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# Occipital emissary foramina in human skulls: review of literature and proposal of a classification scheme of the occipital venous anastomoses in the posterior cranial fossa

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## Abstract

**Objectives:** The present study aims to explain the interesting discrepancy between the occipital emissary foramina and the respective emissary veins in the literature. Majority of the studies report that the foramina have a low and variable frequency, but the emissary veins are reported to be disproportionately present in quite large number of patients in some diagnostic imaging studies.

**Methods:** Seventy-five adult skulls were examined for the presence of occipital foramina.

**Results:** A complete occipital emissary foramen was found only in one skull (1.33%), but a number of other skulls also showed some foramina on the external and internal surfaces of squamous part of the occipital bone.

**Conclusion:** It can be concluded that foramina of another vein which is related to the squamous part of occipital bone, the occipital diploic vein, might be the main reason for the discrepancies present in the literature. The suggested classification scheme of venous anastomoses in the posterior cranial fossa can explain the variable bony foramina observed in skull series.

**Keywords:** human; occipital emissary foramen; occipital emissary vein; skull; vein anastomoses

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## Introduction

In the textbooks of human anatomy there is an interesting discrepancy between one of the skull foramina and the respective structures contained within. According to Terminologia Anatomica,[1] the occipital emissary vein (OEV) is one of the four emissary veins, but the respective occipital emissary foramen (OEF) is not even mentioned in the textbook descriptions of occipital bone and posterior cranial fossa.[2–4] Reviewing the pertinent literature, it seems that this bony foramen in skull series shows low and quite variable frequency.[5–13] Additionally, it is demonstrated with much higher incidence in diagnostic imaging studies.[14,15] With the present study, based on examination of human skulls, and after reviewing the literature, we aimed to explain the discrepancies between the reported incidence of the OEF and OEV, which might help radiologists in diagnosing specific pathologies in the dural sinus system[14,15] and also neurosurgeons performing approaches to the posterior cranial fossa.[16]

## Materials and Methods

A total of 75 adult skulls from the bony collection available at the Department of Anatomy, Histology and Embryology of the Medical University of Sofia, Bulgaria were examined. We used, when necessary, the wire probe method for estimation of size of bony foramina as described by Boyd.[5] Most of the skulls belonged to elderly individuals (60–80-year-old). Forty four belonged to females and 31 to males. For this study, all the foramina on both inner and outer surfaces of squamous part of occipital bone and especially around the midline were recorded and analyzed. A descriptive statistical approach was used to represent the data in terms of frequency (%).

## Results

A complete OEF was found only in 1 skull belonging to a female, that makes the incidence of OEF as 2.27% for female skulls and 1.33% for the total skulls in our series. The foramen (**Figures 1a** and **b**) allowed a wire probe of 1.5 mm to pass completely through. Externally, its opening was located just on the left side of the external occipital crest at a distance of 9 mm from the border of foramen magnum. The inner aperture was in the posterior cranial fossa, slightly to the left of the midline and within the splitting formed by the lower end of the internal occipital crest. In a number of other skulls, the description of occipital foramina was more complicated (**Figures 2a–d**). In some cases, there were only visible openings from outside (6 skulls, 8%) or inside (12 skulls, 16%) of the squamous part of occipital bone, or both inner and outer openings were presented (10 skulls, 13.3%), but not connected and probably belonging to different vessels but the OEV. Passing through all of these aforementioned openings was not possible even with the thinnest wire probe. In most of the cases, the external occipital foramina (EOF) were grouped around the external occipital crest below the level of inferior nuchal line (**Figure 2a**). They were rarely found around the external occipital protuberance and even once found much higher in the midline of the upper part of the squamous part of the occipital bone (**Figure 2b**). The internal occipital foramina (IOF) (**Figures 2c** and **d**) were identified most commonly on the internal occipital protuberance or on the triangular extension of the internal occipital crest. In 42 of the skulls of our series (15 male and 27 female skulls) no foramina were identified on either the inner or outer surface of the squamous part of occipital bone. Some bony lytic defects were observed in 4 of the skulls (5.33%). The data collected from our skull series are summarized in **Table 1**.

## Discussion

Some of the skull bones contain small perforating foramina especially for the emissary veins, which connect the dural venous sinuses with the extracranial veins.[2–4] Four main emissary veins are usually described in Terminologia Anatomica,[1] including parietal emissary, mastoid emissary, condylar emissary and occipital emissary veins.

