Relationships of the cisternal segment of the trochlear nerve

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Object. The cisternal portion of the trochlear nerve (fourth cranial nerve) can easily be injured during intracranial surgical operations. To help minimize the chance of such injury by promoting a thorough understanding of the anatomy of this nerve and its relationships to surrounding structures, the authors present this anatomical study.

Methods. In this study, in which 12 cadaveric heads (24 sides) were used, the authors describe exact distances between the trochlear nerve and various surrounding structures. Also described are relatively safe areas in which to manipulate or enter the tentorium, and these are referenced to external landmarks.

Conclusions. This information will prove useful in planning and executing surgical procedures in and around the free edge of the tentorium cerebelli.

Key Words • anatomical study • trochlear nerve • incisura

The trochlear (or fourth cranial) nerve is the smallest of the cranial nerves (olfactory nerves excepted), and yet has the longest intracranial course. It arises from the dorsal midbrain, and its fibers decussate in the anterior medullary velum to end in the contralateral superior oblique muscle.4 Because of its small caliber and its hidden location under the tentorial edge, the cisternal portion of the nerve can easily be injured during surgical procedures to treat tumors or aneurysms when the surgery involves manipulation of the tentorial edge.9 Thorough understanding of the anatomy of the trochlear nerve is therefore an essential prerequisite for such intracranial operations.

Based on a detailed anatomical study in which 12 cadaver heads (24 sides) were used, we report on the usual distances between the cisternal portion of the trochlear nerve and major surrounding structures or landmarks. We hope that these measurements will help surgeons with preoperative planning and intraoperative navigation, thus minimizing injury to the patient.

Materials and Methods

Twenty-four trochlear nerves obtained in formalin-fixed human cadaveric brains with no obvious intracranial disease were examined. The cadavers ranged in age from 59 to 94 years, with a mean age of 76.5 years.

In each case, the head was shaved and the scalp was incised and peeled away, thereby exposing the calvaria. Using the inion and glabella as two polar points, a line was drawn around the circumference of the head, and an oscillating bone saw was then used to remove the calvaria along this line. The remaining bone was chipped away down to the tentorial plane by using bone rongeurs. The tentorium was opened 1.5 cm posterior and 1.5 cm lateral to the inferior colliculus with a No. 15 blade. This opening was then connected medially to the incisura and anteriorly to a point just lateral to the dural entrance point of the trochlear nerve. Using a 2.0 suture, the divided tentorium was reflected laterally, adhesions were carefully disrupted, and malleable retractors were positioned subtemporally to elevate the brain. Care was taken not to disturb the anatomical position of the trochlear nerve. Structures were moistened and measurements were made using calipers; 2.5 × loupes were used for magnification. After the initial measurements were made, the nerve was divided 1 cm posterior to its dural entry site. The brain was removed and further measurements were taken between the dural entry site of the trochlear nerve and other surrounding structures (Table 1).

Results

The results were divided into three main categories: the first group consisted of measurements between the trochlear nerve and dura; the second group included measurements between the trochlear nerve and various bone structures, and the third group contained measurements...
TABLE 1
Distances in cadaveric heads (24 sides) between the trochlear nerve and selected cranial structures

<table>
<thead>
<tr>
<th>Landmark</th>
<th>Range (mm)</th>
<th>Mean (mm)</th>
<th>Median (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A origin of trochlear nerve to its dural entrance</td>
<td>25–45</td>
<td>35.6</td>
<td>37.3</td>
</tr>
<tr>
<td>B maximum tentorial edge over trochlear nerve in mesencephalic cistern</td>
<td>0.5–6</td>
<td>2.0</td>
<td>1.4</td>
</tr>
<tr>
<td>C anterior clinoid to dural entrance of trochlear nerve</td>
<td>16–26</td>
<td>20</td>
<td>19.5</td>
</tr>
<tr>
<td>D posterior clinoid to dural entrance of trochlear nerve</td>
<td>11–20</td>
<td>16.2</td>
<td>17</td>
</tr>
<tr>
<td>E EAM to dural entrance of trochlear nerve</td>
<td>42–70</td>
<td>58</td>
<td>57.3</td>
</tr>
<tr>
<td>F distance anterior to EAM at which trochlear nerve enters dura</td>
<td>16–28</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>G midpoint of anterior wall of middle fossa to entrance of trochlear nerve into dura</td>
<td>27–51</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>H trochlear nerve to midpoint of lat mesencephalon</td>
<td>0–6</td>
<td>1.9</td>
<td>1.1</td>
</tr>
<tr>
<td>I midpoint of lat mesencephalon to dural entrance of trochlear nerve</td>
<td>12–30</td>
<td>20.3</td>
<td>17</td>
</tr>
<tr>
<td>J SCA to trochlear nerve at midpoint of lat mesencephalon</td>
<td>0–12</td>
<td>4.0</td>
<td>3.5</td>
</tr>
<tr>
<td>K vein of Rosenthal to trochlear nerve at midpoint of lat mesencephalon</td>
<td>2–11</td>
<td>7.5</td>
<td>7.1</td>
</tr>
<tr>
<td>L genu of SCA to dural entrance of trochlear nerve</td>
<td>9–14</td>
<td>11</td>
<td>10.5</td>
</tr>
<tr>
<td>M genu of PCA to dural entrance of trochlear nerve</td>
<td>5.5–23</td>
<td>14</td>
<td>13.5</td>
</tr>
<tr>
<td>N entrance of vein of Labbé into transverse sinus to dural entrance of trochlear nerve</td>
<td>48–83</td>
<td>61</td>
<td>57</td>
</tr>
</tbody>
</table>

