

Radiological and anatomical evaluation of the posterior condylar canal, posterior condylar vein and occipital foramen*

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Abstract

Objectives: This study was carried out to make morphometric and radiological analyses of the occipital foramen (OF), posterior condylar canal (PCC), posterior condylar vein (PCV), and occipital emissary vein (OEV).

Methods: Morphometric analyses were performed on 91 adult human occipital bones and radiological analyses on computed tomography (CT) angiography images of 221 patients. PCC length and mean diameters of the internal and external orifices of PCC were measured and the number of OF on both sides was recorded for bony specimens. Prevalence of PCV and PCV size were investigated using CT angiography.

Results: PCCs were observed in 60 bones (66%) on the left and 60 bones (66%) on the right side. Mean PCC length was 10.85 ± 3.41 and 9.77 ± 3.55 on the left and right sides, consequently. Mean internal orifice diameter was 3.87 ± 1.99 mm on the left and 3.31 ± 4.43 mm on the right side; mean external orifice diameter was 4.02 ± 1.59 mm on the left and 3.89 ± 1.52 mm on the right side. The majority of PCCs (75%-81.6%) had 2-5 mm diameter; only 5-13.3% were small in size (<2mm). In CT angiography, PCV was not identified in 45(22.5%) patients. PCVs were located bilaterally in 114 (57%) and unilaterally in 41(20.5%) patients. Only 4.3% of PCVs (n=17) were large in size, the majority (27.5%) were medium-sized and 35.8% small-sized.

Conclusion: This study will contribute to the limited body of research on OF, PCC, PCV, and OEV as a guide to surgical interventions for pathologies of the posterior cranial fossa such as tumors and injuries.

Keywords: computed tomography angiography; emissary vein; occipital foramen; posterior condylar canal; posterior condylar vein

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Introduction

Emissary veins (EVs) are valveless veins that connect the extracranial venous system with intracranial venous sinuses.^[1] Posterior condylar vein (PCV) and occipital emissary vein (OEV) are two major posterior fossa EVs.^[2] PCV establishes connection between intracranial venous (sigmoid, marginal, or occipital) and internal ver-

tebral venous sinuses.^[1] Posterior condylar foramen (PCF), the foramen that PCV passes through, is the largest emissary foramen in the retromastoid region.^[1-3] OEV passes through the occipital canal (OC) and provides venous drainage from the transverse sinus to the vertebral venous plexus via the occipital vein. These veins play an important role in brain cooling by allowing

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blood to flow bi-directionally through the head in the upright position and providing primary venous drainage.^[1] EVs and foramina on bony structures are better-developed in humans compared to other primates, and it is believed that anatomy and physiology of the cranial venous drainage evolved as a result of human bipedalism.^[5]

Posterior condylar canal (PCC), PCV and OEV are of utmost importance for posterolateral surgical approaches to foramen magnum.^[6] Dilatation and anatomical variations of these veins can change the surgical approach in the posterior fossa.^[7] EVs should be released from other tissues in order to protect the veins from avulsion or laceration that cause hemorrhage, air embolism or sinus thrombosis.^[1-4] Also, these valveless veins connecting the extracranial venous system with intracranial venous sinuses may transfer infections from the superficial tissues into the cranium.^[1] Therefore, a detailed study and the knowledge about the PCC, PCV, OC and OEV are needed. This study was carried out to make morphometric and radiological analyses of the occipital foramen (OF), PCC, PCV and OEV.

Materials and Methods

Morphometric measurements were made on 100 adult human occipital bones from the collection of Department of Anatomy, Ege University School of Medicine. Nine occipital bones were excluded due to damaged condylar canals. PCC length and mean diameters of the internal and external orifices of PCC were measured using a standard stainless caliper. The number of OF on both sides was recorded. All measurements were performed by the same researcher.

