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ORIGINAL ARTICLE

T. Peker · A. Anıl · N. Gülekon · H. B. Turgut · C. Pelin · M. Karaköse

The incidence and types of sella and sphenopetrous bridges

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Abstract The incidence and types of sella and sphenopetrous bridges were investigated in 37 adult male and 43 adult female (a total of 80) dry skulls with removed calvarias. In addition to this, the sellar and parasellar region of ten fixed cadavers (two female and eight male) were carefully dissected, and the individuals were examined for the evidence of sella and sphenopetrous bridges. Sella bridges were seen in 34.17% of the subjects overall. The trace, incomplete and complete types were 11.9%, 3.7% and 17.5%, respectively. On the other hand, sphenopetrous bridges were observed in 15.8% of the male and 4.9% of the female subjects overall. The cadaveric investigation revealed one trace, three incomplete, and one complete sella bridge in three cadavers. In addition to this, a complete sphenopetrous bridge was detected in one of the cadavers. Variations in the cranial base are of importance for surgical approaches in that location.

Keywords Sella bridge · Sphenopetrous bridge · Variation · Cranial base

Introduction

As a result of abnormal developments in the anterior, middle, and posterior clinoid processes, these bony structures could fuse, forming osseous bridges. Bridge formation could occur either between the anterior and the middle (carotico-clinoid bridge; carotico-clinoid foramen of Henle), the anterior and the posterior, or between the middle and posterior clinoid processes. In rare instances, the three processes could fuse with each other. In addition, a bony bridge could also develop between the posterior clinoid process and the superior margin of the pyramidal part of temporal bone, the sphenopetrous bridge [10, 17].

Sella and sphenopetrous bridges have been studied as cranial discrete traits by various authors [6, 9, 15]. The bridge between the anterior and the middle clinoid processes could cause structural and physiological disorders in the cavernous part of the internal carotid artery by changing the anatomical structure of the terminal part of the carotid groove [11, 16]. The presence of a fibrous or osseous bridge between the anterior clinoid process and the middle or the posterior clinoid process makes the approach to the internal carotid artery more difficult and increases the risk in the removal of the sella bridges, especially if an aneurysm is present [8]. Various authors have reported that several endocrinological and neurological disorders are associated with such variations [12, 18]. 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 [1]. Bergerhoff [2] presented exhaustive anatomic–roentgenographic studies about the anatomy and the topography of the sella, and finally Lang [10] investigated the structure and postnatal organization in infrequent ossifications of the sella turcica region.

In the present study, the incidence and types of the bony bridge formation on the sphenoid bone and their distribution in relation to side and gender were studied. The results were compared with those of other studies on different populations [3, 5, 13].

Materials and methods

The study was conducted with 37 adult male and 43 adult female (a total of 80) dry skulls with removed calvarias. Cranial samples were made available from the collection of

T. Peker (✉) · A. Anıl · N. Gülekon · H. B. Turgut · M. Karaköse
Department of Anatomy, Faculty of Medicine,
Gazi University,
Besevler,
Ankara, 06500, Turkey
e-mail: tpeker@gazi.edu.tr
Tel.: +90-312-2026959
Fax: +90-312-2124647

C. Pelin
Department of Anatomy, Faculty of Medicine,
Başkent University,
Bağlıca,
Ankara, Turkey

the Department of Paleoanthropology of Ankara University (Faculty of Letters). The incidence and types of sella and sphenopetrous bridges in these skulls were evaluated statistically. Chi-square and kappa tests were used for statistical evaluations.

For the classification of sella bridges, the method of Ossenberg [14], and for sphenopetrous bridges, the method of De Villiers [3] were used, as below:

(a) No bridging
(b) Trace: existence of spinous bony protrusions or bony tubercles on both sides of the clinoid processes
(c) Incomplete: bony projections on both sides of the clinoid processes separated by a fissure
(d) Complete: completely fused bony projections

The localization of the bony bridging was also classified as below:

(a) No bridge formation
(b) Bridge formation between anterior and middle clinoid processes
(c) Bridge formation between anterior and posterior clinoid processes
(d) Bridge formation between middle and posterior clinoid processes
(e) Bridge formation between anterior, middle and posterior clinoid processes (carotico-clinoid foramen).

The sellar and parasellar regions of ten fixed cadavers (two female and eight male) were carefully dissected, and the individuals were examined for evidence of sella and sphenopetrous bridge on both sides (20 specimens). With the aid of the operating microscope (Zeiss OPMI Pico, Oberkochen, Germany), the dura mater was dissected, beginning at the floor of the middle cranial fossa, from posterior to anterior and from lateral to medial. The same criteria were used on the cadavers for the classification of sella and sphenopetrous bridges.

