A New Segment of the Trochlear Nerve: Cadaveric Study with Application to Skull Base Surgery

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Abstract

Objectives The trochlear nerve is important to preserve during approaches to the skull base. Traditionally, this nerve has been divided into cisternal, cavernous, and orbital segments. However, the authors anecdotally observed an additional segment during routine cadaveric dissections. Therefore, they performed this study to better elucidate this anatomy.

Design Twenty latex-injected cadaveric sides (10 adult cadavers) were dissected with the aid of an operating microscope. Standard microdissection techniques were used to examine the course of the distal cisternal and precavernous segments of the trochlear nerve.

Setting Cadaver laboratory.

Main Outcome Measures Measurements were made using a microcaliper. Digital images were made of the dissections.

Results The authors identified a previously undescribed segment of the trochlear nerve in all specimens. This part of the nerve coursed between the entrance of the trochlear nerve into the posterior corner of the oculomotor trigone to the posterior wall of the cavernous sinus. This segment of trochlear nerve was, on average, 4 mm in length.

Conclusions The authors have identified a new segment of the trochlear nerve not previously described. They propose that this be referred to as the *trigonal segment*. Knowledge of the microanatomy of the trochlear nerve is useful to skull base surgeons.

Keywords
- microanatomy
- cranial nerves
- trochlear nerve
- neurosurgery

Introduction

The anatomy of the cranial nerves is, in general, well understood and lacking controversy.[1] For example, anatomical knowledge of the trochlear nerve has not changed in hundreds of years. Because the trochlear nerve travels through multiple regions of the intracranial compartment, knowledge of its detailed surgical anatomy is necessary for the neurosurgeon, as this nerve may be encountered in many areas such as the supracerebellar, middle cranial fossa, parasellar, and orbital regions.

The trochlear nerve originates from the trochlear nuclei in the caudal midbrain at the inferior collicular level and carries

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primarily motor fibers destined for the superior oblique muscle. The fibers emerge from the dorsal surface of the brain stem, with the rootlets combining to form the cisternal segment of the nerve. These emerge from below the inferior colliculus.[2,3] The initial portion of the cisternal segment travels in the quadrigeminal plate cistern but continues laterally and inferiorly through the ambient cistern. There is some variation as to where the cisternal segment travels, with the nerve passing laterally from the inferior colliculus to the free edge of the tentorium, then travelling perpendicularly to the anterior direction. In 60%, the nerve travels more obliquely, taking a more direct route. In either case, the cisternal segment follows the same path as the superior cerebellar artery, the posterior cerebral artery, and the basal vein of Rosenthal.[2] The nerve then pierces the dura at the level of the rostrolateral free edge of the tentorium cerebelli. The cavernous segment is classically described as beginning at this point, taking an anterior path in the lateral wall of the cavernous sinus with the oculomotor nerve superior and the ophthalmic division of the trigeminal nerve inferior to it. The trochlear nerve then leaves the skull through the superior orbital fissure superior to the common tendinous ring. Once in the orbit, the nerve then travels to its only innervation, the superior oblique muscle, where it usually innervates it from the orbital surface of the muscle.[4]

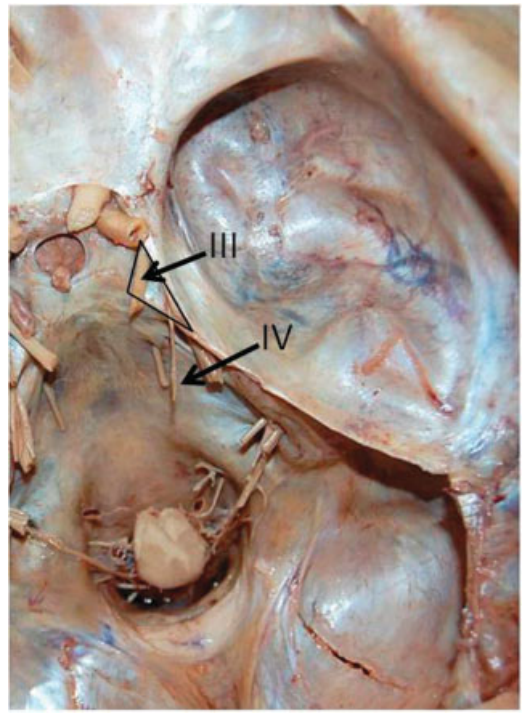

Fig. 1 Superior view of the skull base after removal of the brain. Note the right-sided oculomotor (III) and trochlear (IV) nerves within the oculomotor trigone, which is outlined for clarity.

