Awareness of Foramina of the Head.

[1]Dr. Mrs. S.A. Shedge, [2]Dr. M. M. Thorat, [3]Dr. Mrs. S. D. Kadam,

[1]Associate Professor, Department of Anatomy, Krishna Institute of Medical Sciences, Karad, Maharashra

[2]Associate Professor, Department of Anatomy, Krishna Institute of Medical Sciences, Karad, Maharashra

[3]Associate Professor, Department of Anatomy, Krishna Institute of Medical Sciences, Karad, Maharashra

Abstract

The base of the skull is divided into the anterior, middle and posterior fossae. The anterior cranial fossa includes the frontal and ethmoid bones. The anterior cranial fossa houses the cerebral hemispheres' frontal lobes. “It helps cranial nerve (CN) I fibers flow through the cribriform plate foramina”. The anterior and posterior ethmoidal foramina are openings for ethmoidal arteries, nerves, and veins. Our research aims to describe all human skull openings (cranial foramina). These foramina may not resemble the genuine neurovascular pathways produced within a single bone, but they do. There is still much to understand about the developmental differences between the two foramina, anatomical changes, and different skulls for different skull fracture processes. With further research, we can understand these elements and their clinical effects.

Keywords: Foramina**,** Anterior, Middle, Posterior Fossae**,** Cranial Nerve.

INTRODUCTION

The bone structures of the human skull and skull base are the most intricate. In addition to the numerous intracranial structures, they must offer multiple pathways for arteries, veins, and nerves to access and depart the brain. “Foramina provide passage for neurovascular structures inside a single bone”.[1] “The three sections that make up the base of the skull are the anterior, middle, and posterior fossas. The thinner wings of the sphenoid bone partially define the posterior margins of the anterior skull base”.[2] The frontal and ethmoid bones are found in the anterior cranial fossa. The frontal lobes of both cerebral hemispheres reside in the anterior cranial fossa, a depression at the front of the skull. This also facilitates the passage of cranial nerve (CN) I fibers through the cribriform plate foramina. “The anterior and posterior ethmoidal foramina are designated openings for transporting ethmoidal arteries, nerves, and veins”.[2]

“The middle cranial fossa is formed by the occipital, sphenoid, and temporal bones, with the body of the sphenoid bone serving as its anterior boundary and the basilar part of the temporal bone serving as its posterior border”.[3] Among the various foramina and fissures of the middle cranial fossa are the carotid canal, optic foramen (canal), superior orbital nerve, foramen rotundum, foramen ovale, foramen spinosum, foramen lacerum, and the hiatuses of the greater and smaller petrosal nerves. “The internal carotid artery (ICA), as well as numerous smaller arteries, nerves, and capillaries, as well as CN II–CN VI and their principal branches, pass via these channels”.[2]

The posterior skull base is made up of the sphenoid, temporal, and occipital bones, as well as the cerebellum, pons, and medulla oblongata. The anterior characteristics of the posterior cranial fossa include the dorsum sellae, the body of the sphenoid, and the boundary of the occipital bone's basilar portion.[4] “The foramen magnum is the most visible aperture in the posterior cranial fossa. The spinal cord as well as the spinal and vertebral arteries make use of this particle aperture.The medulla oblongata spreads downward from this aperture as well”.[5] “The spinal branch of the auxiliary nerve travels through the foramen in question. The internal acoustic meatus, jugular foramen, and hypoglossal canal are all important pathways for the internal jugular vein and cranial nerves VII–XII. The orbitomeningeal, retromolar, and sphenoidal emissary foramina are examples of foramina that may be found in the skull”.[1]

Skull location	Name	Surrounding bones	Contained structures
Anterior	Foramen cecum	Frontal, ethmoid	Emissary vein
	Sphenopalatine foramen	Sphenoid, palatine	Sphenopalatine artery and vein, posterior superior lateral nasal nerve, nasopalatine nerves
	Palatovaginal canal	Sphenoid, palatine	Pharyngeal branch of maxillary artery, pharyngeal nerve
	Vomerovaginal canal	Sphenoid, vomer	None
Middle	Foramen lacerum	Sphenoid, temporal, occipital	Meningeal branch of ascending pharyngeal artery, greater petrosal nerve, deep petrosal nerve, vidian nerve
	Superior orbital fissure	Sphenoid	Cranial nerve III–VI branches, ophthalmic veins, branches of middle meningeal and lacrimal arteries
	Inferior orbital fissure	Sphenoid, maxilla, zygomatic bone	Cranial nerve V branches, infraorbital artery
Posterior	Jugular foramen	Temporal, occipital	Inferior petrosal sinus, sigmoid sinus, cranial nerve IX–XI, meningeal branches of ascending pharyngeal artery and occipital arteries

