INCIDENCE OF OSSIFIED INTERCLINOID BARS IN DRY HUMAN SKULLS OF GUJARAT STATE

Daxa Kanjiya*, Mehul Tandel, Sejal Patel, Tushar Nayak, Lajja Sutaria, C.A. Pensi

*Department of Anatomy, B.J. Medical College, Ahmedabad, Gujarat – 380016
E-mail of Corresponding Author: daxa.kanjiya@gmail.com

Abstract
A group of intrinsic ligaments of the sphenoid bone which connect the anterior, middle & posterior clinoid processes occasionally get ossified and give rise to various types of ossified interclinoid bars. In present study the incidence of various types of ossified interclinoid bars were observed in 200 dry human skulls of unknown age & sex belonging to department of Anatomy of various Medical Colleges of Gujarat region. The interclinoid bars are classified on the basis of two classifications, proposed by Rani Archana et al and Keyers. Rani Archana et al, classified interclinoid bars into four types : Type I (caroticoclinoid foramen) bridge present between anterior and middle clinoid process, Type II bridge between anterior, middle and posterior clinoid process, Type III bridge between anterior and posterior clinoid process and Type IV bridge between the middle and posterior clinoid process. Each interclinoid bar was classified into contact, incomplete, complete types based on the classification of Keyers. In present study total incidence of interclinoid bars was 18%. Type I were present in 10.5%, out of which 8% were complete and 2.5% were incomplete. Types II in 3.5%, amongst them 2% were complete and 1.5% was mixed. Type III in 4%, out of which 2% were complete and 2% were incomplete. Total incidence of caroticoclinoid foramens was 14.5%, out of which 11.5% were complete and 3% were incomplete. Total incidence of sellar bridge was 7.5%, out of which 4.5% were complete and 3% were incomplete. Presence of osseous interclinoid bars may cause compression of surrounding structures like the cavernous sinus and its content, sphenoid sinus and pituitary gland. Therefore, detailed anatomical knowledge of various types of interclinoid bars can increase the success of diagnostic evaluation and surgical approaches to the region.
Keywords: Ossified interclinoid bars, Caroticoclinoid foramen, Clinoid processes, Sphenoid bone

1. Introduction:

The ossification of ligamentous structures in various parts of the body may result in a clinical problem such as compression of neighbouring structures and complications in regional surgery. Williams et al[1] describes that there are three clinoid processes present on either side of sella turcica which is saddle shaped depression on intracranial surface of body of sphenoid bone. The anterior clinoid processes are formed by the medial and anterior prolongations of the lesser wing of the sphenoid bone, the posterior clinoid processes are present at the end of the dorsum sellae and the middle clinoid processes are present on either side of tuberculum sellae. The carotico-clinoid ligament connecting anterior and middle clinoid processes sometime get ossified forming the carotico-clinoid foramen which transmits one of the segment of internal carotid artery. Ossification of interclinoid ligament that connecting anterior and posterior clinoid processes is termed as interclinoid osseous bridge or sella Turcica Bridge. Thus ossification of the ligaments connecting the clinoid processes of the sphenoid bone may give rise to bony bridges.

Du Boulay mentioned that this ligamentous ossification occurs in the early age and is possibly an extension of the normal ossification of the anterior and posterior clinoid processes[2].
Bridge formation occur either between the anterior and the middle (carotico-clinoid bridge; carotico-clinoid foramen of Henle), the anterior and the posterior (sella turcica bridge), or between the middle and posterior clinoid processes. In rare instances, the three processes fuse with each other [3,4].
According to Basmajian[5] and Breathnach[6] these bridges are related to the cavernous sinus, internal carotid artery, and pituitary gland. In surgical procedures such as exposure of the cavernous sinus through superior approach and in the management of paraclinoid aneurysm, excision of anterior clinoid process becomes mandatory. The presence of important neurovascular structures in the vicinity of anterior clinoid process makes this procedure very difficult. Presence of ossified interclinoid bars not only poses difficulty in removal of anterior clinoid process but also enhances the risk of damage to the adjacent important structures.

Various authors have reported that several endocrinological and neurological disorders are associated with such variations[7,8]. Sella bridges were demonstrated roentgenologically to a 25% extent in idiots, to 20% in criminals, to 15% in epileptics, and to 38% in other cases with mental disorders [9].

The present study is conducted to determine incidence and types of the ossified interclinoid bars in dry skulls of Gujarat population. The obtained results were compared with those of other studies on different populations.

2. Material and Method:

This study was performed on 200 dry human skulls with removed calvaria of unknown age & sex belonging to department of Anatomy of various Medical Colleges of Gujarat region. In all cases, the anterior, middle, and posterior clinoid processes were examined on both right and left sides to reveal their relationship and the incidence of ossified interclinoid bars. For the classification of the interclinoid bars, the method proposed by Rani Archana et al[10] and the method proposed by Keyers[11] were used.

