intracranial veins. This anatomical channel also provides a potential route for the spread of infection.

Aim: To determine the prevalence of the PCC in adult human skulls.

Materials and Methods: A descriptive, cross-sectional osteological study was conducted in the Department of Anatomy, MS Ramaiah Medical College, Bengaluru, Karnataka, India from March 2020 to March 2022. A total of 150 dry adult skulls of Indian origin, with unknown age and gender were collected from the medical and dental students. Fully ossified skulls with intact occipital bone and preserved condylar region were included in the study. The base of skulls was observed for the presence and absence of PCC on both sides. The laterality of the PCC (unilateral or bilateral) was also noted. The presence and absence of the posterior condylar foramen were recorded in percentage. Chi-square test was used to compare the presence and absence of PCC between the right and left sides using Statistical Package for Social Sciences (SPSS) software version 22.0.

Results: The PCC was present in 201/300 (67%), out of which 98 (65.3%) were present on the left side and 103 (68.7%) were on the right side. The presence of PCC on the right and left was compared using the Chi-square test, which was not statistically significant; the p-value was 0.539. Out of 201 posterior condylar foramina, 165 (82.1%) were patent. The patent foramen openings were of two types: intrasinus type 102 (61.8%) and retrosinus openings 63 (38.2%).

Conclusion: Detailed analysis of PCC will help in the planning of surgical intervention involving the skull base. This study will be useful for the anatomist, neurosurgeons and radiologists.

Keywords: Posterior condylar emissary vein, Skull base, Venous sinuses

INTRODUCTION

The skull has emissary foramina, which functions as an alternative channel for venous blood drainage. These veins establish connections between extracranial veins and the intracranial dural venous sinuses [1]. Under normal physiological conditions, when the primary venous outflow is patent, emissary veins play a minimal role. However, they become vital alternative pathways in situations where the primary venous routes are compromised, such as in jugular vein thrombosis or arteriovenous fistulas. Commonly encountered emissary veins include those associated with the sphenoid, occipital, foramen ovale, mastoid, and posterior condylar foramen [2]. Emissary veins are clinically significant due to their potential role in transmitting infections from superficial structures to intracranial sinuses, for instance, the spread of infections from the mastoid region to the sigmoid sinus or from the paranasal sinuses to the cavernous sinus [3].

The PCC transmits the PCV, meningeal branches of the occipital artery, and nerves innervating the meninges of the posterior cranial fossa. The PCV typically originates from the anterior condylar confluence, the jugular bulb, or the medial end of the sigmoid sinus, and drains into the suboccipital venous plexus or paravertebral veins [3]. PCC forms a venous communication between the jugular foramen and the condylar fossa, allowing veins to pass [4]. During development, as foetal circulation transitions to the adult pattern and jugular sinuses mature, the PCV generally regresses. One possible cause of the patent PCC is the failure of normal development of sigmoid-jugular complex [5,6].

Clinically, the PCC holds significance as it can function as an alternative venous drainage pathway in situations such as internal jugular vein obstruction, cerebral venous congestion, or pathological conditions involving the neck or skull base, thus contributing to the regulation of intracranial pressure [7]. Pathological involvement of the jugular fossa may extend to the PCC. Moreover, on contrast-enhanced Magnetic Resonance Imaging (MRI), a prominent PCC may enhance and be misdiagnosed as a neuroma [8]. Accurate knowledge of skull base anatomy is essential to prevent diagnostic errors, as the PCC may mimic a calcified lymph node or glomus tumour on imaging studies [9]. In skull base surgeries, particularly during lateral transcondylar approaches, significant dissection around this area is necessary, posing a risk to adjacent neurovascular structures [10,11]. Drilling through the condylar fossa is a critical step, and identifying the PCC and the associated emissary vein helps delineate the jugular tubercle from the occipital condyle externally. Thus, the PCC serves as an essential surgical landmark during transcondylar fossa procedures [10], and awareness of its anatomy is crucial to minimise intraoperative complications. Hence, the present study aimed to assess the prevalence of the PCC in adult human skulls.

MATERIALS AND METHODS

A descriptive, cross-sectional osteological study was conducted in the Department of Anatomy, MS Ramaiah Medical College, Bengaluru, Karnataka, India, from March 2020 to March 2022. As the study was carried on dry bones, ethical clearance was not required.

Sample size: The sample size was determined by convenience sampling based on the availability of skulls in the Institution. A total of 150 dry adult skulls of Indian origin, with unknown age and gender, were collected.