Results

The eighty dry Anatolian skulls were examined for the presence of sella and sphenopetrous bridges. In their presence, they were also evaluated from the viewpoint of their classification and localization. Sella bridges were seen in 34.17% (male: 39.5%, female: 29.3%) of the subjects overall. The trace, incomplete and complete types were found to be 11.9%, 3.7% and 17.5%, respectively (Figs. 1 and 2). On the other hand, sphenopetrous bridges were observed in 15.8% of the male and 4.9% of the female subjects overall. When the presence of sella bridges was evaluated according to sides, it was observed that sella bridges were present in 29.1% of the subjects on the right side and in 31.7% on the left side. They were commonly complete on both sides (right: 16.5%, left: 15.2%). In addition to this, bridge formation was observed mostly between the anterior and the posterior clinoid processes on both sides (right: 15.2%, left: 11.4%). However, the localization of the bridge was more homogeneous on the left side than on the right (Table 1). Sella bridges run from frontolateral to posteromedial, and on the level of the Frankfurt horizontal plane.

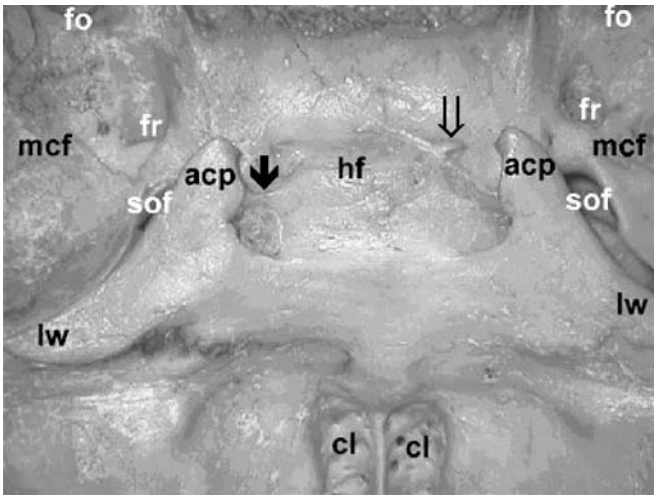

Fig. 1 Photograph of a dry skull specimen showing complete type sella bridge between anterior and middle clinoid processes on the right side (*black arrow*) and trace type sella bridge between anterior and middle clinoid processes on the left side (*open arrow*) (*acp* anterior clinoid process, *cl* cribriform lamina, *fo* foramen ovale, *fr* foramen rotundum, *hf* hypophysial fossa, *lw* lesser wing, *mcf* middle cranial fossa, *sof* superior orbital fissure)

Sphenopetrous bridges were present in 7.6% of the subjects on the right side and in 10.1 % on the left. The bridge formation was mostly trace on both sides (right 6.3%, left: 7.6%) (Table 1).

Right and left sides were also evaluated with regard to type and location of the sella bridges, and then compared with each other. A significant relationship was observed between the sides and in both the type and the localization (K: 0.76, $P<0.001$; K: 0.74, $P<0.001$, respectively). The

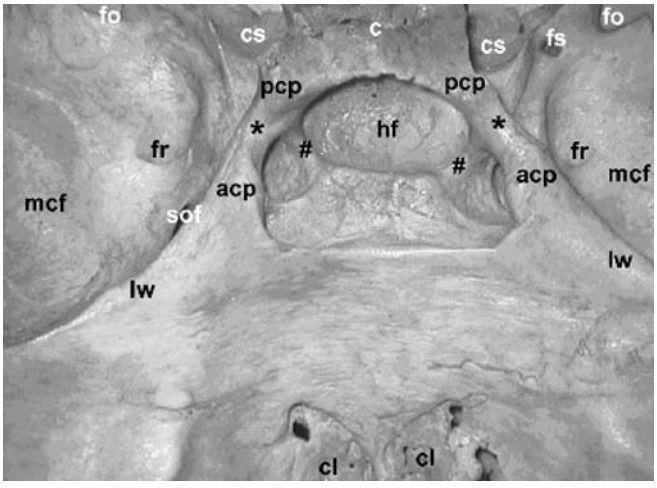

Fig. 2 Photograph of a dry skull specimen showing complete type sella bridge between anterior-posterior (*asterisk*) and middle-posterior clinoid processes (*hash*) on both sides (*acp* anterior clinoid process, *c* clivus, *cl* cribriform lamina, *cs* carotid sulcus, *fo* foramen ovale, *fr* foramen rotundum, *fs* foramen spinosum, *hf* hypophysial fossa, *lw* lesser wing, *mcf* middle cranial fossa, *pcp* posterior clinoid process, *sof* superior orbital fissure)

