



The condylar canal and emissary vein—a comprehensive and pictorial review of its anatomy and variation

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Abstract

The condylar canal and its associated emissary vein serve as vital landmarks during surgical interventions involving skull base surgery. The condylar canal serves to function as a bridge of communication from the intracranial to extracranial space. Variations of the condylar canal are extremely prevalent and can present as either bilateral, unilateral, or completely absent. Anatomical variations of the condylar canal pose as a potential risk to surgeons and radiologist during diagnosis as it could be misinterpreted for a glomus jugular tumor and require surgical intervention when one is not needed. Few literature reviews have articulated the condylar canal and its associated emissary vein through extensive imaging. This present paper aims to further the knowledge of anatomical variations and surgical anatomy involving the condylar canal through high-quality computed tomography (CT) images with cadaveric and dry bone specimens that have been injected with latex to highlight emissary veins arising from the condylar canal.

Keywords Posterior condylar canal · Anatomical variation · Anatomy · Cadaver · Skull · Emissary vein

Introduction

The condylar canal serves as a vital passageway for venous circulation (condylar emissary vein) (Fig. 1) between the intracranial venous sinuses and the extracranial venous system during the embryonic period [9]. Under normal developmental patterns, the transition from fetal to neonatal circulation leads to degeneration of this venous system, which in turn closes the venous bone tunnel. The posterior entrance of the condylar canal (often referred to as the posterior condylar foramen) (Fig. 2) persists when this closure fails [9]. It is the largest emissary opening in the human skull and opens into

the posterior cranial fossa near or in the jugular fossa (Figs. 3 and 4) [2, 7, 9]. Its contents include the condylar emissary vein, which connects the sigmoid sinus or superior jugular bulb to the suboccipital venous plexus, i.e., vertebral venous plexus (Figs. 5, 6, and 7), and meningeal nerves and arteries supplying the dura mater of the posterior cranial fossa [2, 4, 6].

Herein, we discuss the anatomical variations of the condylar canal in detail, with supporting radiological images and cadaveric specimens. This review will hopefully advance our knowledge of the anatomical variations associated with this structure by providing clinicians, surgeons, and radiologists with a better tool for diagnosis and for considering surgical intervention of the skull base.

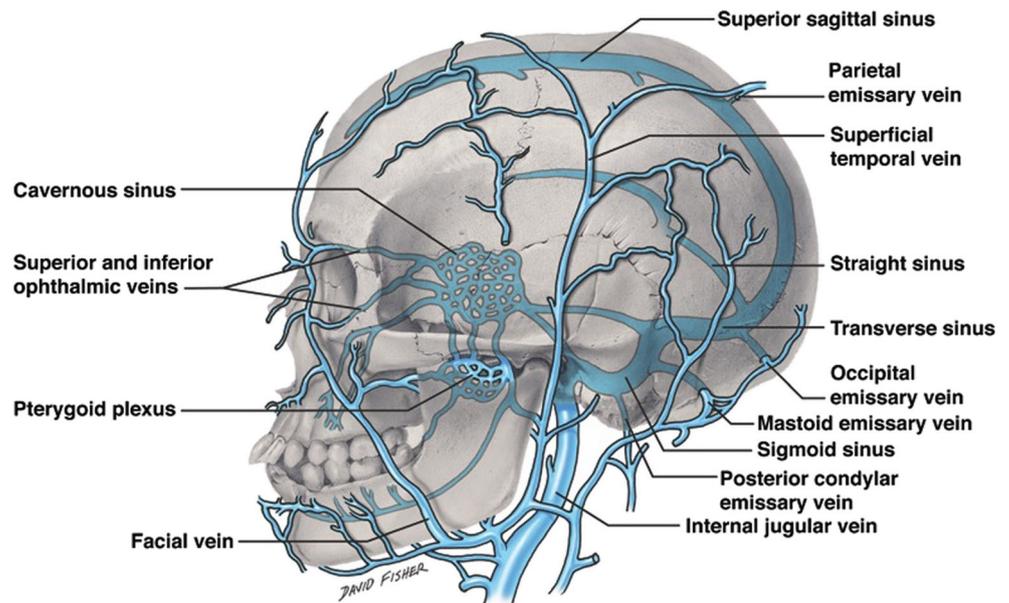
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Methods

A literature search was performed using the PubMed database with focus on articles including descriptions of the condylar canal and case reports of its variants. Cadaveric and dry bone specimens were obtained and injected with latex to highlight the emissary vein of the condylar canal. Computed tomography (CT) images were also examined to identify these structures clearly.

Fig. 1 Schematic drawing of the major emissary veins of the skull including the condylar (posterior) emissary vein highlighted in red



Discussion

Variations of the condylar canal can be bilateral or unilateral, or the structure can be absent [13]. The uncertainties arising from this variability can lead to dangerous misdiagnoses and interpretations. The presence of a condylar canal has led to misinterpretation of a glomus jugular

tumor and therefore the need for surgical intervention [3]. It not only predisposes to misdiagnosis but also to misinterpretation of the contents buried in the canal, which, particularly the vein, can be wrongly identified as pathological and therefore appears as a mass in computed tomography (CT) (Figs. 8 and 9) and magnetic resonance imaging (MRI) [10].