Inclusion criteria: Fully ossified skulls with intact occipital bone and preserved condylar region were included.

Exclusion criteria: Skulls with fractures, deformities, erosion, or damage involving the condylar region were excluded.

Study Procedure

The base of skulls was observed for the presence and absence of PCC on both the sides. Whether the PCC was unilateral or bilateral was noted. The PCC was observed for patency by passing a metal probe (1 mm) through the canal. A PCC was considered patent only if the probe could be passed completely through the canal. It was also noted in patent PCC, if the canal opened into the sigmoid sinus, it was called intrasinus. If the opening was located posterior to the sigmoid sulcus, it was termed the retrosinus type.

STATISTICAL ANALYSIS

The presence and absence of the posterior condylar foramen was recorded as percentages. Chi-square test was used to compare the presence and absence of PCC between the right and left sides using SPSS software 22.0.

RESULTS

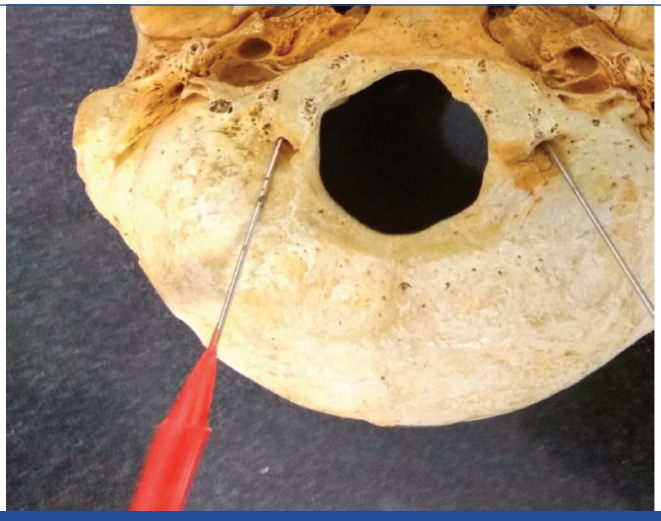
The PCC was present in 201/300 (67%), out of which 98 (65.3%) were present on the left side and 103 (68.7%) were on the right side. The presence of PCC on the right and left was compared using the Chi-square test, which was not statistically significant (p-value=0.539) [Table/Fig-1]. The PCC was present bilaterally in 49.3% of skulls (74/150 skulls), which was higher than the unilateral presence observed in 35.3% (53/150 skulls). Bilateral absence of the PCC was noted in 15.3% of skulls (23/150) [Table/Fig-2]. Total skulls with PCC on at least one side were 74 + 53 = 127 [Table/Fig-3-5].

Side	PCC Present n (%)	PCC Absent n (%)	Chi-square	p-value
Left (150)	98 (65.3 %)	52 (34.7 %)	0.377	0.539
Right (150)	103 (68.7 %)	47 (31.3 %)		
Total (300)	201 (67 %)	99 (33 %)		

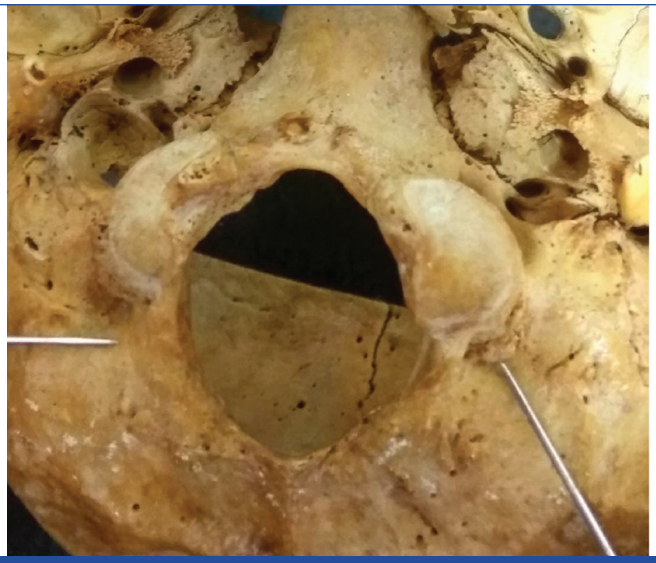
[Table/Fig-1]: Comparison of presence or absence of Posterior Condylar Canal (PCC) on right and left.