Table 1 Degree of completeness and position of the sella bridge and of the sphenopetrous bridge according to gender and side (*M* male, *F* female)

Sella bridge – Degree of completeness

	Absence		Trace		Incomplete		Complete		Bridges with small fissures		Total	
	M	F	M	F	M	F	M	F	M	F	M	F
Right *n*	23	32	4	5	2	0	8	6	0	0	37	43
%	62.2	74.4	10.8	11.6	5.4	0.0	21.6	14.0	0.0	0.0	46.3	53.8
Total *n*	55		9		2		14		0		80	
%	68.8		11.3		2.5		17.5		0.0		100.0	
Left *n*	23	29	5	5	2	2	7	7	0	0	37	43
%	62.2	67.4	13.5	11.6	5.4	4.7	18.9	16.3	0.0	0.0	46.3	53.8
Total *n*	52		10		4		14		0		80	
%	65.0		12.5		5.0		17.5		0.0		100.0	

Sella bridge – Position

	Absence		Ant-med		Ant-post		Med-post		Ant-med-post		Total	
	M	F	M	F	M	F	M	F	M	F	M	F
Right *n*	24	36	8	4	2	2	1	2	1	0	37	43
%	64.9	83.7	21.6	9.3	5.4	4.7	2.7	5.4	2.3	0.0	46.3	53.8
Total *n*	60		12		4		1		3		80	
%	75.0		15.0		5.0		1.2		3.8		100.0	
Left *n*	24	33	6	5	3	3	1	2	3	0	37	43
%	64.9	76.7	16.2	11.6	8.1	7.0	2.7	4.7	8.1	0.0	46.3	53.8
Total *n*	57		11		6		3		3		80	
%	71.2		13.7		7.5		3.8		3.8		100.0	

Sphenopetrous bridge – Degree of completeness

	Absence		Trace		Incomplete		Complete		Bridges with small fissures		Total	
	M	F	M	F	M	F	M	F	M	F	M	F
Right *n*	34	40	3	3	0	0	0	0	0	0	37	43
%	91.9	93.0	8.1	7.0	0.0	0.0	0.0	0.0	0.0	0.0	46.3	53.8
Total *n*	74		6		0		0		0		80	
%	92.5		7.5		0.0		0.0		0.0		100.0	
Left *n*	32	40	4	3	1	0	0	0	0	0	37	43
%	86.5	93.0	10.8	7.0	2.7	0.0	0.0	0.0	0.0	0.0	46.3	53.8
Total *n*	72		7		1		0		0		80	
%	90.0		8.8		1.2		0.0		0.0		100.0	

two sides were examined with regard to the type of sphenopetrous bridges as well. A significant relationship was observed between the two sides (K: 0.85, $P<0.001$).

No gender difference was observed from the viewpoint of the bilateral existence of both the sella and the sphenopetrous bridges ($P>0.05$). In addition, the type and localization of sella and sphenopetrous bridges were independent of gender.

On both left and right sides, a significant relationship was observed between the type and localization of the sella bridges ($P<0.001$). On the right side, complete bridge formation was mostly seen in an anterior-posterior and anterior-middle-posterior location ($P<0.001$). On the left side, a complete bridge was observed mostly in an anterior-middle-posterior location ($P<0.001$).

No significant relationship was observed between the presence and types of sella and the sphenopetrous bridges ($P>0.05$).

The cadaveric investigation revealed one trace, three incomplete and one complete sella bridge in three cadavers. In addition to this, a complete sphenopetrous bridge was found in one of the cadavers. All the sella and sphenopetrous bridges were found in male cadavers. In a 48-year-old male cadaver, there was a trace type sella bridge on the left and an incomplete type on the right side. The gap between the spinous bony protrusions of the trace type was 7 mm. However, it was 3 mm in the incomplete type. A 43-year-old male cadaver had an incomplete sella bridge on the right side. The gap between the spinous bony protrusions was 2 mm, and the left side of the cadaver was normal. In a 78-year-old cadaver, an incomplete sella bridge was observed on the right side, and a complete type was observed on the left (Fig. 3). The spinous bony protrusion of the incomplete type of sella bridge on the right side originated from the posterior clinoid process and extended to the anterior clinoid process. A thin fibrous band attached to the tip of the spinous bony projection connected to the anterior clinoid process, but during dissection the fibrous band was cut by mistake; as a result, a 2 mm gap was formed between the spinous protrusion and the anterior clinoid process (Fig. 3). A 50-year-old male cadaver had a complete sphenopetrous bridge on the left side (Fig. 4). The bony bridge extended from the superior margin of the petrous part of the temporal bone to the back of the posterior clinoid process. There was no structure running through the foramen formed by the petrous part of the temporal bone and the sphenopetrous (petroclinoid) bony bridge. This bony bridge was 12 mm above the entry of the abducent nerve into the Dorello's canal or sulcus. There was also no relation between this bony bridge and the Dorello's canal or sulcus.

