

The Course of the Ophthalmic Nerve Both in the Cavernous Sinus and Orbit

N. Ophthalmikusun Kavernoöz Sinüs ve Orbita İçindeki Seyri

AYSUN UZ, ERAY TÜCCAR, İBRAHİM TEKDEMİR, ALAİTTİN ELHAN

Ankara University Faculty of Medicine Department of Anatomy, Ankara, Turkey

Abstract: Anatomy of the ophthalmic nerve should be well-known in order to perform safe surgical intervention to the Parkinson's triangle, the orbit, and for the causes leading to the superior orbital fissure syndrome. Thirty ophthalmic nerves rising from the trigeminal ganglion and course in the cavernous sinus and orbit, from 15 cadavers fixed with 10% formaldehyde solution were examined. The two dural layers of the lateral wall differ; superficial layer is thick and regular, the deep is thin and irregular. The ophthalmic nerve runs between these two layers. The mean length of the nerve from the trigeminal ganglion to superior orbital fissure was 18,12 mm (13 mm - 22 mm) and part of the nerve forming the inferior border of the Parkinson's triangle was 16,44 mm (11 mm - 19 mm). The ophthalmic nerve gives rise the frontal, the lacrimal, and the nasociliary branches, before passing the superior orbital fissure. The frontal branch crosses the annulus of Zinn with the trochlear nerve laterally. The lacrimal branch, runs superiorly over the superior orbital vein. The nasociliary branch runs over the abducens nerve superiorly and between the two parts of the oculomotor nerve.

Key Words: Anatomy, cavernous sinus, ophthalmic nerve, orbit.

Özet: Kavernoöz sinüse, Parkinson üçgenine ve orbitaya yapılacak cerrahi müdahalelerin daha güvenli olabilmesi için ve fissura orbitalis superior sendromuna neden olan patolojilerin cerrahi tedavisinde n. oftalmikus'un anatomisinin iyi bilinmesi gerekir. Biz %10'luk formaldehit solusyonu ile fikse edilen 15 kadavrada 30 n. oftalmikus'un, ganglion trigeminale'den çıkış yeri, kavernoöz sinüs ve orbita içindeki seyrini Opmi 1 disseksiyon mikroskopunda çalıştık. Kavernoöz sinüsün lateral duvarında iki dural tabaka vardır; yüzeysel tabaka kalın ve düzenli, derin tabaka ince ve düzensizdir. N. oftalmikus bu iki tabaka arasında seyretmektedir. Kavernoöz sinüsün ganglion trigeminale'den fissura orbitalis superior'a (intrakavernoöz bölüm) kadar olan uzunluğu ortalama 18,12 mm (13 mm - 22 mm) idi. Parkinson üçgeninin alt sınırını oluşturan bölümünün uzunluğu ortalama 16,44 mm (11 mm - 19 mm) idi. N. oftalmikus, fissura orbitalis superior'a girmeden önce n. frontalis, n. lakrimalis ve n. nasosiliaris olmak üzere üç dalına ayrılır. N. frontalis, n. troklearis ile Zinn halkasını dıştan çaprazlar. N. lakrimalis, v. orbitalis superior üzerinde seyredir. N. nasosiliaris ise n. abducens üzerinde ve n. okulomotorius'un iki başı arasından geçer.

Anahtar Sözcükler: Anatomi, nervus oftalmikus, orbita, kavernoöz sinüs

INTRODUCTION

The ophthalmic nerve (V₁), the first division of the fifth nerve, is completely sensory. It supplies the eyeball, the lacrimal gland and the conjunctiva, part

of the nasal mucosa, and the skin of the nose, eyelids, forehead and part of the scalp (1,6).

After rising from the trigeminal ganglion (trigeminal ggl.), the ophthalmic nerve enters the

lateral wall of the cavernous sinus. The ophthalmic nerve runs between the two dural layers of the lateral wall of the cavernous sinus inferiorly to the oculomotor nerve (III) and the trochlear nerve (IV). It has relationships with a number of neurovascular structures in the cavernous sinus (2,3,10,11,12). Those relationships are very important in the surgical interventions. Parkinson, for instance, described a triangle through which the intracavernous part of the internal carotid artery (ICA) could be surgically approached with less complication (9). We studied the anatomy of the two parts of the ophthalmic nerve in the cavernous sinus and in the orbit.