Laterality	Patency	n (%)
Laterality of PCC (n=150 skulls)	Bilateral presence of PCC	74 (49.3%)
	Unilateral presence of PCC	53 (35.3%)
	Bilateral absence	23 (15.3%)
Laterality of patency (n=127)	Bilateral Patent	61 (48.03%)
	Unilateral Patent	43 (33.8%)

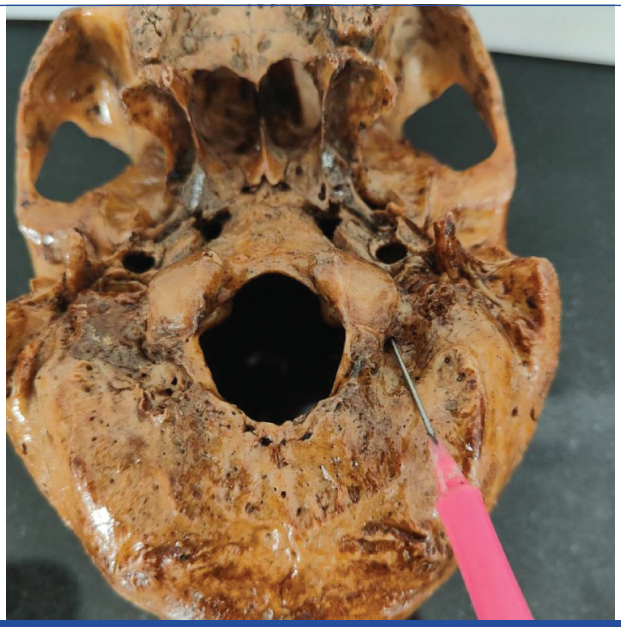
[Table/Fig-2]: Distribution and patency of PCC /Foramen.



[Table/Fig-3]: Bilateral presence of PCC.



[Table/Fig-4]: Bilateral absence of Posterior Condylar Canal (PCC).



[Table/Fig-5]: Unilateral patent Posterior Condylar Canal (PCC) on the left-side.

Of the 201 posterior condylar foramina identified, 165 (82.1%) were patent, with 81 on the left side and 84 on the right. Bilateral patency was observed in 61/127 skulls (48.03%), while unilateral patency accounted for 43/127 skulls (33.8%) [Table/Fig-2]. Among the 165 patent foramina, 102 (61.8%) opened into the sigmoid sinus sulcus within the posterior cranial fossa (intrasinus type), whereas 63 (38.2%) demonstrated retrosinus openings, located posterior to the sigmoid sinus sulcus.

DISCUSSION

Boyd GI studied the emissary foramen in 1500 skulls and noted that the PCC was the largest emissary foramen, present in 77% of skulls. [12]. Ginsberg LE observed that the posterior condylar foramina were found in 55.9% bilaterally and 17.6% unilaterally in skulls and on Computed Tomography (CT) scan, it was found bilaterally in 31% and unilaterally in 50% [2]. According to Krause W, PCC were found bilaterally in 21% and unilaterally in 21% of skulls [13].

In a study conducted by Muthukumar N et al., PCCs were found to be present in 60% of skulls. It was absent in four skulls on right-side and in 16 skulls on left-side [14]. The findings of the present study compared with the previous studies and tabulated in [Table/Fig-6] [2,5,6,13,15-17]. In the current study, bilateral presence of the PCC was observed more frequently than unilateral occurrence. Additionally, bilateral probe patency was more commonly noted, further supporting the predominance of bilateral PCC in a few

Authors	Population	PCC Present	PCC Absent	PCC Present (bilateral)	PCC Present (unilateral)
Ginsberg LE [2]	American 34 Skulls	73.5% (skull)	26.5%	55.9%	17.6%
	123 CT scan	81% (CT scan)	19%	31%	50%
Goda J et al., [5]	West India 64 skull bones	90.62%	9.38%	70.31%	20.31%
Dimple DV et al., [6]	South India 100 skull bones	90%	10%	68.88%	31.11%
Krause W [13]	Spanish	59%	41	21%	38%
Berge JA and Bergman RA [15]	American 100 skull	90%	10%	54%	Right-21%,
					Left-15%
Das SS et al., [16]	Central India 130 skull bones	91.54%	8.46%	60%	31.54%
Kavitha S and Anand A [17]	South India 156 skull bones	94.2%	5.8%	78.9%	21.1%
Present study	Indian 150 skull bones	67%	33%	49.3%	35.3%

[Table/Fig-6]: Comparison of the presence and absence of Posterior Condylar Canal (PCC) in the present study with previous studies [2,5,6,13,15-17].

previously done studies [2,5,6,16,17]. In the present study, there was a slightly higher prevalence of the PCC was observed on the right side compared to the left. Most of the studies have shown a similar higher preponderance of left-sided PCC than right [6,16,17].