Discussion

The sphenoid bone is composed of pre-sphenoidal and post-sphenoidal parts until the eighth month of intrauterine life. The pre-sphenoidal part is located at the rostral side of the tuberculum sellae. The post-sphenoidal part is

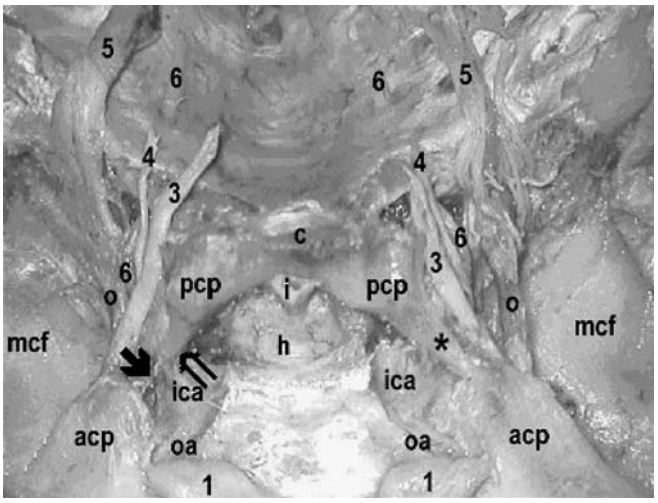

Fig. 3 Photograph of a cadaveric specimen. Note incomplete type sella bridge between anterior and posterior clinoid processes on the right side (*open arrow*). A thin fibrous band extends from the bony protrusion to the anterior clinoid process (*black arrow*). This band was cut by mistake. Note the complete type sella bridge between anterior and posterior clinoid processes on the left side (*acp* anterior clinoid process, *c* clivus, *h* hypophysis, *i* infundibulum, *ica* internal carotid artery, *mcf* middle cranial fossa, *o* ophthalmic nerve, *oa* ophthalmic artery, *pcp* posterior clinoid process, *asterisk* sellar bridge between anterior and posterior clinoid processes, *1* optic nerve, *3* oculomotor nerve, *4* trochlear nerve, *5* trigeminal nerve, *6* abducent nerve)

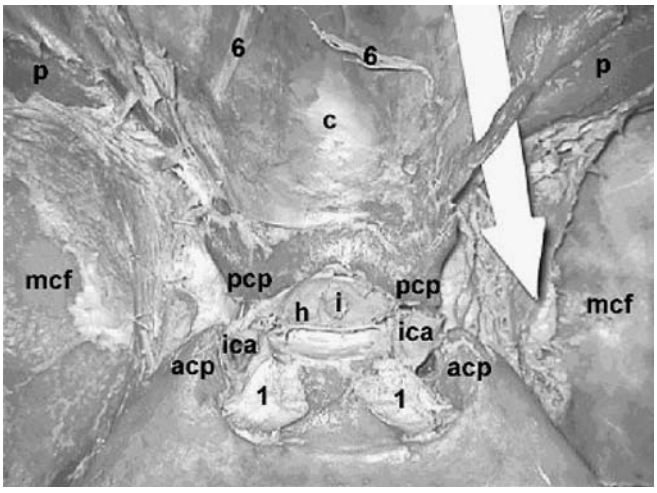

Fig. 4 Complete sphenopetrous bony bridge on the left side of a cadaveric specimen. The *large white arrow* is passing through the bony canal formed by the ossified petrosphenoidal ligament. The entry of the sixth cranial nerve into the Dorello's canal is clearly seen (*acp* anterior clinoid process, *c* clivus, *h* hypophysis, *i* infundibulum, *ica* internal carotid artery, *mcf* middle cranial fossa, *p* petrous part of temporal bone, *pcp* posterior clinoid process, *1* optic nerve, *6* abducent nerve)

composed of a sella turcica, a greater wing and a pterygoid process of sphenoid bone. In approximately the fourth month of fetal life, ossification centers appear on both sides of the sella turcica [20]. Hochstetter's [7] conjecture that the carotico-clinoid foramina are already present in the embryological development concurs with that of Bergerhoff [2]. Bergerhoff's view, that the foramina ossify during the first year post-natally, can be contradicted, because completely ossified carotico-clinoid foramina as well as sella bridges have been demonstrated in new-born infants [2, 7, 10]. The presence of sella bridges during intracartilaginous ossification have been reported in embryos whose crown–rump length (CRL) was between 21.4 mm and 104.0 mm [7]. Lang [10] also reported the presence of sella bridges in embryos and described them as the fusion of the distal parts of the bony projections that were ossified from the cartilaginous tissue, but not because of the ossification of dura mater in that location.

