



# PRESENCE OF ACCESSORY FORAMEN: CAROTICOCALCINOID FORAMEN & FORAMEN VESALIUS IN DRY OSSIFIED HUMAN MIDDLE CRANIAL FOSSA

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## Abstract:

**Background:** Accessory foramina of the middle cranial fossa are clinically significant anatomical variants that may alter neurosurgical approaches and radiological interpretations. Among these, the caroticoclinoid foramen (CCF) and foramen Vesalius (FV) are of considerable importance because of their close relationship with the cavernous sinus, internal carotid artery, trigeminal ganglion, and emissary venous channels. The caroticoclinoid foramen occurs due to the ossification of the caroticoclinoid ligament or dural fold stretching between the anterior and middle clinoid processes. The small foramen of Vesalius occurs in approximately 20% of skulls; it is consistently symmetrical and lies anteromedial to the foramen ovale, lateral to the foramen rotundum, and adjacent to the vidian canal. This foramen transmits an emissary vein, through which the cavernous sinus and pterygoid plexus communicate. The presence of the emissary vein in this foramen is significant for transmitting sepsis from extracranial veins to intracranial venous sinuses, as well as in neurosurgical techniques such as radiofrequency rhizotomy.

**Objective:** The caroticoclinoid foramen may complicate clinoidectomy procedures. Therefore, detailed anatomical knowledge of the region is necessary to obtain satisfactory results from these surgeries. An anatomical study of the foramen of Vesalius contributes not only to the anatomical knowledge of this structure, but also to clinical situations involving this foramen.

**Materials & Methods:** A cross-sectional, analytical study was conducted in the Department of Anatomy of Dhaka Medical College, Dhaka, from January 2011 to December 2011. The study materials consisted of 117 (one hundred and seventeen) dry ossified human middle cranial fossa.

**Results:** The caroticoclinoid foramen was present in 4% of cases on both sides, respectively. Foramen Vesalius was present in 27% on the right side and 30% on the left side.

**Conclusion:** Accessory foramina of the middle cranial fossa, particularly the foramen Vesalius, are relatively common. Awareness of these anatomical variations is essential for anatomists, neurosurgeons, ophthalmologists, and radiologists to ensure accurate diagnosis and to reduce complications during skull base surgery.

## Keywords:

Caroticoclinoid foramen, Foramen of Vesalius, Middle cranial fossa

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## Introduction

The caroticoclinoid foramen is located in the middle cranial fossa, and related medial to the anterior clinoid

process (ACP) and lateral to the tuberculum of the sella turcica. It was also located posterior to the optic canal and anterior to the pituitary fossa.<sup>1</sup> The ACP is

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formed by the medial end of the lesser wing of the sphenoid bone. The ACP provides attachment to the free margin of the tentorium cerebelli and is grooved medially by the internal carotid artery.<sup>2</sup> Sometimes, the ACP is joined to the middle clinoid process (MCP) by the ossified caroticoclinoid ligament (CCL). A dural fold extends between the ACP and MCP, or ossification of the CCL may result in the formation of the caroticoclinoid foramen (CCF),<sup>1</sup> thereby taking part in an opening (caroticoclinoid foramen) for the internal carotid artery.<sup>3</sup> In neurosurgical operations, to enter the clinoid space, the ACP is usually accessed.<sup>4</sup> After leaving the cavernous sinus, the internal carotid artery is related medially to the ACP. An ossified CCL may compress the internal carotid artery. By removing abnormal variations of ACP during regional surgical procedures, a risk may be posed.<sup>4</sup>

The clinoidal segment, one of six segments of the internal carotid artery, passes through this foramen.<sup>5</sup> In clinical practice, when a paraclinoid aneurysm occurs, the anterior clinoid process is removed as treatment for this condition.<sup>4</sup> This treatment is more difficult when the caroticoclinoid foramen is present, causing a higher possibility of serious bleeding in this region.<sup>5</sup> Radiologists can differentiate the caroticoclinoid foramen from the optic canal by using radiologic films.<sup>5</sup>

Radiological studies on the caroticoclinoid foramen and its differentiation from the optic canal may be clinically important for neurosurgeons, ophthalmologists, and radiologists.

