



MORPHOMETRIC ANALYSIS OF THE INTRACRANIAL CLIVUS IN NORMAL ADULT INDIAN SKULLS: IMPLICATIONS FOR SAFE SURGICAL APPROACHES

Anatomy

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ABSTRACT

Aims & Objective- The clivus is a particularly challenging area for neurosurgeons due to its limited space and complex anatomy. This study focuses on the clivus's morphology and its spatial relationships with adjacent structures, examining anatomic variations, dimensions, and its proximity to critical surgical landmarks on the intracranial aspect. Recognized as a crucial bony reference point for neurosurgeons, the clivus's significance is emphasized. **Materials & Methods:** The research was carried out on 50 dry human skull bases housed in the Anatomy Department's Museum at our Medical College. Measurements of the intracranial dimensions of the clivus were taken, including its length, maximum width, and minimum width. Statistical analysis was then conducted on the collected data. **Result-** The clivus consistently displayed a triangular shape in all skulls (100%). On the intracranial surface, the average clival length was found to be 37.59 ± 4.52 mm. The width at the anterosuperior portion, measured just above the impression of the internal carotid artery in the paraclival area, averaged 17.99 ± 2.04 mm. The width between the apices of both petrous temporal bones was recorded as 20.77 ± 2.26 mm. The average breadth of the clivus between the anteromedial ends of the jugular foramina was 36.21 ± 3.45 mm. Additionally, the width between the posterior ends of the hypoglossal canals was measured at 23.93 ± 2.12 mm. **Conclusion**—The data is helpful to neurosurgeons and ENT surgeons in gaining safe access to Clivus in intracranial surgical approaches.

KEYWORDS

Arnold Chiari malformation, Basal-occiput, Basion, Basal-sphenoid, Foramen lacerum, Foramen magnum, hypoglossal canal, internal carotid artery, jugular foramen, petrous apex.

INTRODUCTION

The clivus, derived from the Latin word for "slope," is an inclined bony part located in the posterior fossa, forming the anterior boundary of the foramen magnum. It is composed superiorly of the posterior part of the sphenoid bone and inferiorly of the basilar segment of the occipital bone, contributing to the anterior margin of the foramen magnum [1-3].

By the age of 18, the sphenoid-occipital synchondrosis fuses, creating a single functional bone unit, which is divided anatomically into the upper, middle, and lower clivus. The upper clivus starts at the posterior aspect of the dorsum sellae and extends to the dural foramina of the abducens nerve, being closely associated with the midbrain, upper part of the pons, the superior cerebellar artery, and cranial nerves III and V. The middle clivus continues to the level of the glossopharyngeal meatus and is related to the middle pons, anterior inferior cerebellar artery, and cranial nerves VI, VII, and VIII. The lower clivus stretches to the foramen magnum and is related to the posterior inferior cerebellar artery and cranial nerves IX, X, XI, and XII [3-4].

The clivus is bordered laterally by the petrous part of the temporal bone, with which it is separated by the petroclival fissure. The internal carotid artery partially occupies the foramen lacerum, where the petrous apex, sphenoid, and occipital bones meet [5]. The tectorial membrane covers the clival dura in the lower two-thirds of the clivus [6]. The clivus is adjacent to the inferior petro-occipital vein, which connects the cavernous sinus to the internal jugular vein [6-7]. Posteriorly, it is related to the medulla oblongata, pons, prepontine cistern, tectorial membrane, and the superior longitudinal band of the cruciate ligament [4-5].

Tumors in the clival region such as chordoma can affect the lower seven cranial nerves, with the sixth cranial nerve often traversing the

tumor through Dorello's canal, located laterally on the clivus [8].

Congenitally small posterior cranial fossa may result in Chiari malformation Type I (CMI) which is often linked with basilar invagination and atlantoaxial dislocation, resulting in compression of the cervicomedullary junction, which may necessitate surgical intervention [9]. Clival screw and plate fixation techniques can be used as alternatives or supplements to occipitocervical instrumentation, with anterior fixation to the clivus serving as another option [10-11].