TABLE 1 : FORAMINA AT BASE OF SKULL. [1]

Bone	Cranial fossa	Foramina	Number	Vessels	Nerves
frontal	-	**supraorbital foramen**	2	supraorbital artery supraorbital vein	supraorbital nerve
frontal	anterior cranial fossa	**foramen cecum**	1	emissary veins to superior sagittal sinus from the upper part of the nose[3]	
ethmoid	anterior cranial fossa (osama)	**foramina of cribriform plate**	~20	-	olfactory nerve bundles (I)
ethmoid	anterior cranial fossa	**anterior ethmoidal foramen**	2	anterior ethmoidal artery anterior ethmoidal vein	anterior ethmoidal nerve
ethmoid	anterior cranial fossa	**posterior ethmoidal foramen**	2	posterior ethmoidal artery posterior ethmoidal vein	posterior ethmoidal nerve
sphenoid	-	**optic canal**	2	ophthalmic artery	optic nerve (II)
maxilla	-	**infraorbital foramen**	2	infraorbital vein, tributary of pterygoid plexus	infraorbital nerve
sphenoid	middle cranial fossa	**foramen ovale**	2	accessory meningeal artery, emissary vein connecting cavernous sinus with pterygoid plexus	mandibular nerve (V_3) lesser petrosal nerve (occasionally)[3]
sphenoid	middle cranial fossa	**foramen spinosum**	2	middle meningeal artery	meningeal branch of the mandibular nerve (V_3)
sphenoid	middle cranial fossa	**foramen lacerum**	2	artery of pterygoid canal, Meningeal branch of ascending pharyngeal artery, emissary vein	nerve of pterygoid canal through its anterior wall
temporal	middle cranial fossa	**carotid canal**	2	internal carotid artery	internal carotid plexus, sympathetics from the superior cervical ganglion
temporal	posterior cranial fossa	**internal acoustic meatus**	2	labyrinthine artery	facial nerve (VII), vestibulocochlear nerve (VIII)
temporal	posterior cranial fossa	**jugular foramen**	2	internal jugular vein, inferior petrosal sinus, sigmoid sinus	glossopharyngeal nerve (IX), vagus nerve (X), accessory nerve (XI)

sphenoid	middle cranial fossa	**superior orbital fissure**	2	superior ophthalmic vein	oculomotor nerve (III) trochlear nerve (IV) lacrimal, frontal and nasociliary branches of ophthalmic nerve (V_1) abducent nerve (VI)
sphenoid	middle cranial fossa	**foramen rotundum**	2	-	maxillary nerve (V_2)
maxilla	-	**incisive foramen/canal/Stenson/Scarpa**	4	terminal branch of descending palatine artery	Terminal part of[3] nasopalatine nerve (V2)
palatine	-	**greater palatine foramen**	2	greater palatine artery greater palatine vein	greater palatine nerve
palatine and sphenoid	-	**foramen sphenopalatinum**	2	sphenopalatine artery sphenopalatine vein	nasopalatine nerve rami nasales posteriores superiores (V2)
palatine and maxilla	-	**lesser palatine foramina**	4	lesser palatine arteries lesser palatine vein	lesser palatine nerve, greater palatine nerve[3]
sphenoid and maxilla	-	**inferior orbital fissure**	2	inferior ophthalmic veins infraorbital artery infraorbital vein, tributary of pterygoid plexus	zygomatic nerve and infraorbital nerve of maxillary nerve (V_2) orbital branches of pterygopalatine ganglion
temporal	posterior cranial fossa	**stylomastoid foramen**	2	stylomastoid artery	facial nerve (VII)
occipital	posterior cranial fossa	**hypoglossal canal**	2	-	hypoglossal nerve (XII)
occipital	posterior cranial fossa	**foramen magnum**	1	anterior and posterior spinal arteries, vertebral arteries	lowest part of medulla oblongata, three meninges, ascending spinal fibers of accessory nerve (XI)[3]
occipital	posterior cranial fossa	**condylar canal**	1	occipital emissary vein, meningeal branch of occipital artery	

TABLE 2: LIST OF FORAMINA OF HEAD.[6]

DEVELOPMENTAL DIFFERENCES AND SIMILARITIES

The neural crest , mesoderm and Intramembranous and endochondral ossification are needed for skull creation.[7] The occipital bone is endochondral mesodermal in origin, unlike the intramembranous neural crest palatine and maxillary bones.[8] As a result, the maxillary bone forms the infraorbital fissure, and the occipital bone forms the jugular foramen. These "false" foramina are the result of these bones' ossification patterns. For diverse ossification patterns, the foramen lacerum forms in the endochondral bones[9]. The hypoglossal canal and the palatine foramina of the occipital bone have "true" ossification patterns. The hypoglossal canal of the occipital bone and the palatine foramen of the palatine bone are also excellent examples. Previous studies have shown that the envelopment of the enclosed blood vessel by mesenchymal tissue is critical in the early development of the jugular foramen and hypoglossal canal in chick embryo models.[8]

