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Incidence of Carotico-Clinoid Foramen in South Indian Skulls

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Abstract

The carotico-clinoid foramen (CCF) was first described in 1935 by Keyes as a canal formed by the union of anterior clinoid process on its medial side with the tip of the middle clinoid process as it arises from the tuberculum sella or the lateral wall of the body of sphenoid bone. The CCF has been classified by Keyes into three types based on the degree of ossification as complete, incomplete and contact. The frequency of this bony foramen documented in literature is 4-9%. In the present study two hundred and forty-two macerated skull bases of unknown sex were examined for the incidence of the CCF. A complete CCF was found in 9.92% of the skulls. An incomplete CCF was found in 4.13% of the skulls. The knowledge of the CCF is of utmost importance for a neurosurgeon approaching the internal carotid artery or other skull base surgery.

Key words: Anterior clinoid process, carotico-clinoid foramen, internal carotid artery, skull base surgery.

Introduction

The anterior clinoid process (ACP) of the sphenoid bone gives attachment to free margin of tentorium cerebelli. The middle clinoid process provides attachment to the diaphragma sellae. The dura connecting the anterior and middle clinoid processes known as the - carotico-clinoid ligament - converts the distal end of the carotid sulcus into an ostium. Occasionally the caroticoclinoid ligament may undergo ossification resulting in bony foramen known as the carotico-clinoid foramen (CCF) (1).

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The carotico-clinoid foramen was first described in 1935 by Keyes as canal formed by the union of anterior clinoid process on its medial side with the tip of the middle clinoid process as it arises from the tuberculum sella or the lateral wall of the body of sphenoid bone (2). The CCF has been classified by Keyes into three types based on the degree of ossification as complete, incomplete and contact.

The knowledge of the CCF is of utmost importance for a neurosurgeon approaching the internal carotid artery or other skull base surgery. The ossification of the interclinoid ligament is a rarity in human population. The frequency of this bony foramen documented is 4-9%. More frequently it is found unilaterally than bilaterally. The incidence of the interclinoid osseous bridge in Turkish population has been quoted as 8% (3). There is sparse information concerning the frequency of CCF in Indian population. Hence, this study was undertaken to document the occurrence of CCF in south Indian skulls.

Material and Methods

Material for this study consisted of two hundred and forty-two macerated skull bases of unknown sex available in the Department of Anatomy at St John's Medical College, Bangalore. Each base of the skull was inspected for the presence of any bony spur from the anterior or middle clinoid processes. The degree of completeness of the CCF when present was classified according to ossification as complete, incomplete and contact.

Results

A complete CCF was found in twenty-four skulls: bilaterally in eleven skull bases; unilaterally it was found on the right side in seven skulls and on the left side in six skulls (9.92%). An incomplete CCF was found bilaterally in three skulls and unilaterally in seven skulls (four of right side and three of left side - 4.13%). The thickness of the bony process bridging the anterior and middle clinoid processes was 1.5-3 mm transversely and 3-5 mm antero-posteriorly. The size of the CCF when complete ranged between 6x5 mm to 7x5.5 mm.

Discussion

Incidence of CCF has been investigated in many ways using dry skulls, dissection of cadaveric heads and cephalometric roentgenograms. These reports show a varying incidence of the CCF among the different ethnic groups examined (see table-1) (2-14). It can be seen from the table-1 that the incidence varies from 3.9-35.67%. In the present

Table-1 : Comparative Incidence of the Carotico-Clinoid Foramen in the Literature

Author/year	Material used/ ethnic background	No. of cases studied	No. of cases found	Percentage
Keyes (1935)	Dry skulls; American	2187	—	8.68%
Camp (1949)	X-rays series	Not known	—	5%
Muller (1952)	German		—	7%
Platzer (1957)	Dry skulls; German	220	—	5.9%
Lang (1977)	German		—	5%
Dodo and Ishida (1987)	Dry skulls; Japanese		—	Male-3.9% Female-6.0%
Inoue et al (1990)	Cadaveric heads; American		—	4%
Lee, Chung, Choi, Lee (1997)	Adult skulls; Korean	73	6 sides	4.1%
Ozdoðmus et al (2003)	Turkish cadavers	50	3 cases bilateral	6%
Cederberg, Benson, Nunn, English (2003)	Lateral cephlometric radiographs of American subjects	255		8%
Erturk, Kayalioglu, Gosava (2004)	Adult dry skulls, Adult cadaveric heads (both Turkish)	119 52	Unilateral-23.98%; Bilateral-11.69%	Total -35.67%
Huynh-Le, Natori, Sasaki (2004)	Cadaveric heads; Japanese	35 (55 sides)	8 sides	14.54%
Gupta, Ray and Ghosh (2005)	Dry skulls (Nepalese)	35	3 cases	8.57%
Present study	Dry skulls (south Indian)	242	24 skulls	9.92%