The clivus, located deep within the skull base, presents challenges for surgical access. Various approaches are employed, including anterior (transsphenoidal, transoral, endoscopic endonasal, and high anterior cervical retropharyngeal approaches), anterolateral (subtemporal transtentorial approach), and posterolateral (retrosigmoid and transcondylar approaches). The proximity of a lesion to nearby neurovascular structures plays a critical role in determining the most suitable surgical technique, highlighting the necessity for meticulous preoperative planning [12-14].

A comprehensive understanding of clival anatomy, particularly its relationship with adjacent structures, is critical in skull base neurosurgery.

This study emphasizes the significance of understanding the morphology of the intracranial clivus and its spatial relationships with adjacent structures to establish a safe surgical corridor in this region.

MATERIAL AND METHODS

This retrospective observational study was carried out on 50 dry adult human skull bases available in the Anatomy Department of our Medical College, all of which were of Indian origin.

Inclusion Criteria: Only intact skull bases were considered for inclusion in the study.

Exclusion Criteria: Skull bases that were damaged or broken were excluded from the study.

Methods: All measurements were taken using a digital Vernier caliper with an accuracy of 0.01 mm. The study analyzed the spatial relationships between the clivus and its adjacent structures. The specific parameters (figure 1) chosen for this study are as follows:

- A. Gross appearance and shape.
- B. Intracranial parameters
 1. The intracranial clival length was measured as the distance from the level of the dorsum sellae to the basion on anterior margin of the Foramen magnum
 2. Breadth of clivus between medial edge of grooves for paraclival/ vertical part of ICA
 3. Breadth of clivus between right and left Petrous apices
 4. Breadth of clivus between the anteromedial end of right and left jugular Foramina
 5. Breadth of clivus between anterior end of right and left hypoglossal canals

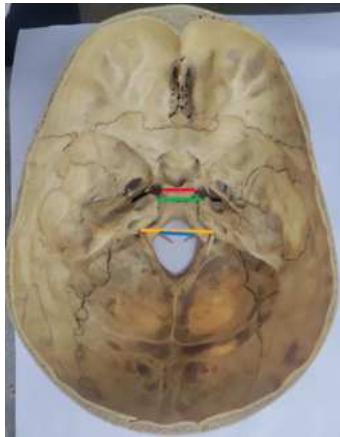


Figure 1- Red line- Width of clivus between the paraclival part of right and left ICA

Green line- Width of clivus between the right and left Petrous apices

Orange line- Width of clivus between anteromedial end of the Jugular foramina

Blue Line- Width of clivus between anterior end of intracranial opening of the hypoglossal canal

RESULTS-

A. Gross appearance and shape- In the present study clivus was triangular in shape in all skulls (100 %), with narrow apex directed antero-superiorly, broader base directed postero-inferiorly continuing with the anterior margin of foramen magnum.

The intracranial surface of clivus was smooth and slightly concave in longitudinal and transverse directions in all skull bases.

B. On the intracranial aspect the mean clival length was 37.59 + 4.52 mm. The width of clivus at anterosuperior end just above the impression of internal carotid artery in the para clival area was measured as 17.99+ 2.04 mm. The width of clivus between apices of both petrous temporal bones was 20.77 + 2.26 mm. The mean breadth of clivus between the anteromedial ends of jugular foramina was measured as 36.21 + 3.45 mm. The width of clivus between posterior ends of hypoglossal canals was 23.93 + 2.12 mm. (Table – 1)

Table 1- Intracranial measurements of Clivus (in mm)

SN	Parameter / Measurements	Range (mm) (n=50)	Mean +/- S.D (mm)
1	Clival Length	27.38 - 46.72	37.59 ± 4.52
2	Minimum breadth (ICA – paraclival part)	13.19- 23.47	17.99± 2.04
3	Breadth of clivus between right and left Petrous apices	15.73- 25.14	20.77 ± 2.26
4	Breadth of clivus between	27.04- 42.71	36.21 ±

	anteromedial end of right and left jugular Foramina		
5	Breadth of clivus between anterior end of right and left hypoglossal canals	19.21-29.2	23.93 ± 2.12

DISCUSSION-

The shape of the clivus was consistently triangular in all observed cases, aligning with findings by Wei Ji et al. (2016) [10].