The radiological part of this study was carried out at the Department of Radiology of Izmir Tepecik Education and Research Hospital. Computed tomography (CT) angiography images of 221 patients referred to the hospital for investigation of vascular pathologies were reviewed. Patients were scanned with a 64-slice CT scanner (Aquilion 64; Toshiba Medical Systems, Tochigi, Japan). All images were obtained with previously reported dose-reduction techniques.^[2] Multidetector CT angiography data were transferred from the archive to a workstation (Aquarius Workstation; TeraRecon, San Mateo, CA) providing 3D post-processing options, multiplanar image reformatting (MPR), and maximum intensity projections. Twenty one of 221 patients were excluded from the study, 15 for inadequate image quality mainly due to patient movement and technical problems, and 6 for mastoid region and/or posterior fossa

surgery prior to CT angiography. The mean age of the 200 patients (96 females, 104 males) was 52.5 years. The prevalence of the PCV was recorded for both sides as absent, unilateral or bilateral. PCV was classified by size into 3 groups: small (<2 mm), medium-sized (2–5 mm), and large (>5 mm).

Statistical analysis of all the parameters was performed using IBM SPSS Statistics for Windows version 20.0, USA. Comparison was done between right and left parameters. $P < 0.05$ was accepted as statistically significant.

Results

The average number of OFs on the left (on 73 bones) and right side (on 76 bones) was 2.66 ± 1.87 and 2.57 ± 2.19 , respectively. Six of the 91 occipital bones had OFs in the midline (6.59%), 68 occipital bones were bilateral, and 13 were unilateral (**Figure 1**). OF could not be observed in 12 on the left side, and in 9 occipital bones on the right side. The foramen was absent bilaterally in 3 bones. In 2 occipital bones, bilateral OFs located near the mid-line formed canals.

PCC was observed in 60 bones (66%) on the left side, and 60 bones (66%) on the right side. Mean length of the PCC was measured 10.85 ± 3.41 (1–18 mm) and 9.77 ± 3.55 (3–19 mm) on the left and right sides, respectively. Mean diameter of the internal orifice was 3.87 ± 1.99 mm (1–14 mm) on the left and 3.31 ± 4.43 mm (1–8 mm) on the right side. For the external orifice, mean diameter was measured 4.02 ± 1.59 mm (1–9 mm) on the left and 3.89 ± 1.52 mm (1–10 mm) on the right

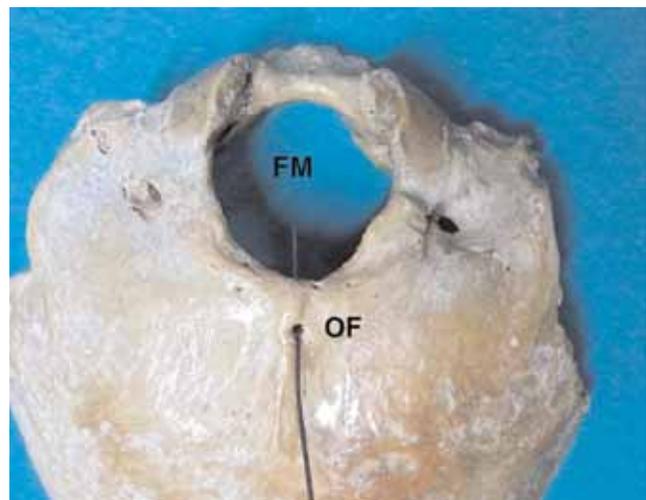


Figure 1. Occipital foramen in the mid-line of the occipital bone (posterior view). FM: foramen magnum; OF: occipital foramen.

Table 1

Mean length and diameter of the internal and external orifices of the PCC in 91 dry bones for the right and left sides. No significant differences were observed for these parameters when right and left sides were compared ($p>0.05$).

	Left		Right	
	Mean±SD (mm)	Range (mm)	Mean±SD (mm)	Range (mm)
Mean length of PCC	10.85±3.41	1–18	9.77±3.55	3–19
Internal orifice diameter	3.87±1.99	1–14	3.31±4.43	1–8
External orifice diameter	4.02±1.59	1–9	3.89±1.52	1–10

Table 2

The distribution of the PCC with regard to diameters of the internal and external orifices on 91 dry bones.