2.1 Rani Archana et al, classified interclinoid bars into four types[10]:

Type I: - Bridge present between anterior and middle clinoid process(caroticoclinoidforamen).

Type II: - Bridge between anterior, middle and posterior clinoid process.

Type III (sella turcica bridge):- Bridge between anterior and posterior clinoid process.

Type IV: - Bridge between the middle and posterior clinoid process.

2.2 Keyers[11] 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,

In Type II variety of osseous bridge a fourth subtype of fusion was also observed where a combination of any of the above two subtypes was present between the adjacent clinoid process and this subtype was termed as mixed type[10].

The incidence of caroticoclinoid foramen (include type I & II) and sella turcica bridge (include type II & III) was also studied separately.

3. Result:

In the present study out of 200 skulls the total incidence of the various types of interclinoid bony bars was 18% (n = 36).

Table:-1 Incidence of various types of ossified interclinoid bars (n = 200)

Subtype	Bilateral		Unilateral (right)		Unilateral (left)		Total incidence
	No.	%	No.	%	No.	%	No. (%)
(a) Type I bridge (Fig. 1)							
Complete	9	4.5	3	1.5	4	2	16(8)
Contact	0	0	0	0	0	0	0
Incomplete	3	1.5	2	1	0	0	5(2.5)
Total	12	6	5	2.5	4	2	21(10.5)
(b) Type II bridge (Fig. 2)							
Complete	4	2	0	0	0	0	4(2)
Contact	0	0	0	0	0	0	0
Incomplete	0	0	0	0	0	0	0
Mixed	3	1.5	0	0	0	0	3(1.5)
Total	7	3.5	0	0	0	0	7(3.5)
(c) Type III bridge (Fig. 3)							
Complete	2	1	1	0.5	1	0.5	4(2)
Contact	0	0	0	0	0	0	0
Incomplete	3	1.5	1	0.5	0	0	4(2)
Total	5	2.5	2	1	1	0.5	8(4)

In present study no skulls showed contact type of interclinoid bony bars.

Table:-2 Incidence of the complete, contact, and incomplete types of caroticoclinoid foramen (n= 200)

Type of Caroticoclinoid Foramen (Fig. 1)	Bilateral		Unilateral (right)		Unilateral (left)		Total incidence
	No.	%	No.	%	No.	%	No. (%)
Complete	15	7.5	4	2	4	2	23(11.5)
Contact	0	0	0	0	0	0	0
Incomplete	3	1.5	2	1	1	1.5	6(3)
Total	18	9	6	3	5	3.5	29(14.5)

Table:-3 Incidence of the complete, contact and incomplete types of the sella turcica bridge (n=200)

Type of sella turcica bridge (Fig. 3)	Bilateral		Unilateral (right)		Unilateral (left)		Total incidence
	No.	%	No.	%	No.	%	No. (%)
Complete	6	3	2	1	1	0.5	9(4.5)
Contact	0	0	0	0	0	0	0
Incomplete	5	2.5	1	0.5	1	0.5	6(3)
Total	11	5.5	3	1.5	2	1	15(7.5)

