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Anterior Clinoid Process and Optic Strut in Koreans

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The anterior clinoid process and the optic strut are often removed during operation on the anterior part of the cavernous sinus. Therefore it is important for neurosurgeons to verify their dimensions and variations. The purpose of this study was to investigate the dimension and the variation of the anterior clinoid process and to describe the locational variation of the optic strut. Seventy-three skulls of Korean adults were used. The average length, basal width and thickness of the anterior clinoid process were 9.18±1.55, 9.63±1.49 and 5.32±1.07 mm, respectively. The average thickness of the optic strut was 2.9±1.15 mm and it was commonly attached to anterior two-fifths of the anterior clinoid process. The complete caroticoclinoid canal was observed in 4.1%, however it was incomplete in 11.6%. The incidence of a caroticoclinoid canal in Koreans was relatively low compared with other races.

Key Words: Anterior clinoid process, caroticoclinoid canal, optic strut, measurement, variation

The anterior clinoid process is a part of the anterior roof of the cavernous sinus. During operations for tumors or aneurysms in the sellar region, the anterior clinoid process and the optic strut are often removed from the lesser wing (Dolenc *et al.* 1987; Parkinson, 1989). For some people, a caroticoclinoid canal is formed by the union of the middle and anterior clinoid processes (Hauser and De Stefano, 1989). It may disturb the exposure of the internal carotid artery or may even cause damage to it. The optic strut, a small bony pillar connecting the body and lesser wing of the sphenoid, is described simply in the literature (Williams *et al.* 1989). Its size and angle have been studied (Parkinson, 1989) but its location and relationship with the anterior clinoid process have not been described. The purpose of this study was to measure the size and to observe the variation of the anterior clinoid process in addition to describing the variation in the location of the optic strut.

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MATERIALS AND METHODS

Seventy-three dry skulls of Korean adults were used for this study. The length, basal width, thickness at the root of the anterior clinoid process and short diameter of the optic strut were measured in 60 skulls (Fig. 1). The incomplete type of caroticoclinoid canal was defined by the existence of the bony spine from the anterior clinoid process and middle clinoid process or lateral side of the body of the sphenoid (Fig. 2). The location of the optic strut was recorded as a

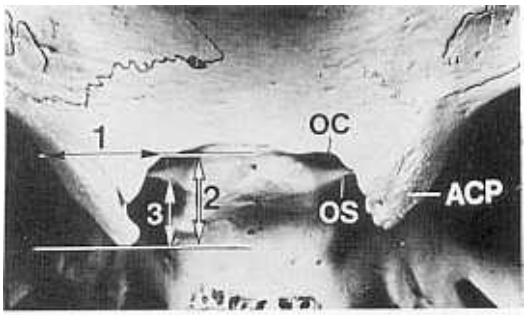

Fig. 1. Measured parameters of the anterior clinoid process. 1: basal width of the anterior clinoid process at the medial margin of the optic canal, 2: length from the anterior clinoid tip to the base, 3: length from the anterior clinoid tip to the posterior margin of the optic strut, ACP: anterior clinoid process, OC: optic canal, OS: optic strut.

Table 1. Dimensions of the anterior clinoid process

	Right side (n=60)	Left side (n=60)
Length	9.26±1.43 (5.90~12.10)	9.09± 1.67* (5.80~14.00)
Width	9.97±1.58 (6.40~12.60)	9.29± 1.39* (6.10~14.10)
Thickness#	5.44±1.02 (3.00~7.70)	5.19± 1.12* (3.00~ 9.90)

*: $p<0.05$ with paired t-test
#: thickness at the base of the anterior clinoid process.
unit: mm, ( ): range

ratio between the length of the anterior clinoid process and the distance from the optic strut to the anterior clinoid tip.

RESULTS

The shape of the anterior clinoid process was variable (Fig. 1, 2). The anterior clinoid process appeared as an inverted triangular shape and its end was medially projected in most cases. The basal width and length of the anterior clinoid process were 9.63±1.49 mm and 9.18±1.55 mm, respectively (Table 1). The difference between the width and the length was larger on the right side than on the left side. The thickness of the process at the root portion was variable and its mean value was 5.32±1.07 mm. Length, basal width and thickness of the anterior clinoid process were longer on the right side than on the left side.

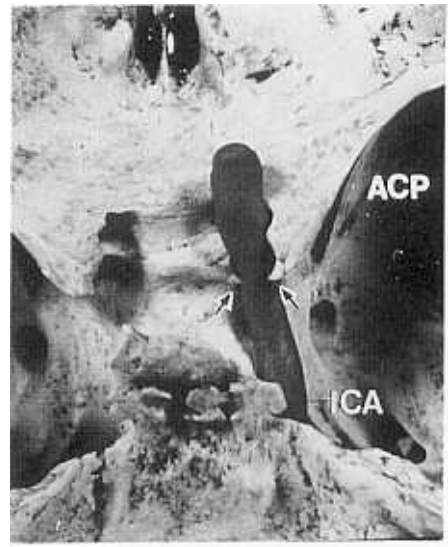

Fig. 2. An incomplete caroticoclinoid canal. Arrows indicate the bony spine from anterior and middle clinoid processes. ACP: anterior clinoid process, ICA: internal carotid artery.

The short diameter of the optic strut ranged from 0.7 to 7.0 mm and its average value was 2.9±1.15 mm. The average diameter of the left strut was slightly larger than that of the right one with a statistical significance. The distance from the optic strut to the anterior clinoid tip ranged from 1.3 to 9.3 mm. The average ratio between the length of the anterior clinoid process and the distance from the optic strut to the anterior clinoid tip was 61.7% on the right and 66.8% on the left. The optic strut was attached to the anterior two-fifths of the anterior clinoid process in 44.9% (Table 2). On the left side, it was located more anteriorly than on the right side. On the right side, the optic strut was located in the posterior one-fifth of the anterior clinoid process in both sides.