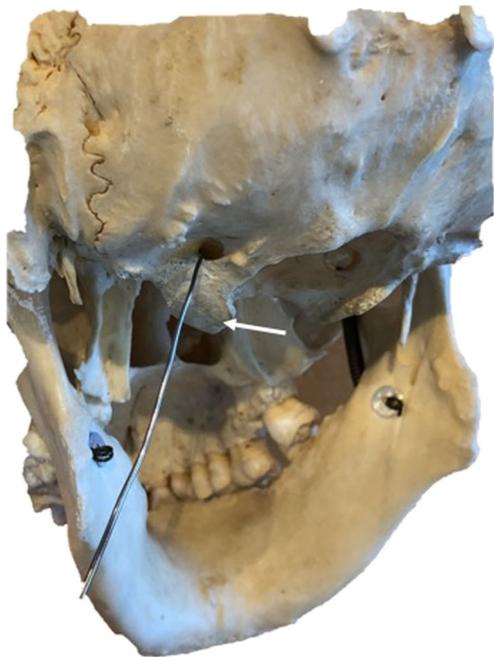


Fig. 2 Posterior view of the left condylar foramen (tip of probe). Also, note the left occipital condyle (white arrow)

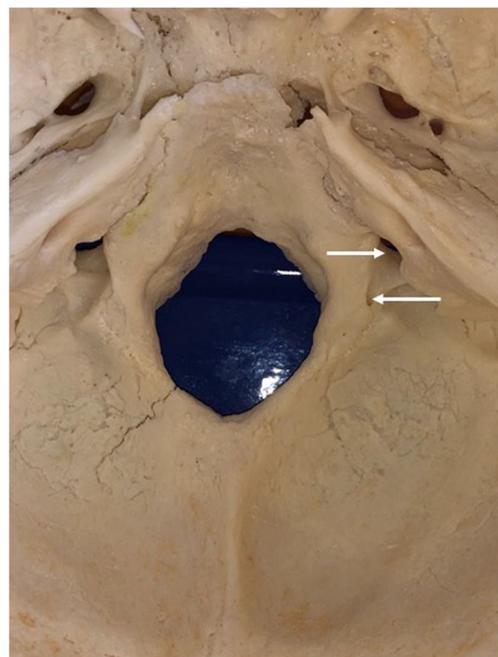


Fig. 3 Internal view of the right condylar canal opening (lower arrow) and for reference, the right jugular foramen (upper arrow)

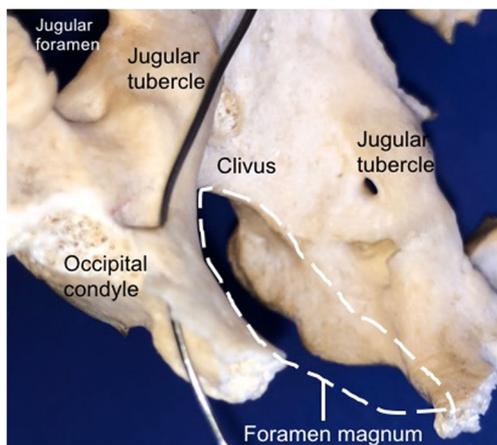


Fig. 4 Left condylar canal with probe inserted traversing it

Sadamate et al. [9] analyzed 228 dry human skulls for such variations. Among those skulls, 190 (83.33%) contained a condylar canal, and in 111 of them (48.68%) it was bilateral. In 44 (19.29%) it was present only on the right and in 35 (15.35%) only on the left. The remaining 38 (16.68%) skulls lacked a condylar canal. Ginsberg et al. [3] used both CT and gross examination of 116 patients’ skulls and found a condylar canal in 94 (81%), 36 (31%) being bilateral, 25 (21.6%) right unilateral, and 33 (28.4%) left unilateral. The structure was absent in the remaining 22 skulls (20%). Gross examination of the skulls revealed bilateral condylar canals in 19 (55.9%) and an equal distribution of right and left unilateral canals in six (17.6%). There was no condylar canal in nine skulls (26.5%). In a similar study of 50 dry human skulls by Kothandaraman and Lokanadham [7], 13 (26%) had a condylar canal, eight (16%) bilateral, two (4%) right unilateral, and three (6%) left unilateral. There was no canal in the other 24 (48%).