Diameter (mm)	Number and % of left internal orifice	Number and % of left external orifice	Number and % of right internal orifice	Number and % of right external orifice
<2	3 (5%)	2 (3.3%)	8 (13.3%)	3 (5%)
2–5	49 (81.6%)	47 (78.3%)	46 (76.6%)	45 (75%)
>5	8 (13.3%)	11 (18.3%)	6 (10%)	12 (20%)

side (**Table 1**). No significant differences were found for the mean length and internal and external orifice diameters between the right and left sides ($p>0.05$). Measurements on dry bones showed that the majority of PCCs (75%–81.6%) had diameters between 2 to 5 mm; only 5–13.3% were small in size (<2 mm) (**Table 2**).

In CT angiography images, PCV was not identified in 45 (22.5%) of the 200 patients. PCVs were located bilaterally in 114 (57%) and unilaterally in 41 (20.5%) patients. The number of unilateral right sided PCVs ($n=23$) was slightly higher than the unilateral left sided PCVs ($n=18$) (**Table 3**). Only 4.3% of PCVs ($n=17$) were large in diameter (>5 mm). The majority of PCVs were medium-sized (diameter 2–5 mm) found in 27.5% ($n=110$), and 35.8% ($n=143$) were small-sized (<2 mm) (**Figures 2–5**).

Discussion

Morphological and radiological studies on OF, PCC, PCV, OEV, and other EVs are of significance in neurosurgery. As the largest emissary foramen in the retromastoid region, the morphological features of PCFs are remarkable specifically for posterior cranial fossa neurosurgical procedures.^[1]

Several types of intracranial orifice connections of PCV in the cranial base were recently identified. Following different courses of PCC through which the

Table 3

Prevalence of PCV in CT angiography of 200 patients

Emissary vein	n	Prevalance
Absent	45	22.5
Bilateral	114	57
Unilateral	41	20.5
Right-sided	23	11.5
Left-sided	18	9

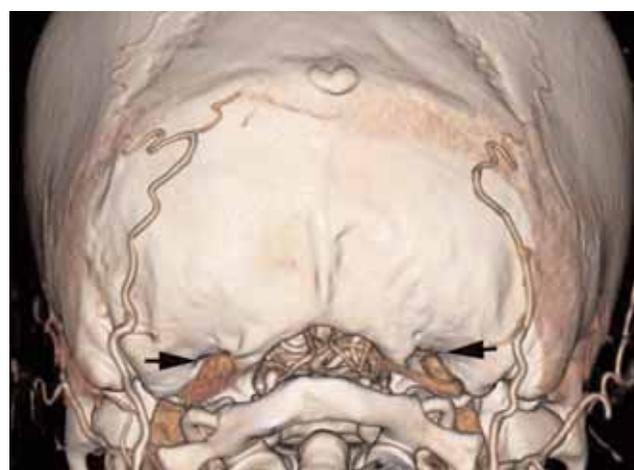


Figure 2. CT angiography of PCC and PCV. Three-dimensional volume-rendered image in posterior view shows bilateral PCFs and the PCVs exiting from PCCs (arrows).

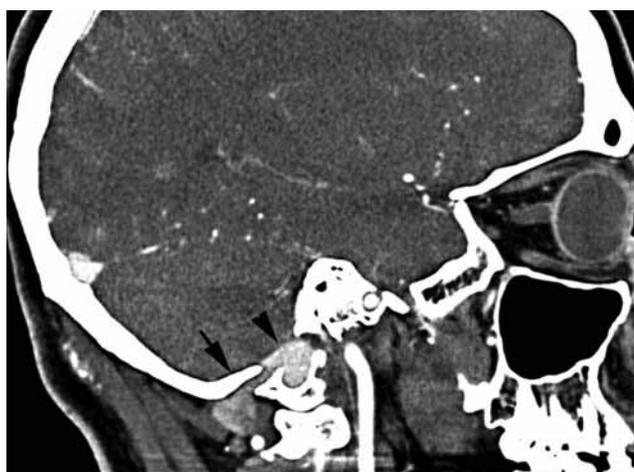


Figure 3. CT angiography of PCF, PCC and PCV. A sagittal multiplanar reformatted image demonstrates the PCV in the PCC (arrow) arising from the jugular bulb (arrowhead) draining into the deep cervical vein and the horizontal portion of the vertebral venous plexus.

