

ANATOMY

The Intracranial Course of The Abducens Nerve

Nervus Abducens'in Kafa İçindeki Seyri

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Abstract: Because of its long intracranial course, the abducens nerve can easily be injured due to the internal carotid artery aneurysm, Gradenigo's syndrome or surgical trauma. Therefore the intracranial course of this nerve is important. In this study, we used 42 dry skulls, 8 fixed and 4 fresh cadavres. We found the subarachnoidal segment to be 13.00 ± 1.19 mm, the intradural segment 7.6 ± 0.95 mm and the intracavernous segment 22.8 ± 2.1 mm in length. Furthermore we measured the distances and discussed the relation of the abducens nerve with the clivus region and other neighbouring structures.

Key Words: Abducens nerve, cavernous sinus, Dorello's canal, internal carotid artery, nerve injury

Özet: Nervus abducens internal karotid arter anevrizması, Gradenigo sendromu veya cerrahi travma nedeniyle hasar görebilir. Dolayısıyla bu sinirin kafa içindeki seyri önemlidir. Bu çalışmada 42 kuru kafatası, 8 tesbit edilmiş 4 taze kadavra üzerinde sinirin seyri incelendi. Sinirin subaraknoid bölümünün uzunluğu 13.00 ± 1.19 mm, intradural bölümünün uzunluğu 7.60 ± 0.95 mm, intrakavernöz bölümünün uzunluğu 22.8 ± 2.1 mm olarak bulundu. Nervus abducens'in klival bölgedeki diğer yapılara olan mesafesi ve ilişkileri belirlenerek tartışıldı.

Anahtar sözcükler: Dorello kanalı, internal karotid arter, kavernöz sinüs, nervus abducens, sinir yaralanması

INTRODUCTION

Somatomotor fibres belonging to the abducens nerve begin from a small nucleus called the nucleus nervi abducentis which is at the colliculus facialis over the rhomboid fossa. The fibres coming out from this region spread to the ventral sides and leave the sulcus bulbopontinus right over the eminentia pyramidalis (1).

The abducens nerve, leaving the brain, follows a path which is upwards and outwards. During its course it remains at the back of the inferior anterior cerebellar artery.

The part of the nerve which lies over the clivus where it passes through the dura mater encephali is called the subarachnoidal or intracisternal segment.

The part of the abducens nerve which draws a sharp curve upwards between the two layers of the dura mater is called the petroclival segment. In its course the abducens nerve is in close relationship with the inferior petrosal sinus and the posterior meningeal artery.

About 3-5 mm above the petrous part, the abducens nerve makes an angle of 120° and goes right into the cavernous sinus. At the level of the petrous part, it passes through the Dorello's canal which is bordered by the petrosphenoidal ligament and the posterior clinoid process (1,2,3,4). Even though the Dorello's canal is not defined by most anatomy books its is usually described and used by clinicians.

The abducens nerve courses over the lateral side of the internal carotid artery in the cavernous sinus,

from the anterior end of the Dorello's canal to the superior orbital fissura. This part in the cavernous sinus is called the intracavernous segment (4).

Due to its long intracranial course and sharp curve over the apex partis petrosae, abducens nerve injuries are frequent (7,1). These can be internal carotid artery aneurysms, cavernous trauma, Gradenigo's syndrome, surgical trauma, lesions, tumours and other factors that increase intracranial pressure or diseases of the cranial basis. It can also be injured while passing from Dorello's canal which has an osteofibrous structure (5,6,7).

Knowing the exact intra and extra dural courses and the surgical anatomy of this nerve is very important in decreasing the risk of complications during operations on the clivus and the cavernous sinus.

In this study our aim was to describe the intracranial course and the surgical anatomy of the abducens nerve in detail and its relation with Dorello's canal.

MATERIAL AND METHOD

For this research on the abducens nerve, we used 42 dry skulls from the University of Ankara, School of Medicine to search for the Dorello's canal.

We also observed the subarachnoidal, intradural and intracavernous course of the abducens nerve, investigated its relation with the petrosphenoidal ligament (Gruber's ligament) and made morphometric measurements on 8 fixed and 4 fresh cadavers.

The calvaria was removed by a cut passing through the arcus superciliaris, external occipital protuberance and zygomatic arcs on the sides. After removing the falx and the cerebellar tentorium, the hemispheres of the brain were cut and removed at the level of the mesencephalon. The abducens nerve, its subdural path, and its relation with the surrounding structures were seen. Later we removed the lateral wall of the cavernous sinus and part of the dura mater, beginning from the posterior clinoid process, and then the intradural and extradural segments of the nerve were seen.