Foramen Vesalius is a small, variable, and inconstant foramen located anteromedial to the foramen ovale and lateral to the foramen rotundum. It is also known as the emissary sphenoidal foramen. It transmits an emissary vein, 'Vein of Vesalius', connecting the cavernous venous sinus and pterygoid venous plexus, thus communicating extracranial veins and intracranial veins.<sup>6</sup> Thus, a septic thrombus of extracranial origin may reach the cavernous sinus and develop a thrombophlebitis.<sup>7</sup> The neurosurgical importance of the foramen Vesalius is highlighted during percutaneous trigeminal rhizotomy; needle insertion through this foramen may puncture the cavernous sinus.<sup>6</sup> The neurosurgical procedure for the treatment of trigeminal neuralgia is performed through the foramen ovale. While approaching this foramen, the needle for microvascular decompression can be misplaced into the foramen Vesalius due to the proximity of these

two foramina. The consequent puncture of the cavernous sinus can produce serious complications.<sup>8</sup>

The foramen Vesalius is usually symmetric, and asymmetry of the foramen Vesalius can be seen with invasion by nasopharyngeal melanoma, angiofibroma, or carotid cavernous fistula with drainage through the emissary vein. Therefore, knowledge about the symmetry and incidence of the foramen of Vesalius is not only important from an anatomical point of view but is also essential for the operating surgeon.<sup>6</sup>

Disease processes (e.g., a perineural tumor) cause pathologic changes in the size or shape of the skull foramina.<sup>9</sup> Anatomical awareness of variations in the middle cranial fossa is important for the radiologist who interprets imaging for this area and for neurosurgeons who operate in the vicinity of the cavernous sinus.<sup>10</sup>

Advancements in radiologic techniques, such as magnetic resonance imaging and computed tomography, are aiding in the difficult diagnosis of pathologic conditions of skull foramina.<sup>9</sup> Information on foramina variants of the human skull provides insight into associations between neurovascular anatomy and cranial morphology.<sup>11</sup> Knowledge of possible variations will help distinguish normal from abnormal structures during computed tomography and magnetic resonance imaging examinations, thereby avoiding misinterpretations that can lead to confusion during surgical interventions.<sup>12</sup>

### Materials and Methods

The study materials consisted of 117 (one hundred and seventeen) dry, ossified human bases of skulls with intact middle cranial fossa. The bases of skulls were collected from the Department of Anatomy of Dhaka Medical College and other government and non-government medical colleges in Dhaka city. Broken, fractured, or missing any part of the middle cranial fossa of the bases of skulls was excluded from the study. Then, the results were compared between the right and left middle cranial fossa.

The caroticoclinoid foramen was studied in dry human skulls, observing various parameters, including completeness, unilateral or bilateral, and recording these findings during morphological examination.<sup>5</sup> The presence of the foramen Vesalius was observed and recorded during morphological examination. To identify the presence of the foramen Vesalius, the posterior part of the greater wing of the sphenoid was examined

for any foramen between the foramen rotundum and the foramen ovale.<sup>6</sup>

**Ethical clearance**

The Ethical Review Committee of Dhaka Medical College, Dhaka, approved the study.