MATERIALS AND METHODS

We examined 30 ophthalmic nerve courses and their relationships within the cavernous sinus and the orbit, obtained from 15 cadavers fixed with 10% formaldehyde solution.

The optic nerves were cut at the chiasma and the cerebral hemispheres were removed. A Zeiss Opmi 1 surgical microscope was used to examine the ophthalmic nerves. Two layers of the lateral wall of the cavernous sinus were detached carefully. Firstly the intracavernous part of the nerve was studied. Then, lesser wings of the sphenoid bone were removed by a dental drill for the intraorbital part to be studied.

All the ophthalmic nerves were photographed by a Leica M3 camera.

RESULTS

In this study we defined two parts of the ophthalmic nerve; the intracavernous and the intraorbital parts.

The intracavernous part refers to the part from the trigeminal ganglion to the superior orbital fissure. It runs between two dural layers in the lateral wall of the cavernous sinus. A dissection was performed from the anterior clinoid process to the Meckel's cave. When the superficial layer of the dura, which was regular, thick and complete, was elevated, the ophthalmic, the trochlear and the oculomotor nerves were situated from inferior to superior, respectively, in all specimens (Figure 1 and 2). The deep layer of the dura, which was irregular, thin and sometimes incomplete, lies between the three nerves. The internal carotid artery and the abducens nerve was observed in the cavernous sinus after dissection was

continued to the Meckel's cave and the deep layer was elevated. The abducens nerve was between the medial of the ophthalmic nerve and lateral of the internal carotid artery. After further dissection of the superficial layer, we reached the trigeminal ganglion. The ganglion was separated from the internal carotid artery by the bony floor of the Meckel's cave. The ophthalmic nerve rose from the anterior-medial of the trigeminal ganglion and continued to the superior orbital fissure making a slope from medial to lateral in all cases. We measured the mean length of this part of the nerve as 18,12 mm (13 mm - 22 mm) in the cadavers. Further, we also found the average length of the part of the nerve forming the inferior margin of the Parkinson's triangle (Figure 1) as 16,44 mm (11 mm - 19 mm) in the cadavers.

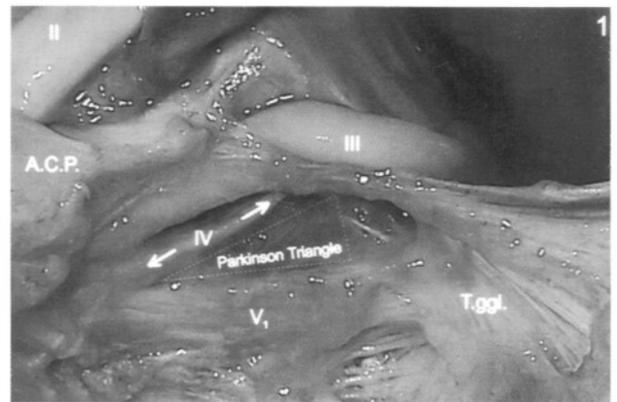


Figure 1. A normal Parkinson triangle on the left cavernous sinus of a cadaver specimen is shown by the dotted lines. The superior border is formed by the inferior margin of the trochlear nerve (IV), the inferior border by the superior margin of the ophthalmic nerve (V_1) and the posterior border by the slope of the dorsum sellae and the clivus. The optic and the oculomotor nerves (II,III) together with the anterior clinoid process (ACP) can also be seen in the figure.

- II: optic nerve
- III: oculomotor nerve
- IV: trochlear nerve
- V_1 : ophthalmic nerve
- T.ggl: trigeminal ganglion
- ACP: anterior clinoid process

The intraorbital part of the ophthalmic nerve lies in the orbital cavity, anterior to the superior orbital fissure. The ophthalmic nerve gives rise the frontal, the lacrimal, and the nasociliary branches, before the superior orbital fissure. The nasociliary nerve entered the superior orbital fissure between the abducens nerve superiorly and the inferior branch of the oculomotor nerve laterally (Figure 3). In the