During this study we filled the internal carotid artery and the ophthalmic artery with latex to see the relation of the intracavernous segment of the abducens nerve and the truncus meningo hypophysialis.

During the dissections a surgical microscope was used.

FINDINGS

Of the 42 dry skulls we examined, the bone canal, which should have been 1 cm below the posterior clinoid process, could only be seen in one (Figure 1). This canal, through which the abducens nerve is thought to pass opened right behind the apex partis petrosae and was considered to be the beginning of the Dorello's canal.

The morphometric measurements of the abducens nerve and its relations with other structures in the clivus region are given in Table 1 and Figure 2.

Table I. Morphometric measurements of the abducens nerve.

	mean (mm)	max (mm)	min (mm)
A-B	16.4	13.2	17.0
A-C	11.3	10.3	12.6
A-D	6.2	5.8	6.7
A-F	11.6	9.7	12.3

A-B From the abducens nerve to the oculomotor trigon
 A-C From the abducens nerve to the trochlear nerve
 A-D From the abducens nerve to the trigeminal nerve
 A-F From the abducens nerve to the facial nerve

We measured and found the subarachnoidal segment to be 13.00±1.19 mm, the intra dural segment 7.6±0.95 mm, and the intra cavernous segment 22.8±2.1 mm on fixed and fresh cadavers (Figure 3).

The abducens nerve was found to pass through Dorello's canal under the petrosphenoidal ligament in all specimens (Figure 4).

In one specimen the abducens nerve was found to emerge from the sulcus bulbopontinus in one arm, than split into two, and after passing through the duramater encephali the two arms joined in the intradural region to form a single arm (Figure 5).

In three specimens the meningo hypophysial artery originating from the internal carotid artery, passed over the abducens nerve but in others it passed near to the petrosphenoidal ligament.

In all specimens the abducens nerve made an upward arch where it passed the dura mater encephali, turning to the medial region over the apex partis petrosae and leading front on the lateral side of the internal carotid artery (I.C.A.). The biggest angle was where it passed the dura mater encephali (135°) (Figure 6).

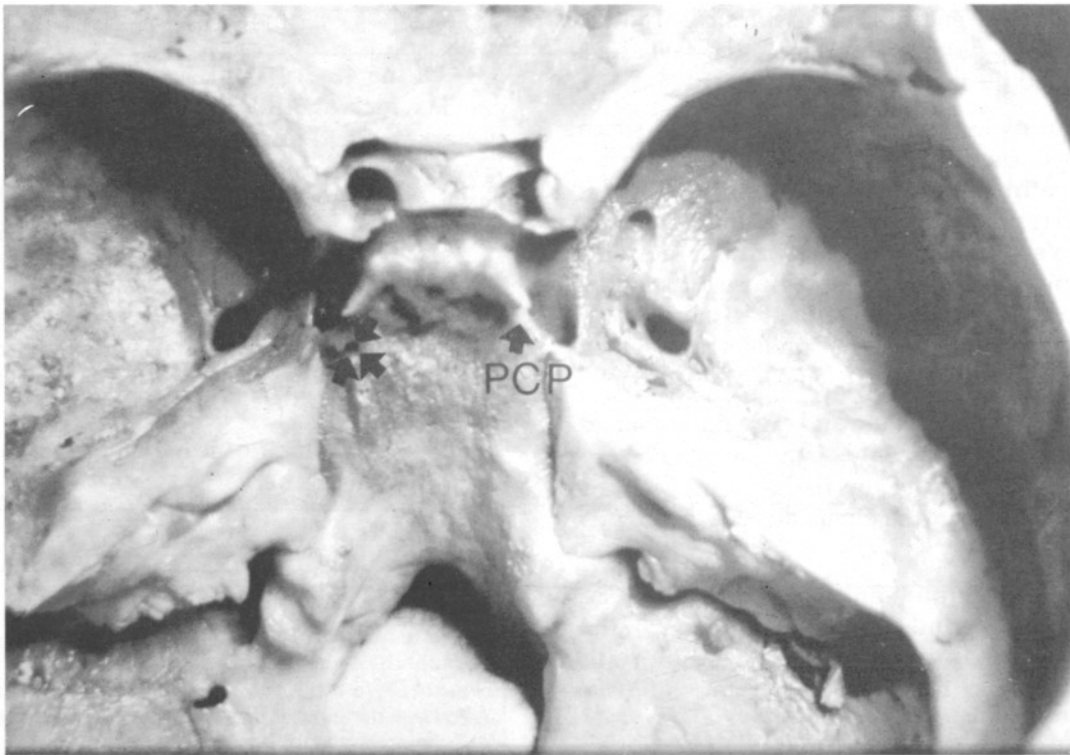


Figure 1: Dorello's canal is situated 1 cm below the posterior clinoid process (arrow: Dorello's canal; PCP: posterior clinoid process).