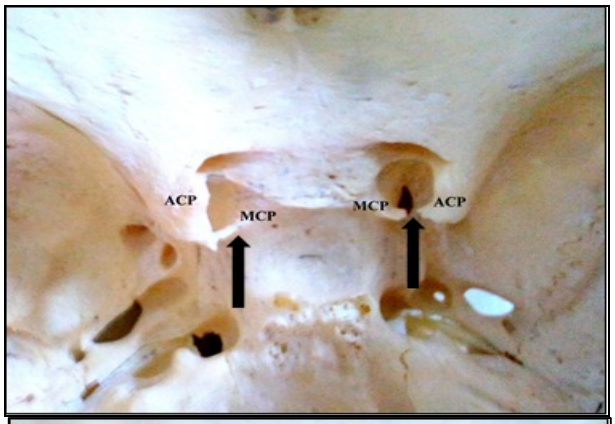


Fig 1: Type I Intercliniod bars

Left side - Complete

Right Side - Incomplete

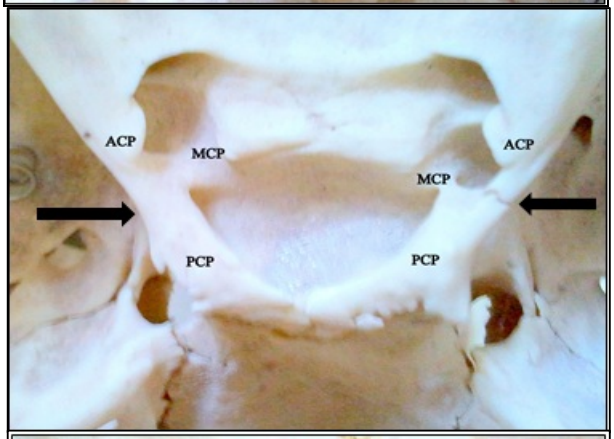


Fig 2: Type II Intercliniod bars

Left side - Complete

Right Side - Mixed

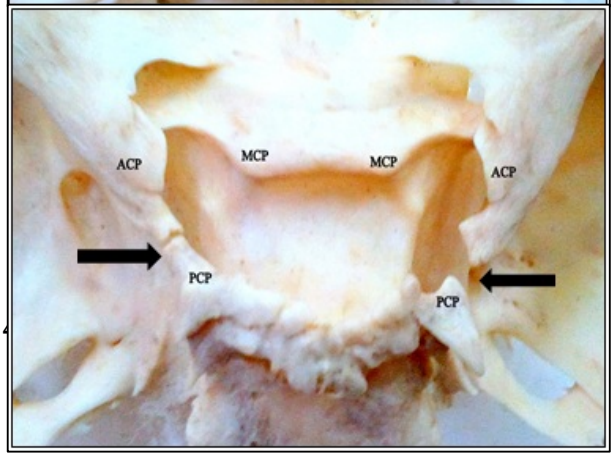


Fig 3: Type III Intercliniod bars

Left side - Incomplete

Right Side - Incomplete

4. Discussion

The interclinoid ligament joins the anterior and posterior clinoid processes while the caroticoclinoid ligament connects the anterior and middle clinoid processes [1]. Frazer did not mention the caroticoclinoid ligament as a separate entity. According to Frazer, the anterior, middle and posterior clinoid processes are connected by interclinoid ligaments[12]. The ossified interclinoid ligament forms a bony bridge between the anterior, middle and posterior clinoid processes of the sphenoid bone. These bony bridges are known as sellar bridge[13].

Table:-4a Comparison of Type-I interclinoid bar between anterior & middle clinoid process

Name of Authors	Population	Total incidence	Bilateral	Unilateral
Keyers[11]	American	34.84%	23.4%	11.43%
Erturk *et al*[14]	Turkish	35.67%	-	-
Rani Archana[10]	Indian	12%	2.8%	9.2%
Present author	Gujarat	10.5%	6%	4.5%

In the present study the total incidence of type I bridges was 10.5% which is nearer to the incidence observed by Rani Archana(12%) but lower than incidence observed by Keyers(34.84%) & Erturk et al(35.67%). In the present study the incidence of bilateral type I bridges(6%) was more as compared to unilateral (4.5%), and the complete subtype (8%) was more than the incomplete subtype (2.5%), while Rani Archana[14] observed that the incomplete subtype(6.8%) was more than complete subtype(3.6%) (Table 4a).

Table:-4b Comparison of Type-II interclinoid bar anterior, middle & posterior clinoid process

Name of Authors	Population	Total incidence	Bilateral	Unilateral
Dyke[15]	American	2-3%	-	-
Keyers[11]	American	7.82%	-	-
Rani Archana[10]	Indian	5.6%	0.8%	4.8%
Present author	Gujarat	3.5%	3.5%	0%

In this study total incidence of type II Bridge (bilaterally) was 3.5% which is nearer to the incidence found by Rani Archana (5.6%) & Dyke (2-3%) but lower than incidence observed by Keyers (7.82%). The incidence of complete type II bridge was more common in present study whereas Rani Archana found that mixed type II bridge was more common(Table 4b).

Table:-4c Comparison of Type-III interclinoid bar between anterior & posterior clinoid process

Name of Authors	Population	Total incidence	Bilateral	Unilateral
Keyers[11]	American	0.86%	-	-
Snyder & Blank[16]	Japanese	5%	-	-
Camp(radiological study)[17]	American	5.5%	-	-
Ozdogmus *et al*[18]	Turkish	6%	-	-
Erturk *et al*[14]	Turkish	8.18%	-	-
Rani Archana[10]	Indian	4%	0.8%	3.2%
Present author	Gujarat	4%	2.5%	1.5%

Total incidence of type III Bridge was 4% in present study. This incidence is almost same as that of other study except the incidence observed by Keyers (0.86%) & Erturk (8.18%). In present study the incidence of complete and incomplete type III was same (2%) while Rani Archana observed incomplete type III bridge more as compare to complete type III bridge(Table 4c).

In present study no skull showed contact type of bridge.

Type IV interclinoid bridge is rarest which is present between middle and posterior clinoid process. Keyes[11] also described this type as rarest one.