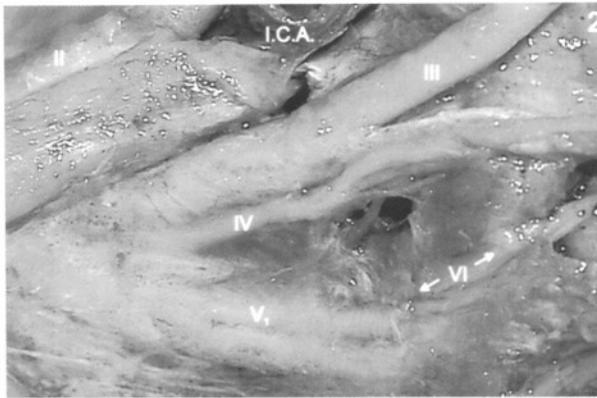


Figure 2. In this left cavernous sinus we can see the V₁ on the lateral wall, lying inferior to the IV and also lateral to the VI, which is situated inside the cavity of the cavernous sinus.

- II: optic nerve
- III: oculomotor nerve
- IV: trochlear nerve
- V₁: ophthalmic nerve
- VI: abducens nerve
- ICA: internal carotid artery



Figure 3. In this figure, which shows the right part of the head, the annulus of Zinn is incised and the cranial nerves III, VI and the nasociliary branch of the V₁ are exposed. The arrows show the annulus of Zinn after being opened. Q shows the inferior branch, H shows the superior branch of the oculomotor nerve. The optic nerve is also seen medial to the superior orbital fissure.

- II: optic nerve
- VI: abducens nerve

orbit, it lay between the two branches of the oculomotor nerve. The nasociliary nerve crossed the ophthalmic artery superiorly with the optic nerve and run obliquely to the medial part of the orbit. The lacrimal nerve was the smallest branch of the ophthalmic nerve and passed from the lateral part

of the superior orbital fissure (Figure 4). It lay between the lacrimal artery and the lateral rectus muscle. It also crossed the superior orbital vein at the level of the superior head of the lateral rectus muscle. The frontal nerve was the largest branch and was in close relationship with the third and the fourth cranial nerves (Figure 4). It crossed two branches of the oculomotor nerve and the optic nerve surrounded by the annulus of Zinn in a superior-anterior direction. It run inferiorly and laterally to the trochlear nerve. The frontal nerve was medial to the lacrimal nerve and crossed the annulus of Zinn laterally with the trochlear nerve.

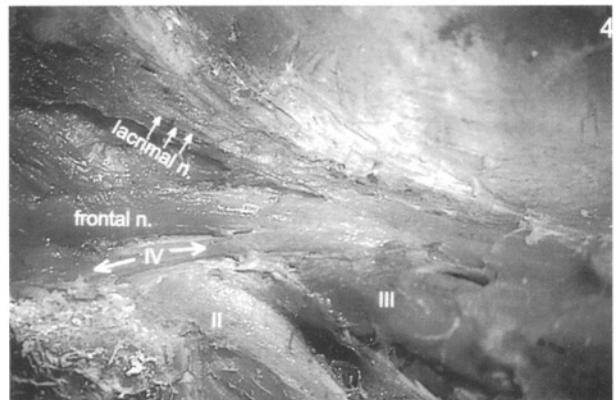


Figure 4. This figure shows the right part of the head. The superficial nerves can be seen after removing the orbital roof and the periorbita. The optic nerve is on the medial side. The superficial nerves on the orbital roof are the frontal and the lacrimal branches of the V₁ and the trochlear nerve. The nerve IV lies on the medial side as it innervates the superior oblique muscle. The lacrimal nerve lies rather laterally to bring parasympathetic fibers to the lacrimal gland.

- II: optic nerve
- III: oculomotor nerve
- IV: trochlear nerve

DISCUSSION

We found two layers of the dura in the lateral wall of the cavernous sinus in which the oculomotor nerve, the trochlear nerve and the ophthalmic nerve situated as stated by the other authors (2,3,10,11,13,14). Furthermore, Umansky et al. pointed out that the deep layer was an extension of the sheath of the third, fourth, and the first and second branches of the fifth nerves and was sometimes incomplete. According to their findings, a superficial compartment of the dura was not found

between the two layers and the nerves were not observed to be running embedded in the superficial layer in any case (13). Kawase et al.'s findings were similar to those of Umansky et al. stating that the deep layer which covered the cranial nerves was a thin and semitransparent one and that his layer passed through the superior orbital fissure with the cranial nerves to enter the orbit; the deep layer continued anteriorly as the periost in the orbit and posteriorly as the inner layer (4).