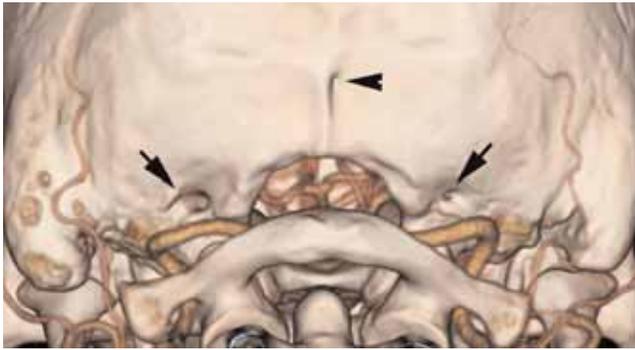


Figure 4. CT angiography of the OF. Three-dimensional volume-rendered image in posterior view shows a small OF in the midline (arrowhead) and bilateral PCFs (arrows).

vein are transferred through the bone, the venous structures the vein is connected to can be identified. Additionally, the shifted location of the intracranial orifice, in specific cases, can indicate the presence of other venous structures, such as marginal sinus or occipital sinus which rarely leave any visible routes on occipital bones.

The difference between radiological and morphological data for the size and prevalence of OF and PCC may be due to the CT angiography technique used. While CT angiography is a successful technique for imaging vascular structures, it does not provide reliable results for imaging of bone structures. Additionally, the discrepancy between radiological and morphological data in the present study may be due to the fact that an enlarged emissary foramen does not necessarily transmit a large EV.^[1]

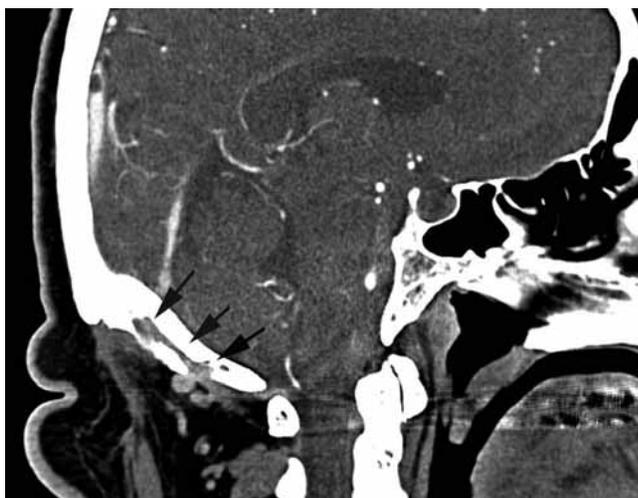


Figure 5. CT angiography of the OF, OC and OEV. A sagittal multiplanar reformatted image in a different patient demonstrates a large OEV and its canal (arrows).

In a former study on 25 dry skulls, Matsushima et al.^[6] measured the internal orifice diameter of PCC as 3.5 mm (1.8–5.4 mm), external orifice diameter 3.6 mm (2–5.6 mm), and mean PCC as length 6.8 mm (1.8–14.8 mm). These measurements are parallel to our findings, except for the mean length of PCC which was slightly higher in our study – measured as 10.85 (1.2–17.6) mm on the left and 9.82 (2.8–19) mm on the right side.

A dilated PCV can have a clinical presentation as pulsatile tinnitus.^[8] Forte et al.^[9] investigated the relation between objective tinnitus and EV flow, and reported a case of objective tinnitus associated with an abnormal mastoid emissary vein. They made a Doppler ultrasound examination of the postauricular region in 30 asymptomatic human subjects and observed PCV in 84%; no the EV flow was found here with Doppler. The prevalence of PCV found in this study was similar to ours using CT angiography, found in 87.5% of our patients. Weissman (1994) stated that recognition of the normal PCV may prevent misinterpretation of the vein as a neoplasm or an abnormal lymph node at CT or MR imaging.^[10]

Conclusion

With the availability of recent imaging techniques, it is possible to evaluate individual cases in the light of morphometric and radiological studies performed in the posterior cranial fossa. The results of this study contribute to the limited body of research on OF, PCC, PCV, and OEV, and provide useful information that will enable effective and reliable surgical interventions for pathologies of posterior cranial fossa such as tumors, condylar fractures and other injuries.

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