The mesenchyme exhibits a lower density in comparison to the adjacent mesenchymal tissue, thereby resulting in the development of cartilage in non-foraminal bone. Consequently, mesenchymal cells located in close proximity to blood vessels and nerves experience morphological changes that bear a resemblance to those of perichondral cells. “It is worth mentioning that the jugular "false" foramen and the hypoglossal "true" foramen exhibit dissimilarities, specifically with regards to their adherence to the enclosed blood vessel”.[1] However, the therapeutic significance of this distinction has received limited attention in existing research. The ongoing discourse centers on the primary factor that governs the formation of foramina, namely whether it is vasculature, neural structures, or a combination of both.

Further investigation could provide understanding regarding the developmental disparities between "authentic" and "spurious" foramina. “Enhanced comprehension of the discipline of embryology could potentially lead to an enhanced understanding of individuals who possess a susceptibility to the emergence of stenosis in diverse skull base foramina, including those afflicted with achondroplasia and stenosis or constriction of the jugular foramen”.[1]

FRACTURES IN HUMAN HEAD INCLUDING FORAMINA

Because of the intricacies of their anatomy and symptoms, skull base injuries are notoriously difficult to treat. The orbit is a common location for fractures due to its relative weakness.[10] “Superior orbital fissure syndrome is caused by a ruptured superior orbital fissure. Diplopia, extraocular muscular weakness, exophthalmos, and ptosis are just a few of the common symptoms”.[11] “A crush injury and fracture of the petrous part of the temporal bone may result in a substantial foramen lacerum deformity”.[12] The temporal bone apex may flex inward, whereas the petrous part of the temporal bone avulses rearward.

The neighboring ICA as well as other buildings are in jeopardy. Because CN VI may be stretched, abducens nerve palsy is common in those who have fractures in this location.[1]

Fractures occurring at the posterior skull base are relatively infrequent; however, they can be recognized when patients exhibit deficiencies in various cranial nerves.[13] Fractures of the jugular foramen that manifest with deficits in the lower cranial nerves have been documented in cases where there is an occipital bone fracture, leading to either direct nerve injury or delayed oedema caused by ischaemia.[14] An occiput fracture induced by a significant blow to the head may sometimes traverse the temporal bone from the jugular foramen to the foramina spinosum and the foramen magnum. Injuries to structures that traverse a "true" foramen of the skull base are 15 times more likely to result from skull fractures than from a "false" foramen. “This is due to the fact that fractures are less likely to traverse a foramen that is formed between two adjacent bones unless there is a considerable blunt force trauma to the area that affects multiple bones. Consequently, the neurovascular structures encompassed within these conduits are comparatively safe”.[1]

DISORDERS OF BONE AND CARTILAGE IN HUMAN HEAD

“Paget's disease (PD) is a chronic skeletal disorder that has the potential to harm the cranial bones and stands out for having an accelerated rate of cellular turnover”.[16] The thickening of the skull, whether localized or widespread, along with the presence of osteoporotic lesions in scattered areas, are frequently observed symptoms of Parkinson's disease in the cranial region.[17] Hearing loss has been identified as the predominant neurological symptom associated with sclerosis.[18] The observed phenomenon can be attributed to a reduction in bone mineral density within the cochlear capsule as opposed to a constriction of the internal auditory meatus (stenosis). As far as current knowledge is concerned, there have been no reported instances of foramina constriction in the skull caused by Parkinson's disease being deemed "false". The occurrence of neuropathy in association with optic canal sclerosis.[19]

“Considering that intramembranous and endochondral ossification processes contribute to the development of "true" and "false" foramina, it appears improbable that cartilaginous disorders would exhibit a selective impact on either type of foramen”.[1] For instance, Foramenaga's disease (PD) is a persistent skeletal ailment distinguished by an overabundance of cellular regeneration, which could potentially impact the cranial bones.[16] Achondroplasia is a medical condition that hinders the complete ossification of cartilage. The thickening of the skull in localized or widespread areas and the presence of osteoporotic lesions in scattered regions are frequently observed symptoms of Parkinson's disease in the skull.[17] Hearing loss is the prevailing neurological symptom linked with sclerosis.[18] “The observed phenomenon can be attributed to a reduction in bone mineral density within the cochlear capsule as opposed to a constriction of the internal auditory meatus (stenosis). To the best of our knowledge, there have been no reported instances of foramina constriction in the skull caused by Parkinson's disease that have been deemed "false". Nevertheless, there have been reports of neuropathy linked to optic canal sclerosis”.[19]

CONCLUSION

Through our research, we try to provide a comprehensive description of all the openings in the human skull (cranial foramina). These foramina may not be a perfect match to the true neurovascular pathways formed inside a single bone, but they do resemble them. There is still much to learn about the developmental variations between the two foramina, anatomical alterations, and distinct processes for skull base fracture. However, with continued research, we can gain a better understanding of these factors and their clinical implications.

