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## Original Article

# Study of ossified clinoid ligaments in sphenoid bone of north Indian skulls

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ABSTRACT

*Introduction:* The sphenoid bone lies in the base of the skull between the frontal, temporal and occipital bones. Certain parts of the sphenoid bone are connected to each other by ligaments, such as caroticoclinoid ligament and interclinoid ligament which occasionally ossify and result in the formation of foramen.
*Methods:* This study was performed on 40 specimens i.e. 30 dried skulls and 10 sphenoid bones, obtained from the Department of Anatomy, SRMS IMS, Bareilly. In all skulls and sphenoids the anterior, middle and posterior clinoid processes were examined to reveal their relationship and the incidence of clinoid foramina and ossification of ligaments around pituitary fossa were noted.
*Results:* The incidence of anterior clinoid foramen is more as compared to posterior clinoid foramen. The ossification of caroticoclinoid ligament is more common than interclinoid ligament. The incidence of presence of anterior clinoid foramen on right and left side is same. Posterior clinoid foramen is present in one sphenoid bone only out of 40 bones.
*Discussion:* The knowledge of anatomy of ossified interclinoid ligament and caroticoclinoid ligament in sphenoid bone around pituitary fossa is important from diagnostic, surgical (especially surgeries involving removal of anterior clinoid process) and clinical point of view and should be evaluated by neurosurgeons before proceeding to skull based surgery. The presence of an ossified CCL ligament is likely to cause compression and straightening of the internal carotid artery thus giving rise to vascular complications.



## 1. Introduction

The sphenoid bone lies in the base of the skull between the frontal, temporal and occipital bones. Certain parts of the sphenoid bone are connected to each other by ligaments, which occasionally ossify, such as the pterygospinous ligament (between the spine of the sphenoid and the upper part of the lateral pterygoid plate), the interclinoid ligament (between the anterior and posterior clinoid processes) and the caroticoclinoid ligament (between the anterior and middle clinoid processes).[1]

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The ligamentous or bony interclinoid connections have important neuronal and vascular relations therefore they are both clinically and surgically important. The knowledge of detailed anatomy of the interclinoid and caroticoclinoid ligaments is important as these ossified ligaments causes confusion in the evaluation of MRI or CT and also in the regional surgery planning. Like, aneurysms surgery of the intracavernous portion of the internal carotid artery[2–5] and surgery for tuberculum sella meningiomas.[6] Removing the anterior clinoid process is an important step in exposing the structures in the cavernous sinus and is highly complicated due to the neuronal and vascular relationships viz occulomotor, trochlear, abducens, ophthalmic and mandibular nerves, internal carotid artery, cavernous sinus. Therefore in the presence of ossified interclinoid ligaments the removal of the anterior clinoid process becomes more difficult.[2] When a paraclinoid aneurysm occurs, the anterior clinoid process is removed as treatment for the above condition.[3,4] This treatment is more difficult when the caroticoclinoid foramen is present, causing higher possibility of serious bleeding in this region.[7] It was observed that caliber of ICA in its clinoid segment being larger than CCF; it was found that there is a high possibility to induce a headache caused by compression of ICA in the presence of CCF. This feature is crucial for the choice of surgical removal of anterior clinoid process.[8]

The anterior clinoid process (ACP) may be joined to the middle clinoid process (MCP) by a ligament or dural fold.[1] The bony bridge joining the ACP and MCP converts distal end of the carotid sulcus into an ostium known as the caroticoclinoid (CCL) foramen[2] or anterior clinoid foramen. The presence of an ossified CCL ligament is likely to cause compression and straightening of the internal carotid artery[8] thus giving rise to vascular complications.

Depending upon the extent of ossification of interclinoid ligaments osseous bridges were classified into four types[9] according to Archana et al.