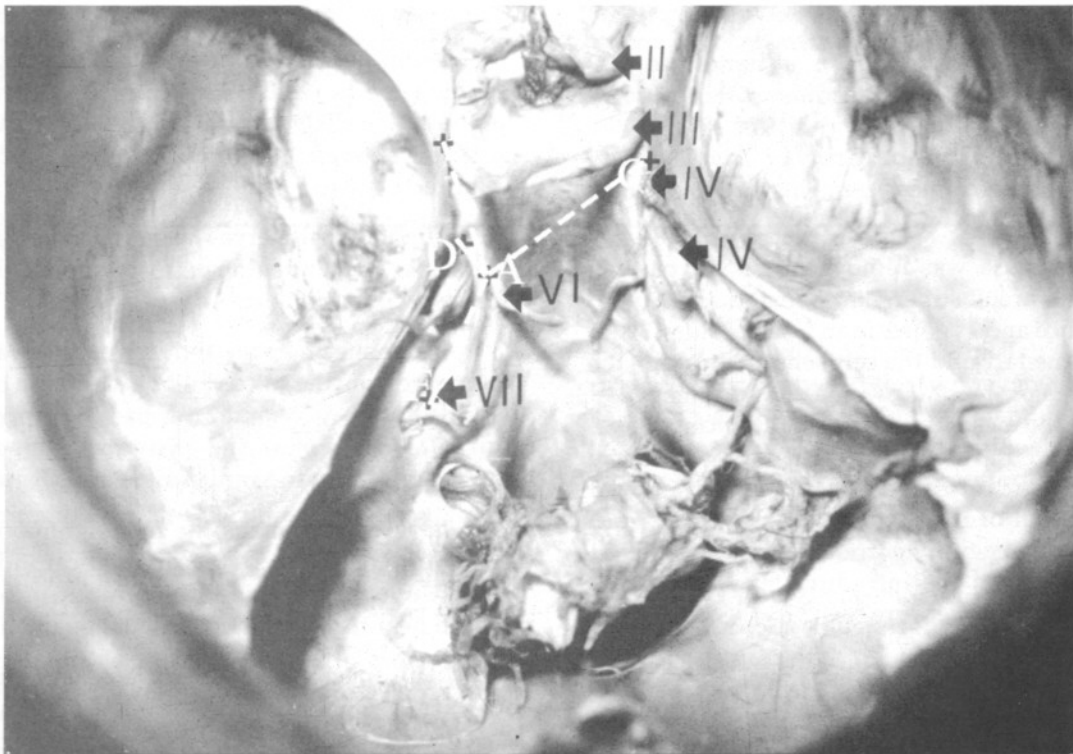


Figure 2: Morphometric measurements of the abducens nerve (II: optic nerve; III: oculomotor nerve; IV: trochlear nerve; V: trigeminal nerve; VI: abducens nerve; VII: facial nerve; A-B: From the abducens nerve to the oculomotor trigon; A-C: From the abducens nerve to the trochlear nerve; A-D: From the abducens nerve to the trigeminal nerve; A-F: From the abducens nerve to the facial nerve).



Figure 3: The intradural segment of the abducens nerve (arrows: abducens nerve).