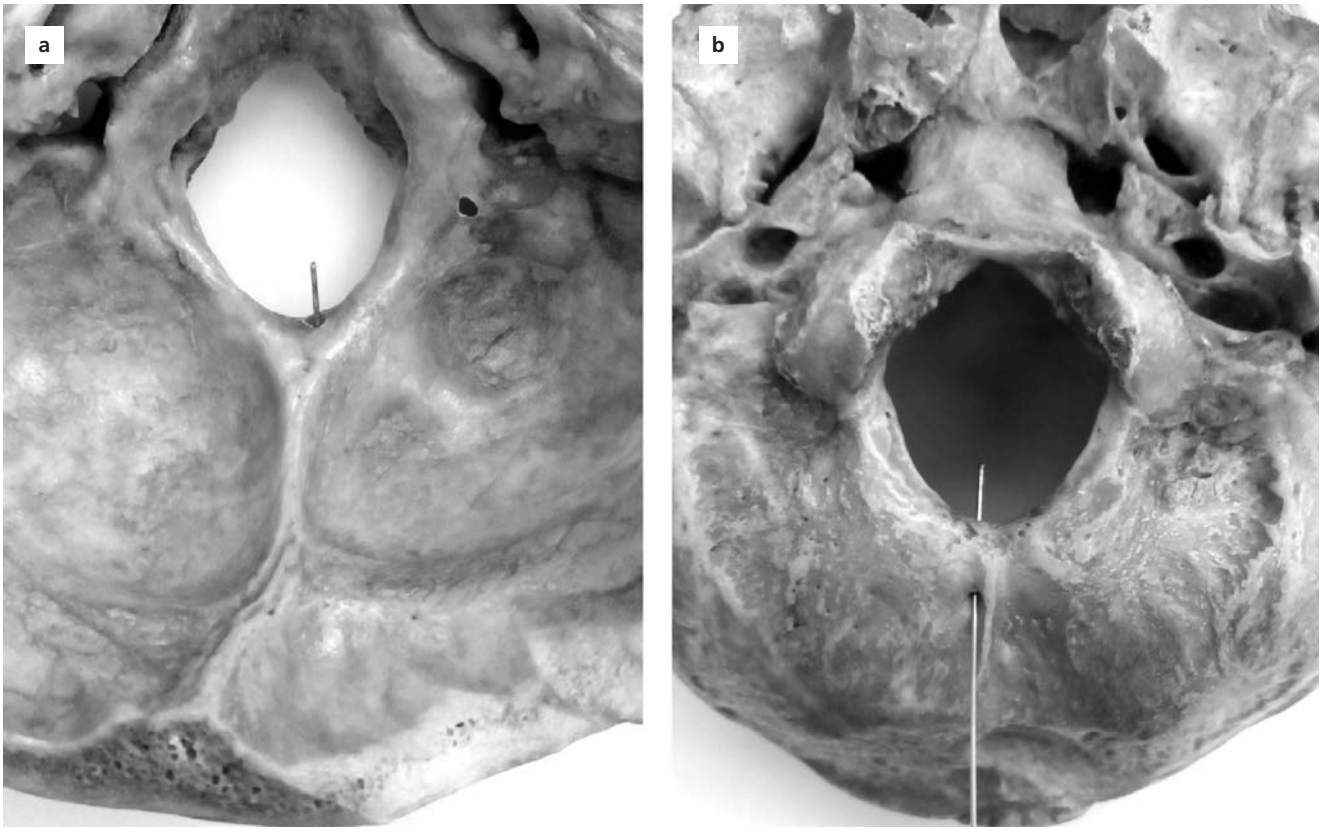


**Figure 1.** Photographs of a complete OEF with the wire probe showing the inner (**a**) and outer (**b**) openings. **OEF:** occipital emissary foramen.

Bearing in mind the morphology of the common (despite not always present) parietal and mastoid foramina and condylar emissary canal, the "emissary foramen" (or canal) should be a complete passage through the skull bone that contains a short anastomosing (emissary) vein between a dural venous sinus and an extracranial vein.

Our examinations revealed that the OEF showed a low incidence and had specific morphology. We observed that OEF is usually a single direct bony passage around the midline and close to the border of foramen magnum. One of the studies describing the lowest frequency of OEF also in a series of Bulgarian skulls was published by Kadanoff and Mutafov.[6] In this extensive study on 5000 skulls, the foramen was found only twice (0.04%) and it was called "foramen occipitale accessorium". In some other studies, the incidence of OEF was reported as 0.46% (1/214),[7] 1.6% (24/1500),[5] 2% (7/338),[8] 2.6% (8/300).[9] There are also papers describing higher incidence of complete OEF in skull series – 9.5% (21/221),[13] 14% (21/150),[10] and 14.1% (11/78).[12] If we consider higher incidence of this foramen in Indian and Bangladeshi populations,[10,12,13] then a very low frequency (0.46%) in the Indian population was also reported by Sharma et al.[7]

In a study of 100 dry skulls and 100 dissected cadaveric heads, Louis et al.[11] reported OEF in 11% (22/200), as the number of emissary foramina varied between one and three. However,the study revealed some limitations. The authors didn't demonstrate a complete emissary foramen by passing of a wire probe through the occipital bone, as reported in other skull studies.[8,9,12,13] Probably, in this study, the percentage of complete emissary foramina was increased by counting all identifiable foramina on the external surface of the occipital bone (in dry skulls) and the foramina through which a vein passes to join the occipital vein (in cadaveric heads).