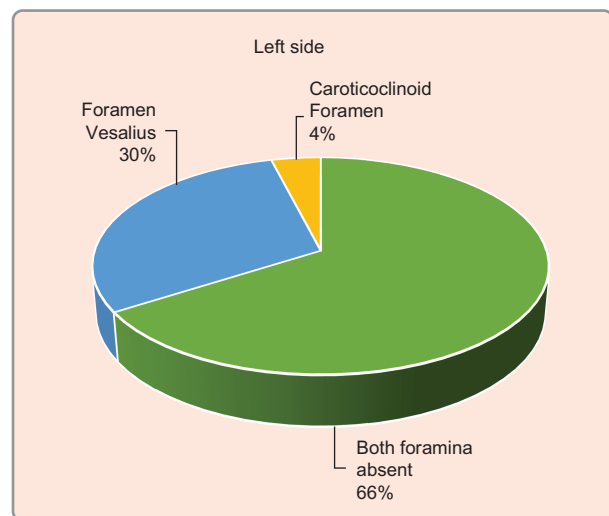
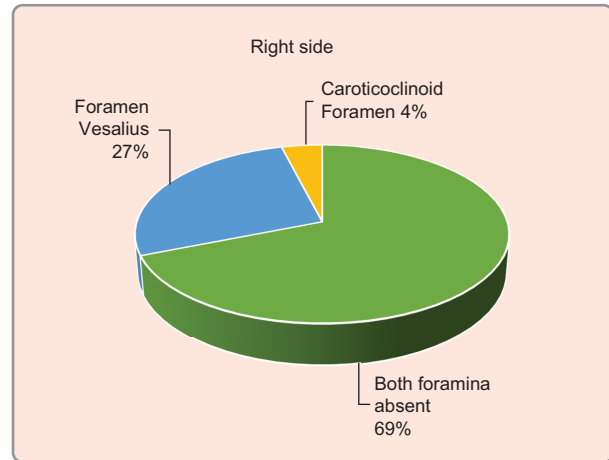
**Results:** The present study was conducted on 117 human dry ossified middle cranial fossa. The caroticoclinoid foramen was present in 4% of cases on both sides, respectively. Foramen Vesalius was present in 27% on the right side and 30% on the left side.



**Figure 1:** Photograph showing the caroticoclinoid foramen (arrow marked).



**Figure 2:** Photograph showing the foramen Vesalius (arrow marked).



**Figure 3:** Presence of the foramen Vesalius and the caroticoclinoid foramen in the right and left middle cranial fossa.

**Discussion**

The present work was undertaken to study various morphometric variables in 117 (one hundred and seventeen) dry ossified human middle cranial fossa. The findings of this study were statistically analyzed and revealed important information regarding morphometric variations of the right and left middle cranial fossa. A comparative discussion of the results with those of other authors abroad is presented below. In the present study, human skulls were collected from different medical colleges in Bangladesh. The base of the skull collected for the present study may or may not be from Bangladeshi people, because medical students using the skeleton for their studies also come from neighboring countries. The majority of Bangladeshis are ethnolinguistically Bengalis, a

**Table-I**

*Presence of the foramen Vesalius and caroticoclinoid foramen in the right and left middle cranial fossa:*

Presence	Right No. (%)	Left No. (%)
Foramen Vesalius (n=117)	32 (27)	35 (30)
Caroticoclinoid Foramen (n=117)	5 (4)	5 (4)

group of Indo-Aryan people. Ethnic minorities in Bangladesh include the Tibeto-Burman, Chakma, Austroasiatic, and Dravidian peoples.<sup>13</sup> There are five races in the Brazilian population: Branco, Pardo, Amarelo, Preto, and Indigenus.<sup>14</sup> A large number of racial subgroups and interracial mixtures are present in Nepal. Chhetri is the largest group of the total population, followed by the Brahmins in Nepal.<sup>15</sup> The Indo-Aryans, Dravidians, Sino-Tibetans, Austroasiatic people, and various indigenous tribes are the Indian major ethnic groups.<sup>16</sup> Polish are the main ethnic group in Poland.<sup>17</sup> The results of the study were compared with the studies carried out by different researchers who used the base of skulls of Brazilian, Nepalese, Indian and Polish.

The results of morphological variables showed both similarities and dissimilarities with the available information in the publications. Similarities may be due to the same race, while dissimilarities may be attributed to racial variation.

An author<sup>5</sup> carried out a study using 80 dry Brazilian skulls and found that the incidence of skulls with at least one caroticoclinoid foramen was 8.5%. Among these, 8.5% were on the right side and 2.5% on the left; 2.5% of the skulls had bilateral foramina, and 6.25% had unilateral caroticoclinoid foramina.