study the incidence of the complete CCF was 9.92% and incomplete CCF was 4.13%. The incidence in the present study closely matches with the figures quoted for Nepalese skulls and some American studies (2,12,14).

Many isolated case reports of CCF are also available in the literature (15-17).

Mechanism of formation of the clinoid bridge: Ossification of the ligamentous structures can usually be regarded as a part of ageing process. However, Hochstetter and Kier (18,19) have hypothesized that the ossified interclinoid ligament is a developmental anomaly and has been demonstrated in fetal and infant skulls by these authors. According to Lang (7) the sellar bridges are laid down in the cartilage stage at an early stage of fetal life and ossified during the early childhood. In the light of these observations the occurrence of CCF cannot be regarded as an age related phenomenon.

Side and sex related incidence of the CCF: According to Cederberg et al. (12) the degree of calcification of the interclinoid ligament does not vary according to gender but shows a weak positive correlation with age. Side related occurrence of the CCF shows a racial variation: In Americans bilateral occurrence was found to be frequent and the unilateral presence preferentially occured on the left side. In Koreans unilateral occurrence was found to be predominant and preferentially on the right side (10).

Clinical importance of the anatomical relations of the interclinoid ligament during surgical procedures: (16, 17, 20) The internal carotid artery is present in the medial groove of the ACP and it may be compressed by the ossified carotico-clinoid ligament, giving rise to vascular complications. An interclinoid ligament bisects the wall of the cavernous sinus, dividing it into two triangles: the carotid trigone antero-medially and the oculomotor trigone posterolaterally. Thus, ossification of this ligament may affect the internal carotid artery or the oculomotor nerve.

The internal carotid artery is conventionally divided into six segments and in its course through parasellar region is surrounded partially by dural folds formed by fusion of various dural fiber groups. Three such folds called as proximal, medial and distal carotid rings have been described in the literature. The proximal carotid ring is located at the exit of the internal carotid artery at the level of the endocranial opening of the foramen lacerum; it is formed by two fiber groups viz., endosteal fibers of the

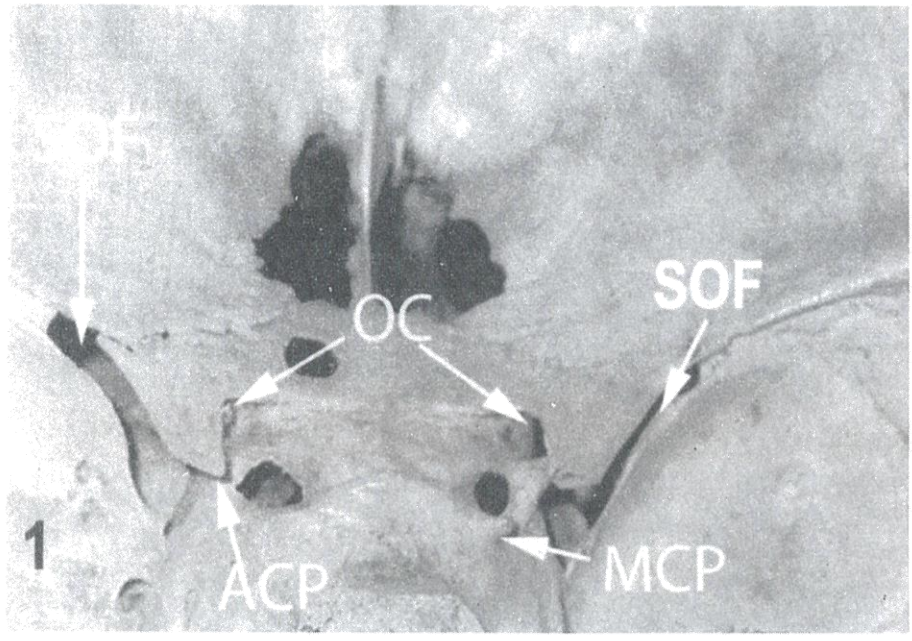

Figure-1 shows prominent middle clinoid tubercle (arrow).