Table:-5 Comparison of incidence of caroticoclinoid foramen

Author	Complete type (%)	Incomplete type (%)	Contact type (%)	Total (%)	No. of cases examined
Keyes[11] (1935)	7.1	19.2	1.2	27.5	2,187 dry skulls
Inoue et al.[19] (1990)	1	16	8	25	50 dry skulls
Deda[20] (1992)	9.1	6.8	6.8	22.7	50 dry skulls
Hochstetter[21] (1940)	0.9	13.2	–	14.1	113 embryos
Lang [22](1977)	9.7	8.5	–	18.2	120 adult and 45 prepubescent dry skulls
Ozdogmus *et al* [23](2003)	27	18	–	45	50 fresh autopsy cases
Mete Erturk et al[14](2003)	4.09	14.91	4.68	23.68	119 Dry skulls & 52 adult cadaveric heads
Bindu Agrawal *et al*[24] (2011)	2.86	12.86	–	15.72	70 dry skulls
Amit Magadum *et al*[25] (2012)	2	1	–	3	50 dry skulls
Bindu Agrawal *et al*[26] (2012)	2.99	13.43	–	16.42	67 dry skulls
Present author(2012)	11.5	3	–	14.5	200 dry skulls

Total incidence of caroticoclinoid foramen was 14.5% in present study which is nearer to the incidence observed by Hochstetter[20] (14.1%), Lang [21] (18.2%) & Bindu Agrawal (15.72%) but lower than the other studies. The complete type of caroticoclinoid foramen was more common in present study while in other studies incomplete type of caroticoclinoid foramen was more common(table 5).

Table: - 6 comparison of incidence of interclinoid osseous bridge (sella turcica bridge)

Author	Number	Interclinoid osseous bridge
Keyers[11] (1935)	2187	8.68%
Azeredo et al.[27] (1988)	270	9 (3.04%)
Inoue et al.[19](1990)	50	2 (4%)
Lee et al.[28] (1997)	73	–
Cireli et al.[29] (1990)	50	1 (2%)
Deda et al.[20] (1992)	88	4 (4.54%)
Gurun et al.[30] (1994)	198	2 (1.01%)
Erturk et al.[14] (2003)	507	21 (4.14%)
Omer Ozdogmus et al[23](2003)	50	6%
Sanjeev Kolagi et al [31](2011)	112	8.04%
Bindu Agrawal et al[26](2012)	67	6.72%
Present author	200	15(7.5%)

In our study, this incidence was 7.5% which is nearer to the results found by Keyers[11], Omer Ozdogmus et al[22], Sanjeev Kolagi et al [31], Bindu Agrawal et al[26] (Table 6).

Various theories have been postulated to explain the formation of these interclinoid osseous bridges. Dyke [15]found the ossification in the dura between the anterior, middle and posterior clinoid processes in 2–3% of skulls. Schaeffer [32] stated that a bony bridge connecting the anterior and posterior clinoid processes is a persisting vestige of the primitive cranial wall. Kier[33] postulated that osseous interclinoid ligament was a developmental anomaly and showed the existence of the foramen that is formed by this ligament in fetus and infant skull. Lang [22]reported that sellar bridges are laid down in cartilage at an early stage of development and ossify in early childhood.

It is a challenging task for neurosurgeons to approach the parasellar region of central skull base in cases of aneurysm of the intracavernous and clinoid segment of the internal carotid artery, carotico-cavernous fistula and tuberculum sella meningiomas. In these cases removal of the anterior clinoid process becomes mandatory for

proper visualization of the structures. The research studies have also reported that the presence of an osseous bridge between the tip of the anterior clinoid process and either the middle or posterior clinoid process makes removal of the anterior clinoid process more difficult and increases the risk of its removal, especially if an aneurysm is present[34]. The segment of the internal carotid artery in the clinoid space—the clinoid segment—and the oculomotor nerve may be damaged during the removal of the anterior clinoid process[35]. Drilling of the anterior clinoid process may also cause inadvertent injury to the optic nerve [36]. From the ongoing discussion it is clear that Types I, II and III varieties of interclinoid osseous bars, if present, will enhance the risk of damage to the adjacent structures in any surgery involving the anterior clinoid process. Therefore preoperative imaging should always be advised, to obtain a satisfactory result from these surgeries. Kim et al.[37]suggested that if interclinoid bars are present extending from anterior clinoid process, then combined extra and intradural approach should be adopted for removal of anterior clinoid process. The existence of Type I interclinoid bony bar or carotico-clinoid foramen may cause compression, tightening or stretching of the internal carotid artery [23].

5. Conclusion:

Among four types of interclinoid bars type I was more commonly found in present study. No skull showed contact subtype. The knowledge of interclinoid bars is important for neurosurgeons to provide information on the limited intraoperative view and reduce mortality and morbidity in surgical approaches.

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