Materials and Methods

Twenty latex-injected adult cadaveric sides (blue into the venous system) (10 adult cadavers; 5 males and 5 females with an average age at death of 78.5 years) were dissected with the aid of an operating microscope (Zeiss, Oberkochen, Germany). Standard microdissection techniques were employed to examine the course of the distal cisternal segment of the trochlear nerve. Measurements were made using a microcaliper (Mituoyo, Kanagawa, Japan). Digital images were made of the dissections (Nikon, Tokyo, Japan).

Results

In all specimens, we identified an additional segment of the trochlear nerve (►**Figs. 1–5**). This part of the nerve coursed between the entrance of the trochlear nerve into the posterior corner of the oculomotor trigone to the posterior wall of the cavernous sinus.[5] This segment of trochlear nerve was, on average, 4 mm in length (range 2.2 to 6 mm). No venous or arterial structures traveled with the trochlear nerve in this segment. On average, the trochlear nerve entered the oculomotor trigone 1 cm posterior to the entrance of the oculomotor nerve into the same trigone (range 0.6 to 1.4 cm).

Discussion

Based on our study, the trochlear nerve can be exposed more distally without entering the cavernous sinus. This knowledge may be useful to the neurosurgeon during approaches near the posterior clinoid process. Retracting the trochlear nerve outside the cavernous sinus can be increased by opening the dura covering it prior to its entering the cavernous sinus.

Recently, Iaconetta et al[6] performed a cadaveric study using microdissection and endoscopic techniques.[6] The authors used median supracerebellar infratentorial,

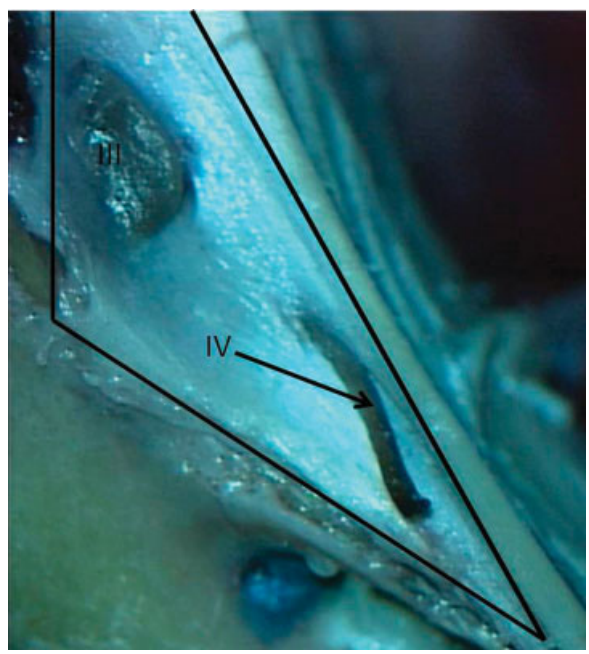

Fig. 2 Right-sided oculomotor trigone zoomed in to note the oculomotor (III) and trochlear (IV) nerves as they enter the oculomotor trigone. Traditionally, the trochlear nerve has been termed the cavernous segment once it pierces this geometric region.

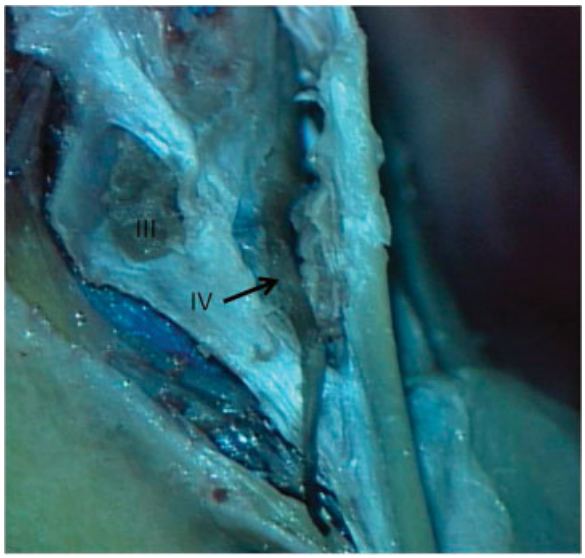

Fig. 3 ►**Figure 2** after opening the dura mater at the entrance of the trochlear nerve (IV) into the oculomotor trigone. Note the absence of venous blood and the relation of the oculomotor nerve (III).