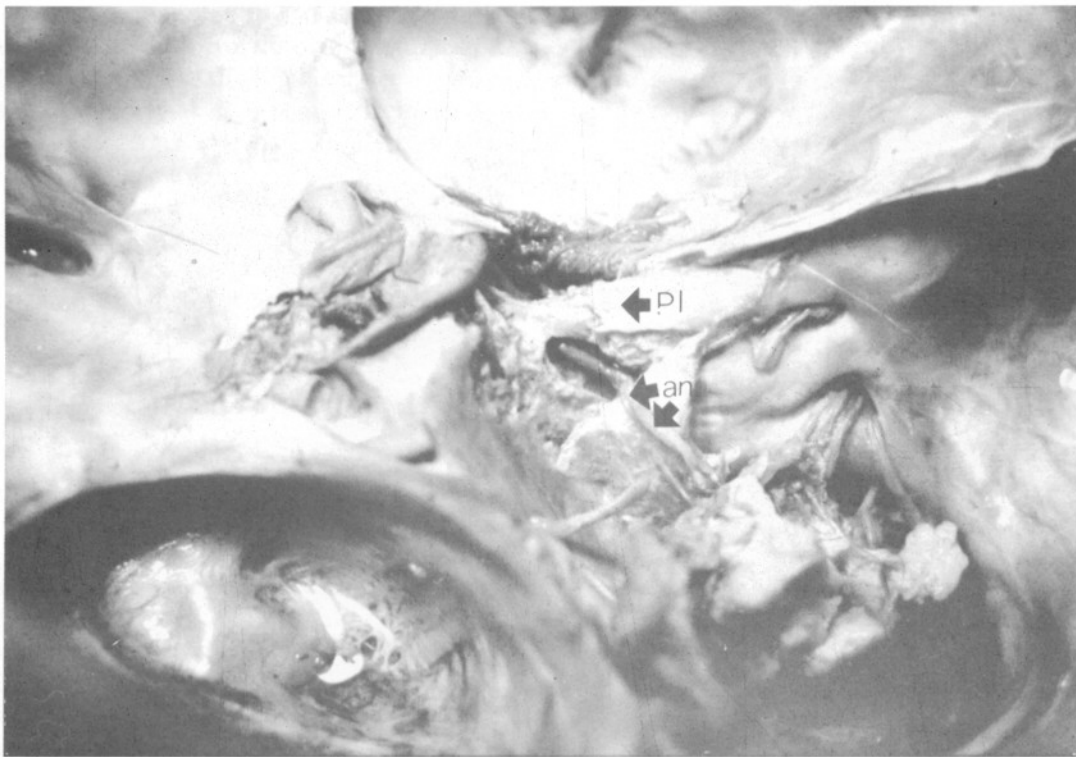


Figure 4: The abducens nerve is under the petrosphenoidal ligament (pl: the petrosphenoidal ligament; an: abducens nerve).



Figure 5: The intracavernous segment of the abducens nerve can be seen as two armed, under the petrosphenoidal ligament (pl: the petrosphenoidal ligament; an: the abducens nerve; double arrow: optic nerve).