REFERENCE

1. Werner C, Mathkour M, Koueik J, Aysenne A, Loukas M, Iwanaga J, Dumont AS, Tubbs RS. “False” foramina and fissures of the skull: a narrative review with clinical implications. Folia Morphologica. 2021 Jun 29.
2. Standring S. Gray’s Anatomy 42nd ed. Standring S.(2020).
3. Linn J, Peters F, Moriggl B, Naidich TP, Brückmann H, Yousry I. The jugular foramen: imaging strategy and detailed anatomy at 3T. American Journal Of Neuroradiology. 2009 Jan 1;30(1):34-41.
4. Skrzat J, Walocha J, Zawiliński J. Accessory spine of the foramen ovale. Folia Morphologica. 2012;71(4):263-6.
5. Ulcay T, Kamaşak B, Görgülü Ö, Uzun A, Aycan K. A golden ratio for foramen magnum: an anatomical pilot study. Folia Morphologica. 2022;81(1):220-6.
6. Chaurasia BD. Human anatomy. New Delhi, India: CBS Publisher; 2004.
7. Macchi V, Regoli M, Bracco S, Nicoletti C, Morra A, Porzionato A, De Caro R, Bertelli E. Clinical anatomy of the orbitomeningeal foramina: variational anatomy of the canals connecting the orbit with the cranial cavity. Surgical and Radiologic Anatomy. 2016 Mar;38:165-77.
8. McGonnell IM, Akbareian SE. Like a hole in the head: Development, evolutionary implications and diseases of the cranial foramina. InSeminars in Cell & Developmental Biology 2019 Jul 1 (Vol. 91, pp. 23-30). Academic Press.
9. Singh R, Kumar R. Variations in the morphology of foramen lacerum. Journal of Craniofacial Surgery. 2020 Sep 1;31(6):1848-50.
10. Katzen JT, Jarrahy R, Eby JB, Mathiasen RA, Margulies DR, Shahinian HK. Craniofacial and skull base trauma. Journal of Trauma and Acute Care Surgery. 2003 May 1;54(5):1026-34.
11. Zachariades N, Vairaktaris E, Papavassiliou D, Papademetriou I, Mezitis M, Triantafyllou D. The superior orbital fissure syndrome. Journal of maxillofacial surgery. 1985 Jan 1;13:125-8.
12. Katsuno M, Yokota H, Yamamoto Y, Teramoto A. Bilateral Traumatic Abducens Nerve Palsy Associated With Skull Base Fracture—Case Report—. Neurologia medico-chirurgica. 2007;47(7):307-9.
13. Gutierrez S, Warner T, McCormack E, Werner C, Mathkour M, Iwanaga J, Uz A, Dumont AS, Tubbs RS. Lower cranial nerve syndromes: a review. Neurosurgical Review. 2021 Jun;44:1345-55.
14. Alberio N, Cultrera F, Antonelli V, Servadei F. Isolated glossopharyngeal and vagus nerves palsy due to fracture involving the left jugular foramen. Acta neurochirurgica. 2005 Jul;147:791-4.
15. Katzen JT, Jarrahy R, Eby JB, Mathiasen RA, Margulies DR, Shahinian HK. Craniofacial and skull base trauma. Journal of Trauma and Acute Care Surgery. 2003 May 1;54(5):1026-34.
16. Cundy T, Reid IR. Reprint: Paget's disease of bone. Clinical biochemistry. 2012 Aug 1;45(12):970-5.
17. Poppel MH, Jacobson HG, Duff BK, Gottlieb C. Basilar impression and platybasia in Paget's disease. Radiology. 1953 Oct;61(4):639-44.
18. Monsell EM. The mechanism of hearing loss in Paget's disease of bone. The Laryngoscope. 2004 Apr;114(4):598-606.
19. Eretto P, Krohel GB, Shihab ZM, Wallach S, Hay P. Optic neuropathy in Paget's disease. American journal of ophthalmology. 1984 Apr 1;97(4):505-10.