The length of the intracavernous part of the ophthalmic nerve was measured 18,12 mm average (13 mm - 22 mm) in our study while 15,52 mm average (9,2 mm - 20,5 mm) by Lang (7).

We found the average length of the part of the ophthalmic nerve forming the lower rim of the Parkinson's triangle as 16,44 mm (11 mm - 19 mm) in the cadavers. The same part was measured as 14 mm (5 mm - 24 mm) by Harris and Rhoton (2) and 16.5 mm (10 mm - 22 mm) by Inoute and Rhoton (3).

Importance of the branches of the ophthalmic nerve in the superior orbital fissure and the orbit and its relationships with neurovascular structures are stated in the literature (5,8). The superior orbital fissure is one of the links between the orbital and the intracranial cavity. This region may be involved by pathological process originating either in the orbital cavity or in the cranial cavity (i.e. superior orbital fissure syndrome is caused by fractures, inflammations, tumors, aneurysms, a-v fistulas and other vascular anomalies) (5,8). Any intervention to the ophthalmic nerve in the orbit can lead to oculocardiac and even trigeminocardiac reflexes. Those reflexes can result in bradycardia and asystole because their afferents are carried by the vagus nerve (6). In addition, lesions of the ophthalmic nerve and its branches may result in anesthesia or hypesthesia of the cornea (occasionally keratitis), anesthesia in the area supplied by the ophthalmic nerve, and sometimes by neuralgia's in this area (5).

In conclusion, anatomy and relationships of the ophthalmic nerve with the neural structures in the cavernous sinus and in the orbit should be well-known by both the surgeons and the clinicians for appropriate diagnosis and therapy.

Correspondence: Aysun Uz
AÜ Tıp Fakültesi,
Morfoloji Binası,
Anatomi Anabilim Dalı
06100 Sıhhiye, Ankara, Turkey

REFERENCES

1. Gray H: Anatomy, Gray's Anatomy, 38th edition. Great Britain, 1994, 1230+9 p.
2. Harris FS, Rhoton AL Jr: Anatomy of the cavernous sinus: A microsurgical study. *J Neurosurg* 45:169-180, 1976
3. Inoute T, Rhoton AL Jr, Theele D, Barry ME: Surgical approaches to the cavernous sinus: A microsurgical study. *Neurosurgery* 26:903-932, 1990
4. Kawase T, van Loveren H, Keller JT, Tew JM: Meningeal architecture of the cavernous sinus: Clinical and surgical implications. *Neurosurgery* 39:527-535, 1996
5. Lang J: Skull Base and Related Structures: Atlas of Clinical Anatomy, Stuttgart, New York: Schattauer, 1995, 188 p.
6. Lang J, Langigan DT, Van der Wal M: Trigemino-cardiac reflexes: maxillary and mandibular variants of the oculocardiac reflex. *Can J Anaes* 38:757-760, 1991
7. Lang J, Reiter W: Über die dem orbitadach und-rand angelagerten strecken des n. ophthalmicus und seiner aste. *Neurochirurgia* 30:129-134, 1987
8. Morard M, Tcherekayev V, de Tribolet N: The superior orbital fissure: A microanatomical study. *Neurosurgery* 35: 1087-1093, 1994
9. Parkinson D: A surgical approach to the cavernous portion of the carotid artery: Anatomical studies and case report. *J Neurosurg* 32:474-483, 1965
10. Perneczky A, Knosp E, Matula C: Cavernous sinus surgery approach through the lateral wall. *Acta Neurochirurgica (Wien)* 92:76-82, 1988
11. Sekhar LN, Burgess J, Akin O: Anatomical study of the cavernous sinus emphasizing operative approaches and related vascular and neural reconstruction. *Neurosurgery* 21:806-816, 1987
12. Sekhar LN, Lanzino G, Sen CN, Pomonis S: Reconstruction of the third through sixth cranial nerves during cavernous sinus surgery. *J Neurosurg* 76:935-943, 1992
13. Umansky F, Nathan H: The lateral wall of the cavernous sinus with special reference to the nerves related to it. *J Neurosurg* 56:228-234, 1982
14. van Loveren HR, Keller JT, El-Kalliny M, Scodary DJ, Tew JM: The Dolenc technique for cavernous sinus exploration (cadaveric prosection). *J Neurosurg* 74:837-844, 1991