Fig. 5 Latex injected skull base noting a prominent left condylar vein seen through the bone (arrows)

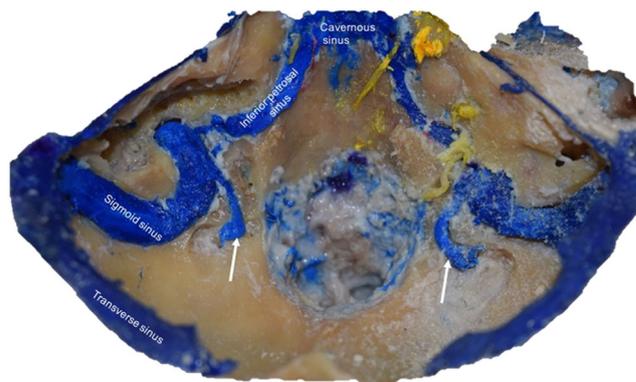


Fig. 6 Further dissection of the specimen seen in Fig. 5 after the removal of overlying bone of the occiput, i.e., the roof of the condylar canal. Note the left and right condylar veins (arrows)

In 1930, Boyd [2] mentioned that the condylar canal had received little attention in the literature. He found bilateral condylar canals in 46.6% of skulls, and right and left unilateral canals in 16.5% and 13.8%, respectively. Berge and Bergman [1] noted the condylar canal in 90 of 100 dry human skulls, 54% bilateral, and 21% and 15% right and left unilateral, respectively; the structure was absent in the other 10%. Kapakin [5] highlighted an unusual finding of a doubled right condylar canal with a single canal on the left side. Kapakin mentioned that Berge and Bergman had identified a doubling of the condylar canal in only six of the 144 foramina (posterior condylar) that were patent. A tripling of the condylar canal, reported by Berge and Bergman, was observed in only one case (< 1%) [1].

Clinical significance

Surgeons who utilize a transcondylar fossa approach for skull base surgery identify the posterior condylar canal as a vital

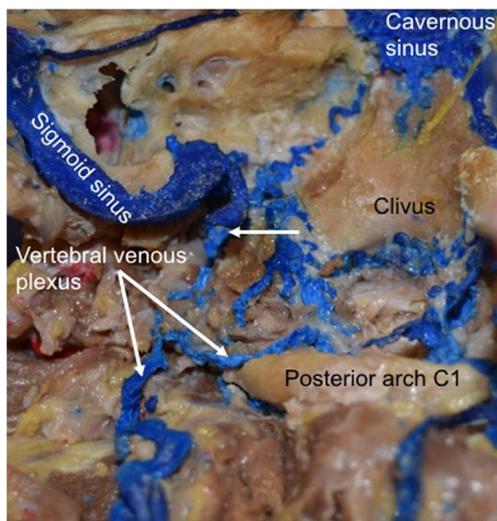


Fig. 7 Specimen seen in Figs. 5 and 6 after removal of all surrounding bone and the connections of the posterior condylar vein (arrow) with the superior jugular bulb proximally and the vertebral venous plexus distally

landmark. When surgical intervention is needed, the posterior condylar canal functions as a key landmark from the outside to allow the differentiation between the jugular tubercle occipital condyle [8]. With the potential of the posterior condylar emissary vein forming an anastomosis with either the sigmoid sinus or jugular bulb to the vertebral venous plexus, a risk is posed to surgeons during a transcondylar fossa approach [10].

Conclusion

Previous studies illustrate the variability of the condylar canal and the potential difficulty it poses to clinicians when surgical intervention is needed or radiological diagnoses are made. By

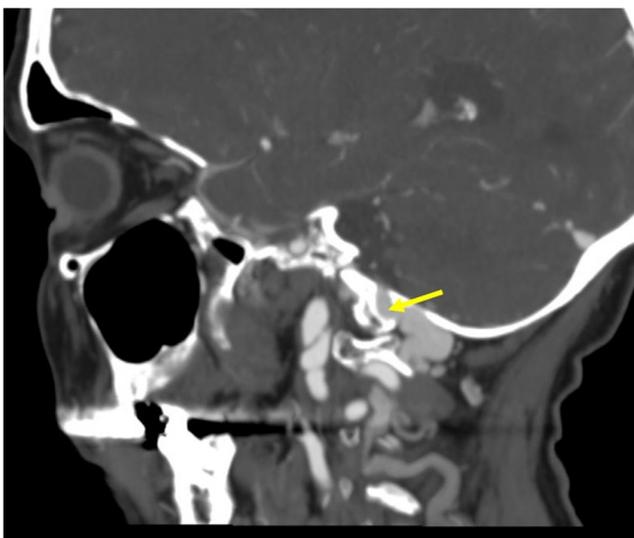


Fig. 8 CTA noting an enlarge posterior condylar vein (arrow). Courtesy Dr. Joel Curé



Fig. 9 CTA MIP noting bilaterally enlarged posterior condylar veins (arrows). Courtesy of Dr. Joel Curé

providing cadaveric specimens highlighting the posterior condylar canal and its associated emissary veins alongside CT imaging, it serves as a vital tool for surgeons. Surgical anatomy serves as fundamental for operative techniques. Skull base surgeons who operate in the posterior cranial fossa (e.g., lateral transcondylar approaches to the skull base) or suboccipital region should be aware of the normal and variant anatomy of this canal and its emissary vein.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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