Most osteological studies have identified only two internal opening sites of the PCC: intrasinus (within the sigmoid sulcus) and retrosinus (located behind the sigmoid sulcus) [5,6,18]. Among these, the intrasinus type is the most frequently observed, similar with the findings of previous research [5,6,18]. Understanding these variations in imaging studies is essential to avoid misdiagnosis, as it may resemble a glomus jugulare tumour or a calcified lymph node [2,8]. The morphological differences in cranial foramina may result from various pathological conditions or external influences, such as osteoporosis, osteopetrosis, neurofibromatosis, brachycephaly and microcephaly [19-21].

The PCC and its emissary vein play a crucial role in the surgical management of tumours and Dural Arteriovenous Fistulas (DAVFs) in this area [9,22]. They serve as key anatomical landmarks that help distinguish the transcondylar fossa (supracondylar transjugular tubercle) approach from the transcondylar approach, thereby reducing the risk of unintentional injury to the atlanto-occipital joint [22]. These structures are also utilised as reference points in posterolateral surgical techniques aimed at accessing lesions near the jugular foramen and hypoglossal canal, including the juxta-condylar and extreme lateral approaches [10,11]. Additionally, the PCVs may provide access routes for treating hypoglossal and transverse-sigmoid DAVFs in cases where the jugular vein is obstructed [23]. These veins potentially serve as conduits for the spread of infections [3].

Limitation(s)

The primary limitation of the osteological study of the PCC relates to the lack of its contents, such as the posterior condylar emissary vein or meningeal arterial branch in a living individual, which are critical for surgical planning. The age, gender and ancestry of the dry skulls used in anatomical collections are unknown, which limits the ability to establish population-specific or demographic variations in canal morphology.

CONCLUSION(S)

Understanding the normal anatomy of the PCC is valuable for neurosurgeons when planning and performing surgical procedures in the occipital region. The emissary channels can serve as alternate pathways for venous drainage in cases of unilateral or bilateral jugular vein obstruction, allowing blood to escape from the brain during surgery. Therefore, knowledge of cranial emissary foramina and veins is beneficial during endovascular and posterior skull base surgery.

Authors' contribution: 1 Dr Radhika PM- Concept, design, literature search, data analysis, statistical analysis, manuscript preparation, manuscript editing, manuscript review; 2 Dr Jyothi K C - Literature search, data analysis, statistical analysis, manuscript preparation, manuscript editing, manuscript review; 3 Dr Anupama K -Manuscript preparation, manuscript editing, manuscript review; 4 Dr Shailaja Shetty-, Manuscript review