Fig. 1. Drawing depicting distances between dura and the trochlear nerve. Lines with letter labels show the paths of measurements between two points. A = origin of the trochlear nerve to its dural entrance. E = EAM to dural entrance of the trochlear nerve. F = distance anterior to the EAM at which the trochlear nerve enters the dura. K = vein of Rosenthal to trochlear nerve at the midpoint of the lateral mesencephalon. N = entrance of the vein of Labbé into the transverse sinus to the dural entrance of the trochlear nerve. Inset: L = “genu” of SCA to the dural entrance of the trochlear nerve. M = “genu” of the PCA to the dural entrance of the trochlear nerve.
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FIG. 2. Drawing depicting position of bones in relationship to the trochlear nerve. Lines with letter labels show the paths of measurements between two points. B = maximum tentorial edge over the trochlear nerve in the mesencephalic cistern. C = anterior clinoid to dural entrance of the trochlear nerve. D = posterior clinoid to dural entrance of the trochlear nerve. G = midpoint of the anterior wall of the middle fossa to the entrance of the trochlear nerve into the dura. I = midpoint of the lateral mesencephalon to the dural entrance of the trochlear nerve. Inset: H = trochlear nerve to the midpoint of the lateral mesencephalon. J = SCA to the trochlear nerve at the midpoint of the lateral mesencephalon.

between the trochlear nerve, the brain, and vascular structures along the nerve’s cisternal course.

Dural Relationships to the Trochlear Nerve

The first measurement was the distance from the origin of the trochlear nerve on the dorsal brainstem to its dural entrance (Fig. 1A). This is the cisternal segment or infratentorial portion of the nerve. It should be noted that in all specimens the dural entrance point of the trochlear nerve was near the posterior edge of the oculomotor trigone. In our series, this point was always near the intersection of the free and attached portions of the tentorium. The cisternal segments in our series ranged from 24 to 45 mm in length (mean 35.6 mm). The maximum length of tentorium covering the cisternal segment (Fig. 2B) ranged from 0.5 to 6 mm (mean 2 mm).

Relationships of Bone to the Trochlear Nerve

Measurements were made between both anterior and posterior clinoid processes and the dural entrance of the trochlear nerve. The range from the anterior clinoid to the dural entrance of the trochlear nerve (Fig. 2C) was 16 to 26 mm (mean 20 mm). The distance from the posterior clinoid to the dural entrance point of the trochlear nerve (Fig. 2D) ranged from 11 to 20 mm (mean 16.2 mm).

Measurements from the lateral-most portion of the external auditory meatus (EAM) to the dural entrance site of the trochlear nerve (Fig. 1E) ranged from 42 to 70 mm (mean 58 mm). The nerve entered the dura 16 to 28 mm (mean 23 mm) anterior to the lateral-most portion of the external auditory meatus (Fig. 1F). The distance from the midpoint of the anterior wall of the middle cranial fossa (or tip of the lesser wing of the sphenoid bone) to the dural entrance of the trochlear nerve (Fig. 2G) was 27 to 51 mm (mean 40 mm).