subtemporal, fronto-temporo-orbito-zygomatic, and endoscopic endonasal transsphenoidal approaches to expose the trochlear nerve. The authors concluded that there are five segments of the trochlear nerve: cisternal, tentorial, cavernous, fissural, and orbital. Based on our findings, an additional segment should be included, a trigonal segment, located between the tentorial and cavernous segments.

In describing a combined petrosal approach, Terasaka et al[7] included transection of the tentorium cerebelli medially

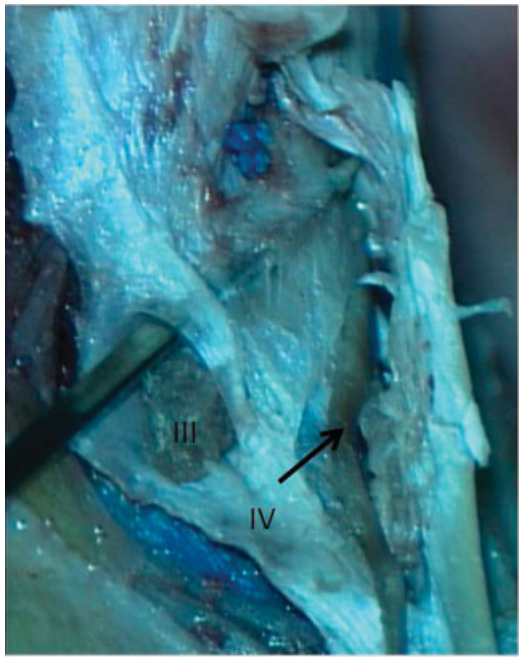

Fig. 4 Additional dissection reveals a septation between the oculomotor nerve (III), which is within the cavernous sinus after its entrance into the oculomotor trigone and the trochlear nerve (IV), which is still outside of the blood-filled cavernous sinus.

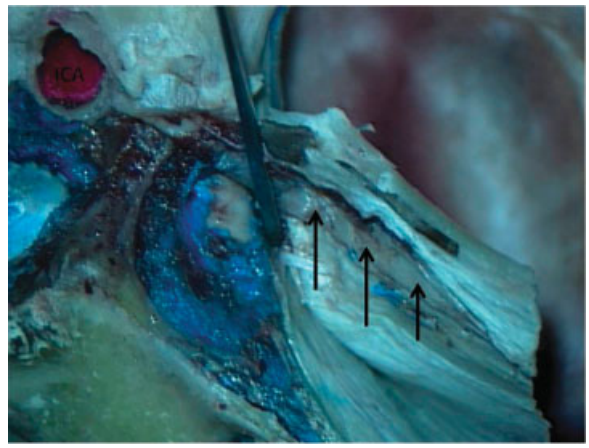

Fig. 5 After full exposure of the oculomotor trigone, the trochlear nerve (IV) is seen traveling through the dura (trigonal segment) and entering the cavernous sinus (blue latex) at the site of pin insertion. For reference, note the internal carotid artery (ICA).

toward the incisura to a point posterior to the trochlear nerve's entrance into the posterior corner of the oculomotor trigone. Stopping at the trochlear nerve's entrance into the oculomotor trigone was based on the misconception that the nerve enters the cavernous sinus at this point.

Conclusions

We have identified a new segment of the trochlear nerve not previously described. We propose that this be referred to as the *trigonal segment*. Knowledge of the microanatomy of the trochlear nerve may be useful to the skull base surgeon. Additionally, in future publications and texts, the trigonal segment of the trochlear nerve should be mentioned as a part of the trochlear nerve.

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