The location and the route of these bony foramina were explained in some earlier studies. In a corrosion cast study describing the craniocervical venous system and the venous anastomoses in the posterior cranial fossa, OEV was found in 8.3%.[17] It was observed that the OEV was connecting confluence of sinuses (torcula) with an occipi-

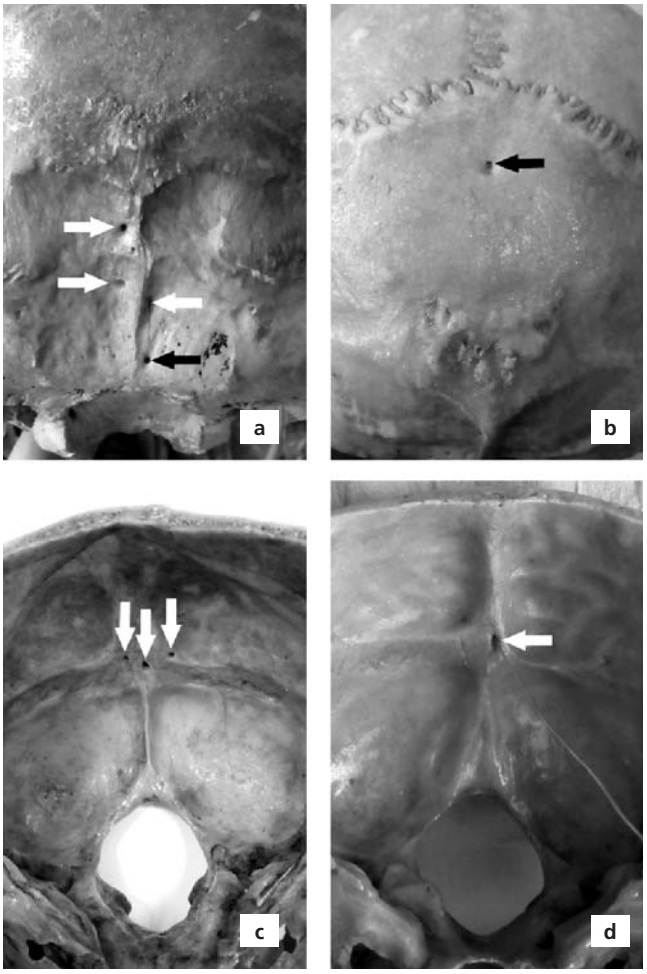


**Figure 2.** Photographs of the external (**a**,**b**) and internal (**c**,**d**) occipital foramina. (**a**) The foramina were grouped around the external occipital crest; (**b**) an external foramen in the midline in the upper squamous part of occipital bone is shown; (**c**) three foramina on the internal occipital protuberance are demonstrated; (**d**) single internal foramen.

**Table 1**
Data on 75 human skulls.

| | Male skulls | | Female skulls | | Total skulls | |
|---|---|---|---|---|---|---|
| **Bony findings** | **Number** | **Percentage** | **Number** | **Percentage** | **Number** | **Percentage** |
| Complete OEF | 0 | 0 | 1 | 2.27% | 1 | 1.33% |
| EOF | 3 | 9.68% | 3 | 6.82% | 6 | 8.00% |
| IOF | 5 | 16.13% | 7 | 15.91% | 12 | 16.00% |
| EOF+IOF | 6 | 19.35% | 4 | 9.09% | 10 | 13.33% |
| Bony lytic defects | 2 | 6.45% | 2 | 4.55% | 4 | 5.33% |
| None | 15 | 48.39% | 27 | 61.36% | 42 | 56.00% |

**EOF:** external occipital foramen; **IOF:** internal occipital foramen; **OEF:** occipital emissary foramen.

tal vein, but the precise passage through the squamous part of occipital bone was not described because all the soft tissues and bones were already dissolved.

In a MRI study on axial images, Cakmak et al.[14] reported the OEV in 28% of the cases examined. In another imaging study on subtracted CT venography and contrast enhanced MRI, Hedjoudje et al.[15] examined the OEV and reported its presence in 65.2% of the patients with increased pressure in the transverse sinus system versus 31.5% of the patients without pressure signs. Interestingly, however, the whole study is based on an identifiable occipital anastomosing vein connecting the confluence of sinuses or distal part of the superior sagittal sinus with the occipital vein. This anastomosing vein was descending intraosseously for several centimeters within the squamous part of occipital bone. The exit point of the OEV was described between the external occipital protuberance and the foramen magnum, as multiple foramina were also found in 3.2%.