Brain–Vascular Relationships in the Cisternal Segment of the Trochlear Nerve

All specimens demonstrated single compared with multiple trunks at the origin of the trochlear nerve below the inferior colliculus. In the next set of measurements, we found the midpoint of the distance from the apex of the inferior colliculus to the most anterior portion of the crus cerebri, and then the distance from this midpoint of the lateral midbrain to the trochlear nerve (Fig. 2H) was measured. This distance ranged from 0 to 6 mm (mean 1.9 mm). Also, using the same midpoint we measured the distance to the dural entrance of the trochlear nerve (Fig. 2I), which ranged from 12 to 30 mm (mean 20.3 mm). Again using this calculated midpoint of the lateral midbrain, distances from the trochlear nerve to the superior cerebellar artery ([SCA], Fig. 2J) and basal vein of Rosenthal (Fig. 1K) were measured. The distance of the former was 0 to 12 mm (mean 4 mm) and the latter was 2 to 11 mm (mean 7.5 mm).
The distance between the apex of the genu of the SCA and the dural entrance of the nerve (Fig. 1L) was 9 to 14 mm (mean 11 mm), whereas that from the apex of the genu of the posterior cerebral artery (PCA) to the nerve’s dural entry (Fig. 1M) was 5.5 to 23 mm (mean 14 mm). In our final measurement, the trochlear nerve was found to enter the dura 48 to 83 mm (mean 61 mm) from the entrance of the vein of Labbé into the transverse sinus (Fig. 1N).

Discussion

The trochlear nerve arises lateral to the frenulum of the anterior medullary velum and below the inferior colliculus. It then courses anteriorly in the cerebellomesencephalic cistern. While traveling from the quadrigeminal to ambient cisterns, the trochlear nerve perforates the cerebellar precentral membrane, which is an arachnoid plane separating the two cisterns. It should also be mentioned that the superior cerebellar membrane, which is an arachnoid plane that divides the ambient cistern into superior and inferior compartments, often encases the trochlear nerve as it courses anteriorly. This cisternal segment of the nerve parallels the SCA, PCA, and basal vein of Rosenthal. Although variable in their courses, these structures are themselves adequate as landmarks to measure distances to the trochlear nerve. None of our specimens exhibited any gross anomalies in this area. The relationships of the nerve to the clinoids were the least variable among different specimens, and the relationships of the trochlear nerve to the vein of Labbé entrance into the transverse sinus were the most variable. Also, all veins of Labbé entered into the transverse sinus via a single trunk.

It was never evident that the nerve’s cisternal segment became associated with any subtentorial groove or became encased in “leaflets” of the tentorium. Although not seen in our study, this possibility should be noted by the surgeon so as to avoid encountering the nerve within the tentorium or stumbling on it more posteriorly. We chose a point just posterior to the level of the tectum to open the tentorium. This seemed to be the easiest way to avoid damaging the trochlear nerve. This would be ideal, whether trying to stay clear of the nerve while entering the posterior fossa or seeing the nerve at its origin and initial course when performing manipulations in and around the incisura. However, it is unusual for surgical approaches to the tentorial edge to be this far posterior. Therefore, we have also roughly estimated portions of the tentorium that may be opened with less possibility of harm to vulnerable surrounding structures. These data would be especially useful to surgeons operating via lateral approaches around the tentorium. In general, the trochlear nerve first becomes subtentorial or abuts the tentorium at the cerebellomesencephalic fissure (that is, at the posterior border of the cerebral peduncle). This is the point at which the surgeon may first lose sight of the nerve. This point is generally 1.5 to 2 cm posterior to the most external portion of the EAM. It is interesting to remember that the EAM lies on the same coronal plane as the internal auditory meatus, with the latter inclined approximately 5 to 7˚ on this plane. Therefore, an imaginary line drawn from the external to the internal canal can be used as a reference line. If one then stays at least 1.5 cm behind this line one can avoid several structures. For example, the seventh and eighth cranial nerves will again enter the internal canal on this line, and at this distance posterior to the line the trochlear nerve is usually not subtentorial. One should also remember to stay at least 1 cm away from the lateral edges of the tentorium. This not only keeps clear of the trochlear nerve medially but also avoids entering any of the tentorial venous sinuses. Figure 3 demonstrates the “safe” area of the tentorium in which many vulnerable structures are avoidable.

The exact knowledge of the anatomical relationships between the cisternal segment of the trochlear nerve and various intracranial and skull landmarks would assuredly be of use to a surgeon operating in this area. This is especially true if the opening of the tentorium is planned. The small caliber and infratentorial location of the trochlear nerve make it susceptible to injury, but historically, there has been little gross description of this nerve. Our study uses enough points of reference to make it easier to triangulate onto the trochlear nerve when entering its domain.

Conclusions

In this study we have analyzed several key anatomical relationships between the trochlear nerve and various intracranial and extracranial landmarks, most of which are not described in the current literature. We hope thereby to enhance anatomical knowledge about this nerve while simultaneously giving surgeons data that will aid their navigation while in the vicinity of the trochlear nerve.
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References


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