The famous book "De Humani Corporis Fabrica" stated that there was a similarity between the unilateral right and left foramen Vesalius.<sup>6</sup> A study of 70 sides of 35 dried Nepalese skulls found that foramen Vesalius was present in 23 sides (14 right, 9 left) out of the 70 sides observed, the incidence being 32.85% (20.0% right side, 12.85% left side) of all the sides observed. The incidence of bilateral and unilateral foramen Vesalius was 22.85% (8 out of 35 skulls) and 20% (7 out of 35 skulls), respectively.<sup>6</sup>

An author<sup>7</sup> worked on 80 dried human Brazilian skulls, the results demonstrated a total incidence of 40% foramen Vesalius, 13.75% skulls with the bilateral presence of the foramen, 26.25% skulls with the unilateral presence of the foramen, 31.25% skulls with foramen only of the right side, 22.50% skulls with foramen only of the left side.

A study of Indian skulls found that the foramen Vesalius was present in 90 (60%) of 150 observed skulls. The incidence was 41 (27.33%) on the right side and 49 (32.67%) on the left side. The foramen Vesalius was present unilaterally in 32 (35.56%) and bilaterally in 29 (32.23%) of 90 skulls.<sup>8</sup> A study on 100 macerated skulls of Poland reported that the foramen Vesalius was present in 17% of cases and was always single.<sup>18</sup>

Foramen Vesalius was bilateral in 35%, unilateral in 24% and absent in 41% of skulls, as cited in a study.<sup>9</sup> Another study<sup>9</sup> found that the foramen Vesalius was present on both sides in only 14.7% of skulls and absent on both sides in 64.5%. It was presented unilaterally in 21.8% (10.6% on the right and 11.2% on the left). A double foramen was also found in one skull.

The observed incidence of the caroticoclinoid foramen in this study is lower than that reported in some Brazilian and Indian populations but comparable to findings from other regional studies.<sup>6-9</sup> Such variation across populations may reflect ethnic, genetic, or developmental differences. Clinically, the presence of an ossified caroticoclinoid ligament forming a complete foramen may pose challenges during anterior clinoidectomy and increase the risk of internal carotid artery injury.

The foramen Vesalius demonstrated a higher frequency than the caroticoclinoid foramen, consistent with previous reports from Nepalese and Indian studies. Its close proximity to the foramen ovale makes it particularly significant during percutaneous trigeminal procedures, where inadvertent cannulation may lead to cavernous sinus injury or intracranial infection through emissary veins.<sup>8-12</sup>

During Neurosurgical procedure, the caroticoclinoid foramen may complicate anterior clinoidectomy, cavernous sinus surgery, and aneurysm clipping. The foramen Vesalius is important during percutaneous trigeminal rhizotomy because inadvertent cannulation may injure the cavernous sinus.

On radiological perspectives, High-resolution CT and MRI help identify accessory foramina and prevent misdiagnosis of pathological lesions or fractures.

Although the present study was limited to dry skull examination without radiological or morphometric correlation, the findings reinforce the importance of recognizing accessory foramina as normal anatomical variants rather than pathological entities. Accurate identification can prevent misinterpretation in imaging and reduce intraoperative complications.

Further studies incorporating radiological evaluation and larger sample sizes are recommended to better correlate anatomical variations with clinical outcomes.

### Conclusion

If a CCF is present, it is likely to cause compression of the internal carotid artery. Radiological studies on the CCF and its differentiation from the optic canal may be clinically important for radiologists and ophthalmologists. Knowledge about the CCF is also beneficial for skull surgeons. The present study may be particularly relevant

to neurosurgeons and radiologists in their day-to-day clinical practice. The analysis of the foramen Vesalius could be important for anatomists and equally essential for clinicians who approach the middle cranial cavity for various procedures.

### Limitations of the study

The study is limited by its cross-sectional design. The size of the caroticoclinoid foramen and the foramen Vesalius was not evaluated. Articles from studies conducted in Bangladesh were not available, so they could not be compared with existing resources, which may aid in gathering more data for further research in clinical applications. Studies with a larger sample size can help guide anatomists, neurosurgeons, ophthalmologists, and radiologists in adopting appropriate plans for the diagnosis and treatment of their respective fields.

**Conflict of interest:** None to declare.

**Ethical approval:** The Ethical Review Committee of Dhaka Medical College, Dhaka, approved the study.

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