Type 1 – Bridge present between anterior and middle clinoid process
Type 2 – Bridge between the anterior, middle and posterior clinoid process
Type 3 – Bridge between anterior and posterior clinoid process
Type 4 – Bridge between the middle and posterior clinoid process

Keyers[10] further classified each type of bridge into three subtypes depending upon the extent of fusion between the bony bars arising from the respective clinoid process.

a. Complete type: A complete fusion between two bony bars
b. Contact type: Presence of a dividing line or suture between bony bars
c. Incomplete type: If a spicule of bone was extending from one clinoid process towards the other with a gap in between.

The aim of this study was to present the ossified interclinoid and caroticoclinoid ligament morphologically and to assess its possible impact on the surrounding neurovascular structures. The existence of bony or ossified caroticoclinoid and interclinoid ligament causes compression, tightening or stretching of the internal carotid artery, especially of the clinoidal segment. Research studies have also reported the fact that an ossified caroticoclinoid ligament makes the removal of anterior clinoid process more difficult, especially in the presence of an aneurysm.[10]

## 2. Materials and methods

This study was performed on 40 specimens i.e. 30 dried skulls and 10 sphenoid bones, obtained from the Department of Anatomy, SRMS IMS, Bareilly. In all skulls and sphenoids the anterior, middle and posterior clinoid processes were examined to reveal their relationship and the incidence of clinoid foramina and ossification of ligaments around pituitary fossa were noted.

In the present study we found ossified caroticoclinoid, interclinoid ligaments and clinoid foramina. Clinoid foramen may be anterior and posterior. The presence of bony trabeculae was noted. The length of bony trabeculae was measured from anterior to the posterior clinoid process.

The morphometry of foramen was performed using a digital vernier calliper and measuring the maximum transverse diameter of each foramen. To avoid errors, the measurement was performed three times by the same examiner considering the repeated values to increase the accuracy. We took average of these values. These values were obtained in millimeters (mm).

## 3. Results

The sphenoid bones collected from Department of Anatomy were observed and findings were noted down. The present study revealed the presence of various types of interclinoid bony bars were 7.5% (n = 3 out of 40 sphenoids). Our study revealed the presence of bilateral ossification of caroticoclinoid ligament in one sphenoid out of 40 (2.5%), as it was forming anterior clinoid foramen. Anterior clinoid foramen was therefore present bilaterally (2.5%).The presence of complete bridge (measuring length – 11.90 mm) on left side from anterior to posterior clinoid process resulting into formation of both anterior and posterior clinoid foramen (2.5%), was also observed in the same sphenoid.

Our study also revealed the unilateral presence of ossified caroticoclinoid ligament (Figs. 1 and 2) in 2 sphenoids out of 40 (5%).It was found one on each side and the frequency of occurrence in above is same i.e. 2.5%. Therefore, type 1 interclinoid bars were present in 3 sphenoids (7.5%) and type 3 interclinoid bar was present in 1 sphenoid[9] (2.5%) out of 40. All the bars were having complete fusion.[10]

We also observed incomplete ossification of caroticoclinoid ligament (Fig. 3) in 8 sphenoids out of 40 (20%) i.e. incomplete ossification which did not destined to the formation of foramina.

Incidence of caroticoclinoid foramen in the sphenoids (n = 40) evaluated, according to sides (left, right, unilateral, bilateral). Also shows the values of morphometry of the foramen.

| | Incidence | Mean diameter (mm) ± S.D. |
|---|---|---|
| Total | 7.5% | 5.27 ± 1.18 |
| Right | 2.5% | 5.5 ± 1.91 |
| Left | 2.5% | 5.05 ± 0.56 |
| Unilateral | 5% | – |
| Bilateral | 2.5% | – |

On applying the statistics we found the mean diameter of caroticoclinoid foramen regardless of sides was 5.27 ± 1.18 mm. Our study also revealed that the transverse diameter of bilateral present anterior clinoid foramen was 5.5 ± 1.91 mm on right side and 5.05 ± 0.56 mm on left side.