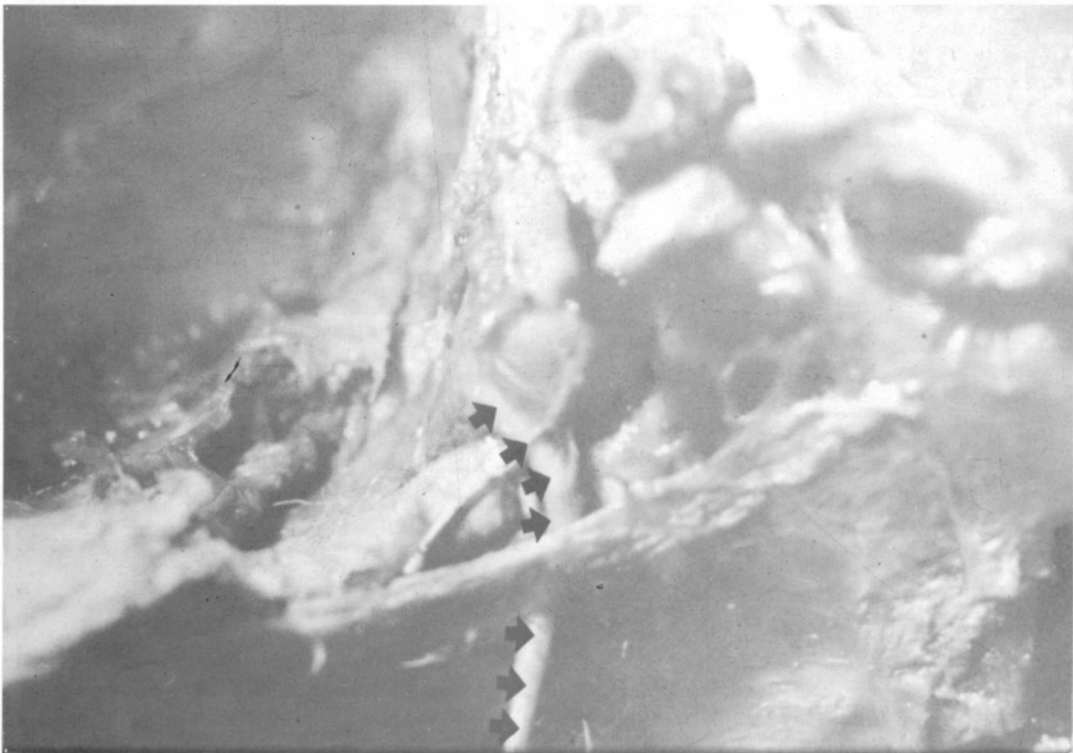


Figure 6: The abducens nerve making an arch of approximately 135° (arrow heads).

In its intracranial course the abducens nerve was attached weakly where it passed from the duramater encephali and under the petrosphenoidal ligament, on the other hand it was strongly fixed to the lateral wall of the I.C.A. These are the three points of fixation.

Most authors on anatomy do not mention the bone canal found in dry skulls which, according to Umansky (6) and Lang, (3) is formed by ossification of the petrosphenoidal ligament. In our studies when present, it formed the beginning of the complete Dorello's canal.

Understanding the relation of the abducens nerve with the surrounding structures and its localisation in the clivus is important for topographical anatomy.

Lang (3) found the intradural segment of the abducens nerve to be 6.1 mm away from the trigeminal nerve, 13.9 mm from the facial nerve, 20 mm away from the posterior clinoid process, and 20 mm from the point where it passed through the dura mater encephali.

In our research we found the abducens nerve 16.4 mm away from the top of the oculomotor trigon, and 11.3 mm from where the trochlear nerve passes the dura mater encephali. These measurements are important for surgeons operating on the cavernous sinus.

In this detailed work defining the abducens nerve's course, the intra cisternal segment was 15.05 ± 1.19 mm on the right and 15.7 ± 1.99 mm on the left. The petroclival segments were 10.9 ± 1.11 mm on the right and 10.7 ± 1.49 mm on the left and finally the intra cavernous segment was 25.67 ± 2.36 mm on the right and 25.5 ± 2.03 mm on the left. No right-left discrimination was made when gathering the results (7). We think that it would be better to call the petroclival segment the intradural segment because of its route between the two layers of the dura mater.

Nathan (4) reported that the abducens nerve emerged from the bulbopontin sulcus as one trunk, then split into two, and passed under and over the petrosphenoidal ligament in 6 percent of their material. But in 7.5% they also saw the nerve coming out in two arms and again following the same course.

In our study, all the abducens nerve fibres passed under the ligament as one trunk except for one case where it was two-armed.

The abducens nerve is reported to make a wide angle at the point where it passes the dura mater encephali, and a right angle over the apex of the petrosal part (2).

Researchers working on abducens nerve trauma, have reported that the abducens nerve formed an angle of 120° over the apex partis petrosae (6), but according to our observations, it makes an angle of 100° over the apex partis petrosae and its widest angle is at the intradural segment. The path of the intracavernous segment completely depends on the location and width of the I.C.A. (4).

The petroclival segment of the abducens nerve is in close relationship with the meningohypophysial truncus and the inferior petrosal sinus. The meningohypophysial truncus is responsible in feeding the abducens nerve and the dura mater of this region (5). We observed the posterior meningeal artery passed through Dorello's canal in 80% of our material and over the channel in 20%.

In three of our specimens, the meningohypophysial truncus passed over the abducens nerve and in others it passed close to Gruber's ligament.

The abducens nerve was fixed where it passed from the intradural space to the extradural space, under Gruber's ligament in Dorello's canal. In addition, it was tightly bound to the lateral wall of the I.C.A., with sympathetic fibres originating from the internal carotic plexus.

The fixation at the level of the dura mater encephali and Gruber's ligament is important in explaining abducens nerve injuries in head trauma.

In our research the abducens nerve was found to be completely fixed to the dura mater and consequently to Gruber's ligament at Dorello's canal and (by sympathetic fibres) to the lateral wall of the I.C.A.

CONCLUSION

The abducens nerve, which runs in the intradural and extradural space at the posterior

cranial fossa, median cranial fossa and orbital space, can easily be injured because of its long course. Its relationship with important structures is important for researchers and surgeons.

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