In the current study, the mean intracranial clival length was 37.59 + 4.52mm, with a range of 27.38 - 46.72mm. In another study conducted by Thiru et al, 2020 the average length of clivus was found to be 35.30 ± 3.24 mm [15] while Ozan Alper Alkoç reported it as 39.82±2.952 mm [16]. Morali Güler T, 2022 analyzed CT images of 103 patients and found the mean length of the clivus at the sagittal plane as 38.40±5.82 (range: 13–52) mm [17]. The reduced length of clivus is an important criteria to diagnose Chiari malformation I. It is often accompanied with basilar invagination [9-11]

The other parameters studied were selected due to their surgical significance, with the goal of avoiding complications such as damage to the internal carotid artery (ICA), internal jugular vein (IJV), trigeminal ganglion, lower six cranial nerves, and brainstem. Notable surgical landmarks exposed in the transnasal approach that assist in identifying the junction of the clival divisions include the lower limit of the paraclival segment of the ICA and the pharyngeal tubercle [18].

On the intracranial aspect, the mean clival breadth at the impression of the paraclival part of the ICA was 17.99 ± 2.04 mm. Another study reported this measurement as 18.8 ± 1.9 mm [19]. This is the narrowest breadth of clivus. In the study done by Ji et al. 2015 the average narrowest breadth of the clivus was 19 mm [11]. During transclival surgery, caution is required to avoid injury to the lacerum and cavernous segments of the clivus [20]. This knowledge is crucial for preventing injury to the internal carotid artery, the osseous portion of the eustachian tube.

The mean clival breadth between the petrous apices was 20.77 ± 2.26 mm in this study. Meckel's cave, which houses the trigeminal ganglion, is located on the petrous apex. Chang et al, 2015, in their study reported the distance between the lacerum segment of internal carotid arteries which lies at the exocrine base of petrous apex as 23.6 +11.8mm [20]. In another study the mean clival width was 29.96 ± 3.86 mm in the Adult Group [21], the difference in the value could be because the latter measured the clival width between the petrous ends of petrosphenoidal ligaments while exploring its relation with abducens nerve.

On the intracranial aspect, the mean clival breadth between the anteromedial ends of the right and left jugular foramen was 36.21 ± 3.45 mm. This is the widest breadth of intracranial Clivus. In the study done by Ji et al. 2015 the average widest breadth of the clivus was 33 mm[11]. Chang et al 2015 reported the distance of Internal jugular vein from median plane in the plane of foramen magnum as 21.45±0.34 mm[20].

The mean clival breadth between the hypoglossal canals on the intracranial aspect was 23.93 ± 2.12 mm, while another study reported it as 24.9 ± 1.3 mm [19]. In another study the Clivus width was measured on Axial reconstructed image and was defined as the longest distance from left to right side near the anterior peripheral margin of foramen magnum inferiorly which measured as 2.814±0.3107cm [22]

When compared to previous studies, our data is largely consistent, with minor differences potentially attributed to racial variations. No other study was found that collectively analyzed all the parameters considered in this research.

CONCLUSION

This data is valuable for neurosurgeons and otolaryngologists navigating the surgical corridor to the clivus, brainstem, and vertebrobasilar arterial system through endoscopic transoral, transphenoidal, approaches. The surgical window on the intracranial aspect should be limited within the lateral boundaries set by the bilateral carotid arteries, measuring 17.99 ± 2.04 mm in the superior parts of the clivus, and the internal openings of the hypoglossal canals, which measure 23.93 ± 2.12 mm in the inferior clivus.

Conflict of interest-None

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