The development of the OEV in human embryos was mentioned in a study by Okudera et al.,[18] and it was noted that this vein appeared occasionally from the confluence of sinuses and penetrating the occipital bone as it passes below the external occipital protuberance to join the suboccipital veins.

One of the main reasons for the discrepancies in the reported incidence of the OEF and OEV might be simply the descriptions of some bony openings for another venous systems but the emissary vein system. Basically, the OEV should connect a dural venous sinus with an extracranial vein, however, another vein is also drained here, and that is the occipital diploic vein.[2–4] In anatomy textbooks, the occipital diploic vein is described as the largest one that drains internally to the transverse sinus or confluence of sinuses or externally to the occipital vein.[2–4] Bearing in mind the great variability of the veins in the human body and lack of valves in the emissary veins,[2,3] we can speculate that actually we have three venous systems anastomosing here, including dural venous sinuses, occipital diploic vein and the extracranial occipital vein, that makes possible several variant venous patterns to exist among individuals (**Figures 3a–d**). Most importantly, the variant venous patterns will be reflecting the variable patterns of the occipital foramina on the surface of the occipital bone and will explain the direct (through the emissary vein) and indirect (through the diploic vein) connections between the dural venous sinuses and the occipital vein.

## Conclusion

In conclusion, we can identify some kind of misunderstanding between the anatomical and clinical descriptions of the OEF and OEV. From anatomical point of view, if we refer to the proposed classification system (**Figure 3d**), an OEV should rarely found having a short course andmaking a direct anastomosis through a complete OEF, which connects a dural sinus with an extracranial vein. In the imaging studies, however, even a longer intraosseous anastomosis is called as OEV,[15] although it should be

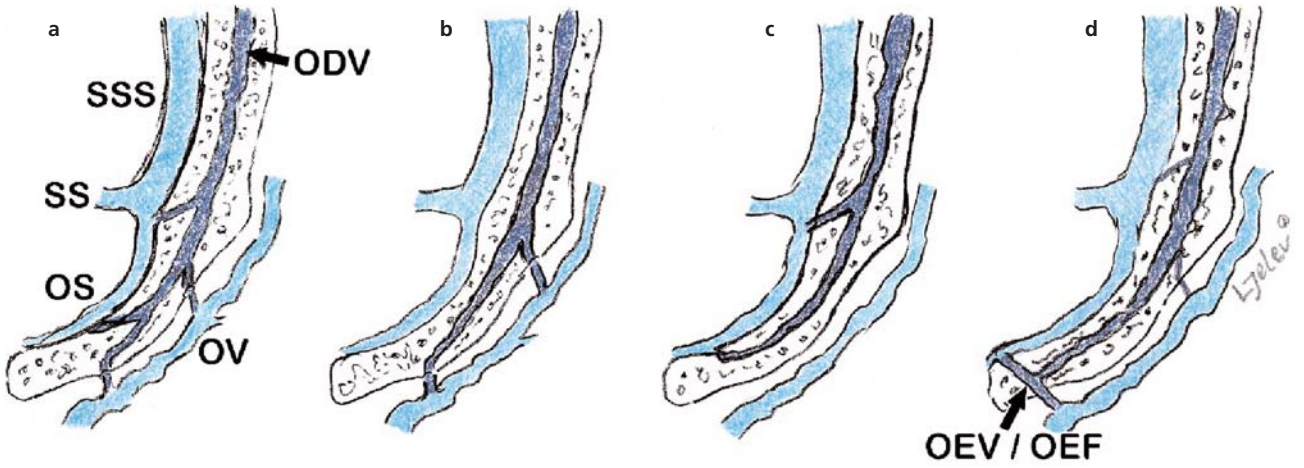


**Figure 3.** Classification scheme of the variable anastomoses between the dural venous sinuses, occipital diploic vein and extracranial occipital vein. In (**a**) the diploic vein is drained to both dural sinus and occipital vein; in our series corresponding IOF+EOF were found in 13.3% of the skulls. In (**b**) the occipital diploic vein drains only to the occipital vein through EOF (8%). In (**c**) the draining of the occipital diploic vein is only toward dural sinuses through IOF (16%). The short direct anastomosis in (**d**) is the OEV passing through OEF (1.3%). **ODV:** occipital diploic vein; **OEV:** occipital emissary vein; **OS:** occipital sinus; **OV:** occipital vein; **SS:** straight sinus; **SSS:** superior sagittal sinus.

described as an anastomosing venous channel along the occipital diploic vein. Any incomplete foramina on the midline of the inner or outer surfaces of the squamous part of occipital bone (**Figures 3a–c**) are most probably for the occipital diploic veins draining to the dural sinuses or extracranial occipital vein.

### Author Contributions

All authors equally contributed.

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