REFERENCES

[1] Standring S. Gray's Anatomy: The Anatomical Basis of Clinical Practice. 40th ed. London: Elsevier Churchill Livingstone; 2008. p. 432-433.
[2] Ginsberg LE. The posterior condylar canal. AJNR Am J Neuroradiol. 1994;15:969-72.
[3] Lachkar S, Kikuta S, Iwanaga J, Tubbs RS. The condylar canal and emissary vein – A comprehensive and pictorial review of its anatomy and variation. Childs Nerv Syst. 2019;35:747-51.
[4] Matsushima K, Kawashima M, Matsushima T, Hiraishi T, Noguchi T, Kuraoka A. Posterior condylar canals and posterior condylar emissary veins-a microsurgical and CT anatomical study. Neurosurg Rev. 2014;37(01):115-26.
[5] Goda J, Patel S, Chandravadiya L, Rupareliya S, Patel S, Chavda S. Variations of the posterior condylar canals. Int J Res Med. 2013;2:118-20.
[6] Dimple DV, Suman U, Shubha R. Study of incidence, laterality and patency of the posterior condylar canal in 100 dry human skulls.Int J Anat Res. 2015;3:831-34.
[7] Wang J, Manaenko A, Hu Q, Zhang X. Cerebral venous impairment and cerebral venous sinus thrombosis. Brain Hemorrhages. 2024;5(3):131-42.
[8] Haas LL. The posterior condylar fossa, foramen and canal, and the jugular foramen. Radiology. 1957;69:546-52.
[9] Kiyosue H, Okahara M, Sagara Y, Tanoue S, Ueda S, Mimata C, et al. Dural arteriovenous fistula involving the posterior condylar canal. AJNR Am J Neuroradiol. 2007;28(8):1599-601.
[10] Matsushima T, Kawashima M, Masuoka J, Mineta T, Inoue T. Transcondylar fossa (supracondylar transjugular tubercle) approach:Anatomic basis for the approach, surgical procedures, and surgical experience. Skull Base. 2010;20:83-91.
[11] Matsushima T, Natori Y, Katsuta T, Ikezaki K, Fukui M, Rhoton AL. Microsurgical anatomy for lateral approaches to the foramen magnum with special reference to transcondylar fossa approach. Skull Base Surg. 1998;8(3):119-25.
[12] Boyd GI. The emissary foramina of the cranium in man and the anthropoids. J Anat. 1930;65(Pt 1):108-21.
[13] Krause W. Posterior condylar canal. In: Treatise of Human Anatomy. Barcelona: Salvat; 1998. Vol 1:152-158.Barcelona, Salvat. 1998;1:152-58.
[14] Muthukumar N, Swaminathan R, Venkatesh G, Bhanumathy SPA. Morphometric analysis of the foramen magnum region as it relates to the transcondylar approach. Acta Neurochir (Wien). 2005;147(8):889-95.
[15] Berge JK, Bergman RA. Variations in size and in symmetry of foramina of the human skull. Clin Anat. 2001;14:406-13.
[16] Das SS. Sexual dimorphism and clinical importance of posterior condylar canal. Natl J Clin Anat. 2022;11:10-16.
[17] Kavitha S, Anand A. A study of the condylar canal and its incidence, morphology and clinical significance. Int J Cur Res Rev. 2013;5:66-70.
[18] Galarza M, Hyoun YJ, Merlo A, Albanese AH, Alfonso AR. Channel anatomical variations condylar. Chilean Journal of Anatomy. 1998;16(1).
[19] Akintoye SO, Adisa AO, Okwuosa CU, Mupparapu M. Craniofacial disorders and dysplasias: Molecular, clinical, and management perspectives. Bone Rep. 2024;20:101747.
[20] Reddy AT, Hedlund GL, Percy AK. Enlarged parietal foramina: Association with cerebral venous and cortical anomalies. Neurology. 2000;54:1175-78.
[21] Shaffer LG, Hecht JT, Ledbetter DH, Greenberg F. Familial interstitial deletion 11(p11.12p12) associated with parietal foramina brachymicrocephaly, and mental retardation. Am J Med Genet. 1993;45:581-83.
[22] Mondel PK, Saraf R, Limaye US. Acute subarachnoid hemorrhage in posterior condylar canal dural arteriovenous fistula: Imaging features with endovascular management. J Neurointerv Surg. 2015;7:e26.
[23] Hellstern V, Aguilar-Pérez M, Schob S, Bhogal P, AlMatter M, Kurucz P, et al. Endovascular treatment of dural arteriovenous fistulas of the anterior or posterior condylar vein: A cadaveric and clinical study and literature Review. Clin Neuroradiol. 2019;29(2):341-49.

PARTICULARS OF CONTRIBUTORS:
1. Associate Professor, Department of Anatomy, M.S. Ramaiah Medical College, Bengaluru, Karnataka, India.
2. Associate Professor, Department of Anatomy, M.S. Ramaiah Medical College, Bengaluru, Karnataka, India.
3. Associate Professor, Department of Anatomy, M.S. Ramaiah Medical College, Bengaluru, Karnataka, India.
4. Professor, Department of Anatomy, M.S. Ramaiah Medical College, Bengaluru, Karnataka, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Radhika Paramesh Mudaliar,
MSR Nagar, Mathikere MSR Post, Bengaluru-560054, Karnataka, India.
E-mail: radhikapm.rmc@msruas.ac.in

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Jul 29, 2025
- Manual Googling: Jan 03, 2026
- iThenticate Software: Jan 05, 2026 (1%)

ETYMOLOGY: Author Origin

EMENDATIONS: 6

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? No
- Was informed consent obtained from the subjects involved in the study? No
- For any images presented appropriate consent has been obtained from the subjects. No

Date of Submission: **Jul 17, 2025**
Date of Peer Review: **Nov 13, 2025**
Date of Acceptance: **Jan 07, 2026**
Date of Publishing: **May 01, 2026**