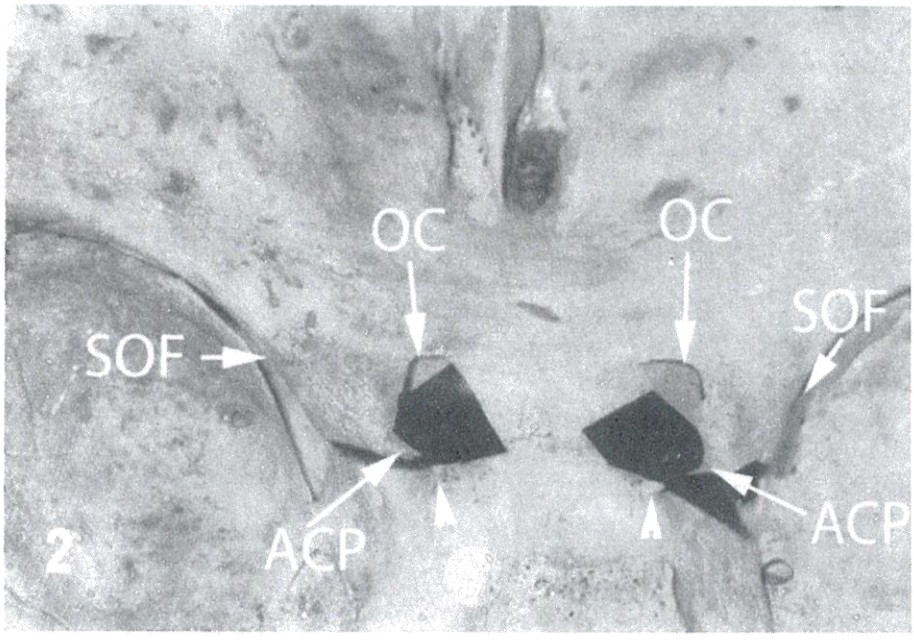

Figure-2 shows an incomplete carotico-clinoid foramen (arrow).

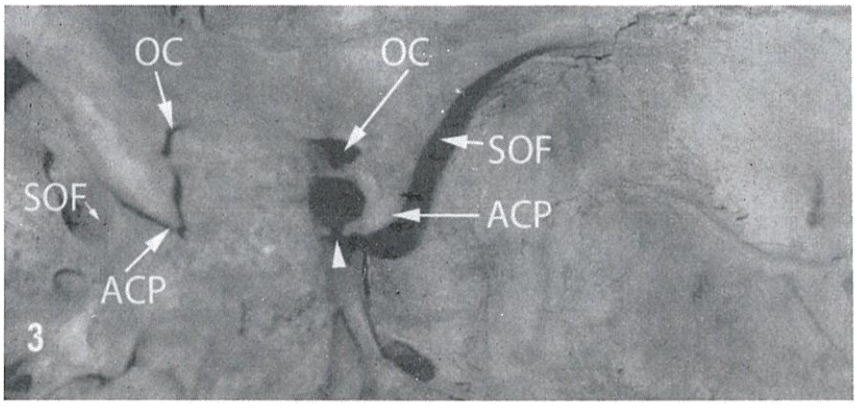

Figure-3 shows an incomplete carotico-clinoid foramen but nearly contact type.