As regards the unilateral presence of anterior and posterior clinoid foramen, we observed that anterior clinoid foramen was present in 2 sphenoids in which one was present on right side (Fig. 2) and other was present on left (Fig. 3) side. With respect to side the incidence of presence of anterior clinoid foramen was same on both sides.

On applying the Fischer exact test between the distributions of CCF regarding the side examined, the data reveal that there was no statistically significant difference between the diameter of right and left anterior clinoid foramen as p value = 0.82 (p value > 0.05).

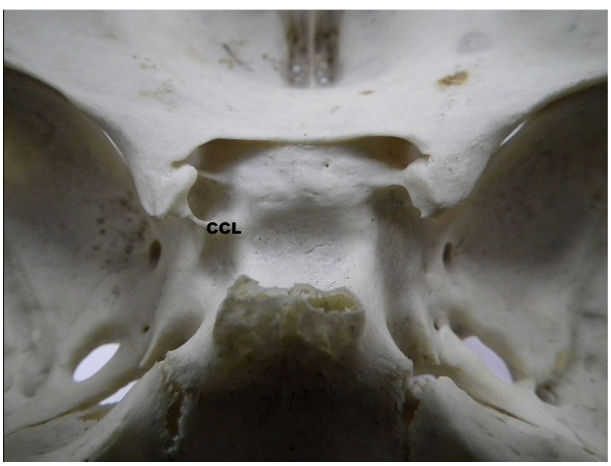


**Fig. 1 – Showing presence of ossified caroticoclinoid (CCL) on left side.**

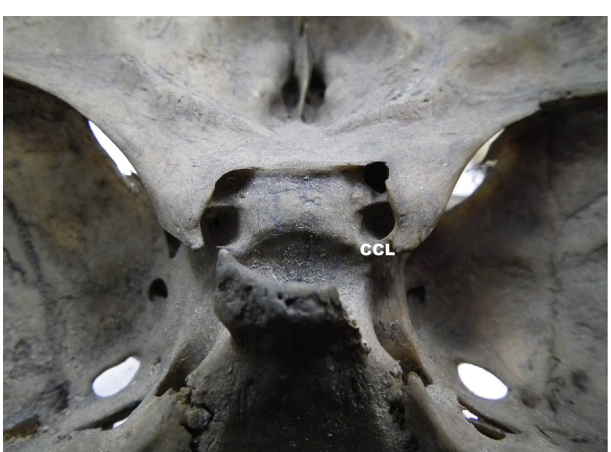


**Fig. 2 – Showing presence of ossified caroticoclinoid ligament on right side.**

**Fig. 3 – Showing incomplete ossification of caroticoclinoid ligament (white arrow).**

Our study also revealed the unilateral presence of posterior clinoid foramen on left side in 1 sphenoid out of 40 (2.5%) which is less frequent as compare to the unilateral presence of anterior clinoid foramen. The transverse diameter of posterior clinoid foramen was 3.05 mm which was found lesser than anterior clinoid foramen of the same side.

## 4. Discussion

The ossification of ligamentous structures in various part of the body is frequently observed resulting in compression to neighboring structures which may produce complex symptoms and create complications in surgery if opted for surgery. Although clinoid ligaments are very important for regional surgery, its anatomy has received less attention.

The ossified ligaments form sellar bridge between ACP and PCP. Hochstetter F.[11] showed precartilage connections between the anterior and posterior clinoid processes. He concluded that cartilaginous interclinoid taenia were extremely rare therefore they were not found routinely. Lang J.[12] reported that sellar bridges are laid down in cartilage at an early stage of development and ossify in early childhood. Ozdogmus et al.[8] also showed that ossification of interclinoid ligament is not age related. These ossifications that observed in early life can be due to the complex embryology of the sphenoid bone in which there are 18–19 ossification centers.

Ossified interclinoid ligament is rare in human population, with varying frequency of 4–17%, as found in the literature.[2,13]

In the present study the total incidence of type 1 bridges was 7.5% and this is lesser than the incidence as observed by Kanjiya et al[14](10.5%), Rani Archana et al[9] (12%), Keyers[10] (34.84%), and Erturk et al[15] (35.67%). However it is important to mention that our study was based on 40 skulls whereas their study was on more skulls.