When the embryological development is taken into consideration, sella bridges are thought to cause several endocrinological and neurological disorders [12, 18]. They are located very close to the hypophysis and could cause pressure on the trochlear and the abducens nerve that are in their way, while passing laterally to the clinoid process [20]. On the other hand, bridge formation between the anterior and middle clinoid processes could cause pressure on the internal carotid artery that lies in the cavernous sinus, changing the morphology in the terminal end of the groove of the carotid artery [16].

In the literature, complete sella bridges are rarer than incomplete ones, and incomplete sella bridges occur at a higher rate between the anterior, middle and posterior clinoid processes than do complete sella bridges in the same location [3, 5]. However, contrary to the literature, sellar bridges were mostly complete in the present study. It is also reported that both incomplete and complete fusions generally are more frequent in male than in female individuals [3, 5]. There was no gender difference detected with regard to the type of sella bridges in the present study. It was also reported that sella bridges—if present—were usually bilateral [10]. Complete sella bridges were observed to be usually bilateral and, in the study presented here, the most commonly observed bridge position was the anterior-middle type of bridge.

The lesions of the cavernous sinus for which a direct surgical approach may be considered are carotico-cavernous fistulae, aneurysms of the intracavernous carotid, ophthalmic, and trigeminal arteries, and certain neoplasms. Approaches to the cavernous sinus commonly involve removal of the anterior clinoid process. Removal of the anterior clinoid process is an important step in exposing the structures in the superior part of the cavernous sinus. The presence of an osseous bridge between the tip of the anterior clinoid process and either the middle or posterior clinoid processes makes removal of the anterior clinoid process more difficult and increases the risk of this removal, especially if an aneurysm is present. 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. Therefore, serious weighing of the risks and benefits of operative approaches must be done before the operation because of the magnitude of the operating procedure and the risks of neural and vascular injury [8].

Table 2 Variation among populations

Populations	Male	Female	Total	Authors
Sardinians	–	–	23.4%	Maxia, 1950
South African Blacks	19.2%	14.8%	–	De Villiers, 1968
Amerind Indian	–	–	16–33%	Ossenberg, 1976
Amerind Eskimo	–	–	6–14%	Ossenberg, 1976
African Negro	–	–	30%	Ossenberg, 1976
American Negro	–	–	12%	Ossenberg, 1976
Alaskan Eskimo	17.3%	17.0%	–	Dodo and Ishida, 1987
Ontario Iroquois	34.9%	31.7%	–	Dodo and Ishida, 1987
Japanese	3.9%	6.0%	–	Dodo and Ishida, 1987
Anatolian Population	*39.47%*	*29.26%*	*34.17%*	*Peker et al., 2003*

The incidence of sella bridges shows great variation among different populations. The lowest incidence was found in a Japanese population (male: 3.9%, female: 6.0%), and the highest in an Ontario Iroquois population (male: 34.9%, female: 31.7%) [5]. In South African blacks, sella bridges were observed in 19.2% of male and 14.8% of female subjects [3]. In the study presented here, sella bridges were observed in 39.5% of male subjects, this being the highest incidence when compared with other populations reported in the literature. The incidence in Anatolian female subjects was close to that in the Ontario Iroquois population (Table 2).

The petrosphenoidal ligament (Gruber's ligament), which is a fibrous bundle extending from the apex of the petrous bone to the lateral border of the upper clivus and the posterior clinoid process can sometimes completely ossify [4, 19]. Umansky et al. [19] reported one completely ossified petrosphenoidal ligament and stated that the sixth cranial nerve coursed through a bony canal formed by this ligament. Destrieux et al. [4] reported one calcified petrosphenoidal ligament in 28 specimens. They concluded that the sixth cranial nerve was located below this ligament, except in one case. We also observed one completely ossified petrosphenoidal ligament that formed a bony canal in our cadaveric specimens. No structure was coursing through the bony canal.

In conclusion, the morphological characteristics of sella and sphenopetrous bridges were surprisingly different in the present study among various populations that were reported in the literature. It should be kept in mind that variations in the cranial base are of importance for surgical approaches in that location.

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