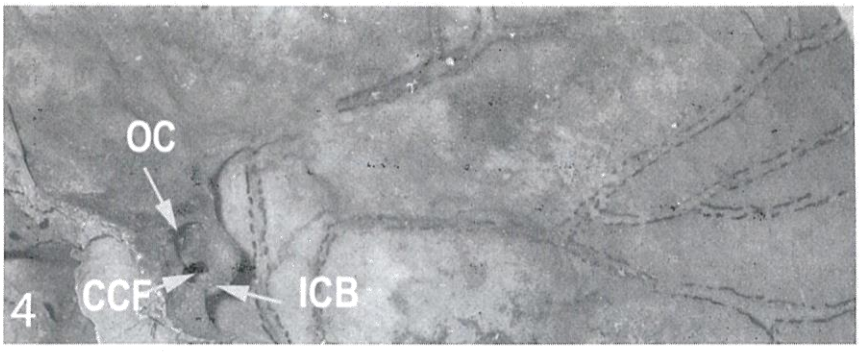

Figure-4 shows a complete carotico-clinoid foramen formed by a carotico-clinoid bar (interclinoid bar–ICB) on the right side of sagittal section.

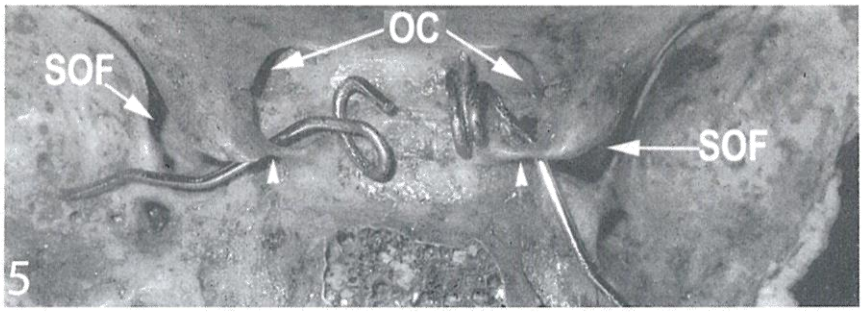

Figure-5 shows completely formed bilateral carotico-clinoid foramen by carotico-clinoid bars of bone (with metal probes passed).

Abbreviations used:

ACP- anterior clinoid process; **CCF-** carotico-clinoid foramen; **MCP-**middle clinoid process; **OC-**optic canal; **SOF-**superior orbital fissure.

trigeminal impression, and innermost area of the superior aspect of the petrous vertex. The medial carotid ring is formed by the free border of the deep layer of the superior wall of the cavernous sinus. It surrounds intimately the posterolateral aspect of the internal carotid artery immediately at the exit from the cavernous sinus. The interclinoid ligament joins it on the posterior aspect. Anteriorly and medially this ring fuses with the endosteal dura of the carotid canal. Distal carotid ring is formed by the convergence of dural fibers from lateral aspect of the tuberculum sellae together with the dural fibers of the optic canal, and it courses over the superior aspect of the internal carotid artery just anterior to the origin of the ophthalmic artery. The clinoid segment of the artery is located between the proximal and distal dural rings. In any surgical operation involving exposure of the clinoid segment of the internal carotid artery, excision of the anterior clinoid process is mandatory. Even to expose the cavernous sinus superiorly and to manage paraclinoid aneurysm, the ACP has to be removed. The clustering of the neurovascular structures in the vicinity of the ACP renders the surgery risky. Prior anatomical knowledge is essential for identifying any inadvertent injury to the internal carotid artery. An MRI scan of the skull of this region can clearly demonstrate ossification of the carotico-clinoid ligament, if done prior to any neurosurgical procedure of this region, and can put the neurosurgeon on alert.

Research studies also have reported the fact that an ossified carotico-clinoid ligament makes the removal of the ACP more difficult, especially in the presence of any aneurysm. The presence of an ossified carotico-clinoid ligament is likely to cause compression and straightening of the internal carotid artery. Drilling of the ACP when required, may cause inadvertent injury to the internal carotid artery and the optic nerve.

Another important clinical characteristic is the pneumatization of the ACP, which has to be evaluated pre-operatively, in order to avoid serious complications like pneumoencephalus and rhinorrhea.

The ACP in 60% of the cases is pierced by narrow venous channels arising from the anterior cavernous sinus and traversing through the clinoid space. These are considered to be a potential source of bleeding during removal of the ACP. It must also be remembered that the extraocular nerves traverse to the superior orbital fissure inferomedial to the ACP and it is essential for the surgeons to adopt a careful approach when operating on the ACP.

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