We also observed the incidence of type 3 bridges was 2.5% which is nearer to the incidence observed by Kanijya et al[14] (4%) but more than Keyers[10] (0.86%) and less than Erturk[15](8.18%).

Argao et al[16] reported two cranium with the ossification occurred bilaterally and completely while in other skull interclinoid ossification was only completed on the right side and incomplete ossification on left side. We also found one sphenoid with complete ossification on left side and incomplete ossification on right side.

Mrinmoy Pal and Sangma[17] reported the presence of bony bridge between anterior and middle clinoid process on one side and on other side between anterior and posterior clinoid process in a dry specimen of adult sphenoid that was similar to our findings.

Kolagi et al[18] showed the presence of bilateral sellar bridges in 3 skull (2.6%) and unilateral sellar bridges in 6 skulls (5.3%) out of 112 skulls. They also found that bridge formation was more frequent on right than left side and the length of bridge was 11.67 mm. We also observed bilateral sellar bridges in 2.5% and unilateral sellar bridges in 5% sphenoids, and the length of sellar bridge was 11.67 mm but the incidence of bridge was same on both sides. The above findings are nearer to the findings of Kolagi et al and both are of same racial origin i.e. Indian.

Bindu Agarwal et al[19] observed 22 sides out of 140 sides of skulls had an ossified caroticoclinoid ligament and out of these 22 sides the ligament was present bilateral in 3 skulls. It was observed in the present study 4 sides out of 80 having ossified caroticoclinoid ligament. Though our study was on the less number of skulls, the incidence of bilateral presence of ossified caroticoclinoid ligament was more than the above mentioned study.

Erturk et al.[15] observed the presence of caroticoclinoid foramen in 35.67% of specimens, unilateral in 23.98% and bilateral in 11.69% but in the present study the incidence is lower (2.5%-unilateral, 5%-bilateral).

Freire et al[20] analyzed 80 dry skulls and observed that in 8.5% skulls were having at least one caroticoclinoid foramen regardless of side and sex. They also observed 2.5% bilateral, 6.25% unilateral incidence of caroticoclinoid foramen. In the present study the incidence of unilateral CCF was 5% and bilateral was 2.5%. So above findings are nearer to our findings. They found that the mean diameter of anterior clinoid foramen, regardless of side or sex, was 5.23 mm which also coincide with our findings (5.27 mm).

Sanobar I Saikh et al.[21] observed 6% incidence of complete CCF and 18% incidence of incomplete foramen. They also found 2% incidence of unilateral and bilateral complete caroticoclinoid foramen, same incidence of caroticoclinoid foramen on both sides. In the present study the incidence of bilateral caroticoclinoid foramen 2.5% and same incidence of caroticoclinoid foramen on both sides.

Kanjiya et al[14] found total incidence of caroticoclinoid foramen was 14.5% while in the present study the incidence of caroticoclinoid foramen was less i.e.7.5%.

Brahmbhatt RJ et al[22] showed 6% incidence of caroticoclinoid canal and the maximum diameter was 6.08 mm while we found 7.5% incidence of caroticoclinoid canal and the diameter was 5.27 mm which is nearer to the finding of Brahmbhatt et al.

Tabinda hasan[23] reported the maximum diameter of caroticoclinoid foramen was $5.23 \pm 0.52$ mm and we also found same dimension of caroticoclinoid foramen i.e. 5.27 mm.

## 5. Conclusion

The knowledge of anatomy of ossified interclinoid ligament and caroticoclinoid ligament in sphenoid bone around pituitary fossa is important from diagnostic, surgical (especially surgeries involving removal of anterior clinoid process) and clinical point of view and should be evaluated by neurosurgeons before proceeding to skull based surgery.

## Conflicts of interest

All authors have none to declare.

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