A complete caroticoclinoid canal was observed in 4.1% of 146 sides (Fig. 3) and an incomplete type was observed in 11.6% (Fig. 2). Among them, there was one skull (1.4%) with a bilateral complete caroticoclinoid canal, three skulls (4.1%) with bilateral in-

Table 2. Location of the optic strut

	Right side (n=69)	Left side (n=69)
Anterior to ACP root	1.4%	4.3%
Anterior 1/5 of ACP	11.6%	14.5%
Anterior 2/5 of ACP	42.0%	47.8%
Anterior 3/5 of ACP	37.7%	27.5%
Anterior 4/5 of ACP	4.3%	5.9%
Posterior 1/5 of ACP	2.9%	0.0%

ACP: anterior clinoid process

complete canals and one skull with the right canal complete and the left incomplete. Both complete and incomplete types were more frequent on the right side (9.2%) than on the left side (5.5%).

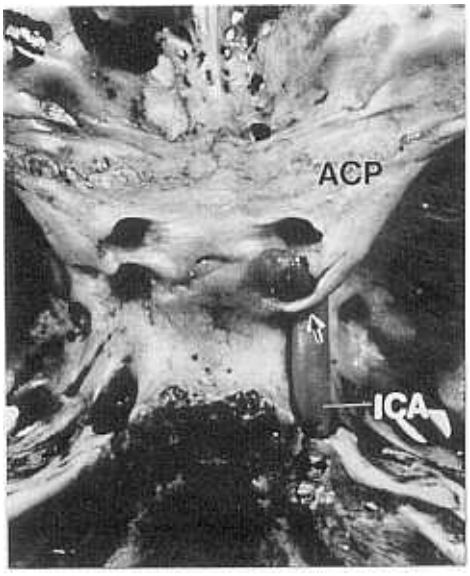

Fig. 3. A complete caroticoclinoid canal. Arrow indicates complete bony bridge between anterior and middle clinoid processes. ACP: anterior clinoid process, ICA: internal carotid artery.

DISCUSSION

The length and basal width of the anterior clinoid process of Koreans were smaller than those of Americans (Inoue *et al.* 1990), but the thickness was larger. Measurements on the right side were larger than those on the left side with statistical significance, even though the difference between the two sides was less than 1 mm.

The posterior root of the sphenoid, or the optic strut, is located between the optic canal and the superior orbital fissure. During surgery of the sellar region, it is often detached from the lesser wing with the anterior clinoid process to provide better access to the anterior portion of the cavernous sinus or the posterior portion of the orbit. The complex anatomy surrounding the anterior clinoid process is important for a surgical approach to the cavernous sinus (Umansky *et al.* 1994). The superficial dural layer and the thin deep-layer cover the anterior clinoid process from above and below. Removal of the anterior clinoid process will reveal a clinoid space, and the anterior vertical segment of internal carotid artery, which is located medially, can be identified. However, surgical exposure requires removal of the optic strut as well because the anterior clinoid process is continuous with the optic strut and the remaining part of the optic strut may cause injury to the optic nerve or the carotid artery during surgery. The clinoid segment of the internal carotid artery, still extracavernous, is surrounded by two fibrous rings: a distal ring formed by the superficial dural layer, and a proximal dural ring related to the deep dural layer. The internal carotid artery becomes intracavernous below the proximal ring, and the cavernous segment of the internal carotid artery could be mobilized after cutting both carotid rings. In Koreans, the average thickness of the optic strut was 2.9 ± 1.15 mm, however a thin optic strut with a thickness of less than 2 mm was not infrequently observed. In this study, the location of the optic strut was described based on the length of the anterior clinoid process. It was located commonly on the anterior two-fifths of the anterior clinoid process. When the optic strut was located on the posterior one-fifth, it was thick and stout. Therefore it may require careful drilling and dissection in such cases during surgery.

The caroticoclinoid canal is formed by a union of the anterior clinoid process on its medial side with the tip of the middle clinoid process that arises from the tuberculum sellae or the lateral side of the body of the sphenoid. It converts the terminal part of the

carotid groove into the foramen which frequently affects the course of the internal carotid artery in the cavernous sinus (Platzer, 1957). The internal carotid artery has proximity to the optic nerve when it enters its foramen, and it is of particular interest to neurosurgeons. When the anterior and middle clinoid processes fuse to form the caroticoclinoid canal, it is impossible to retract or mobilize the cavernous segment of the carotid artery even after releasing the proximal and distal carotid rings. Preoperative recognition of the caroticoclinoid canal is important, because undue retraction of the cavernous segment of the internal carotid artery may tear or rupture it and cause fatal cerebral infarction. Therefore, detection of the caroticoclinoid canal by imaging studies has much greater clinical significance than identification of pnematization or erosion of the anterior clinoid process (Korouse and Heros, 1992) when approaching a surgical lesion within the cavernous sinus.

There is a racial difference in incidence of the caroticoclinoid canal. The frequencies of the combined complete and incomplete types are 3.9% in male and 6.0% in female Japanese (Dodo and Ishima, 1987), 17% in Alaskan Eskimos (Dodo and Ishima, 1987), 23.4% in Sardinians (Maxia, 1950) and 34.84% in Americans (Keyers, 1935). Koreans (15.7%) show relatively lower frequency. In Americans, bilateral caroticoclinoid canals were frequent and unilateral ones preferentially occur on the left side (Keyers, 1935; Lang, 1977). However, in Koreans, unilateral caroticoclinoid canal was predominant and occurred on the right side preferentially.

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