Microanatomy of the optic canal

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The human optic canal, an intricate anatomical structure with several normal variations, was studied in 83 individual cadaver specimens. The landmarks and dimensions of the adjacent structures were noted and correlated with surgical exposure of the area. The transorbital-ethmoidal route for extracranial decompression of the optic canal was also studied.

KEY WORDS • microanatomy • optic canal • decompression, transorbital • decompression, extracranial

This report is based on a study of the optic canal and adjacent structures in 83 individual orbits. The purpose of this study was twofold: 1) to delineate the microanatomic structures and document their dimensions, and 2) to evaluate an extracranial route for optic canal exposure.

Surgery of the orbital region and the optic canal requires detailed knowledge of the anatomy of the area and its normal variations. Widespread use of the operating microscope has enhanced the results and safety of established neurosurgical procedures. The extracranial approach to the sella turcica is an example of a surgical procedure made safer because of micro-neurosurgery. Knowledge of surgical microanatomy has paralleled the development and incorporation of this new operating tool.

Recently, the feasibility of an extracranial, microsurgical approach for decompression of the optic canal has been demonstrated,1-3 but has raised the questions of whether the optic nerve can be adequately decompressed extracranially, and what are the indications for optic nerve decompression. This study attempts to answer the first question by evaluating the extracranial route of optic canal decompression in a laboratory model. The second question, although crucial to surgery of this region, is beyond the scope of this anatomical study.

Materials and Methods

Eighty-three optic canals were studied in human cadavers. Normal anatomy and its variants were studied under ×3 to ×40 magnification.

Extracranial exposure of the optic canal was achieved by the transorbital-ethmoidal approach. A standard medial canthal incision was made, and by subperiosteal dissection the lacrimal sac, the anterior and posterior ethmoidal neurovascular bundles, and the medial wall of the orbit were exposed. Exposure of the optic canal was then obtained through an opening into the ethmoid and sphenoid sinuses (Fig. 1). Complete decompression of the optic canals was performed medially through this transorbital-ethmoidal approach by means of a diamond microdrill and microcurette (Fig. 1, shaded area).

To evaluate the effectiveness of decompression, the exposed portion of the optic nerve in
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FIG. 1. Diagram showing the transorbital-ethmoidal approach for extracranial exposure of the optic canal.

Each specimen was painted with latex. A standard frontal craniotomy was then performed and the proximal portion of the optic canal was inspected intracranially. The specimens were then divided sagittally and the entire lengths of the decompressions were examined and measured by direct inspection of the medial portion of the optic canals through the ethmoid and sphenoid sinuses.

Anatomical Observations

The measurements of the orbital and optic canal structures are listed in Table 1. The optic canal lies between the two bases or roots of the lesser sphenoid wings (Fig. 2). When viewed laterally, the canal is shaped somewhat like a parallelogram that is inclined forward. The proximal opening of the optic canal is formed superiorly by a thin fold of dura (falciform process) (Fig. 3). The length of nerve covered by this fold of dura averaged 3 mm and has been described in a previous study.4 The falciform process may take the appearance of a sharp band over the nerve that could potentially injure the optic nerve during closed head trauma. This thin fold of dura and the lack of bone leaves the nerve particularly vulnerable to injury during surgery if the surgeon is unaware of this anatomical detail.

The proximal opening of the optic canal (intracranial) is elliptical in shape and the

FIG. 2. Horizontal and lateral sketches of optic canal anatomy. The canal is shaped like a parallelogram inclined forward into the orbit. The canal arises from the base of the lesser sphenoid wing.
FIG. 3. The falciform process is a thin fold of dura that covers the optic nerve as the nerve enters the proximal optic canal.

horizontal width is consistently greater than its height. The average proximal canal width measured 7.18 mm, and the average distal canal width (orbital) 4.87 mm. The distal canal opening is also elliptical with its widest diameter oriented vertically. Figure 4 illustrates horizontally sectioned optic canals and points out two important observations: the canal is narrow distally as it approaches the orbit, and the medial wall of the distal canal is very dense in comparison to the proximal segment.

The distal thick portion of the optic canal has been termed the “optic ring” in this study and is formed medially, in part, by the bony partition that separates the ethmoid sinus from the sphenoid sinus. While the medial canal wall averaged 0.21 mm, the optic ring

<table>
<thead>
<tr>
<th></th>
<th>Average (mm)</th>
<th>Range (mm)</th>
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<tbody>
<tr>
<td>optic canal length</td>
<td>9.22</td>
<td>5.5–11.5</td>
</tr>
<tr>
<td>horizontal canal width</td>
<td></td>
<td></td>
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<tr>
<td>proximal</td>
<td>7.18</td>
<td>5.0–9.5</td>
</tr>
<tr>
<td>distal</td>
<td>4.87</td>
<td>4.0–6.0</td>
</tr>
<tr>
<td>roof thickness</td>
<td>2.09</td>
<td>1.0–3.0</td>
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<tr>
<td>medial canal wall (proximal) thickness</td>
<td>0.21</td>
<td>0.1–0.31</td>
</tr>
<tr>
<td>optic ring thickness</td>
<td>0.57</td>
<td>0.4–0.74</td>
</tr>
<tr>
<td>dacryon to ant. ethmoidal foramen</td>
<td>11.7</td>
<td>8.0–15.0</td>
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<tr>
<td>anterior to post. ethmoidal foramen</td>
<td>12.25</td>
<td>8.0–19.0</td>
</tr>
<tr>
<td>post. ethmoidal foramen to optic ring</td>
<td>6.78</td>
<td>5.0–11.0</td>
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FIG. 5. The optic canal and carotid canal bulge into the sphenoid sinus and are viewed here from within the sinus. The ethmoid-sphenoid septum contributes to the formation of the optic ring.

FIG. 6. Artist's sketch of orbital landmarks.

averaged 0.57 mm. Thus, the distal portion of the optic canal is both the narrowest (horizontally) and the densest section. These anatomical findings have important clinical implications: 1) To be complete and adequate, surgical decompression of the optic canal must include the narrow distal segment of the canal. 2) Decompression of the optic ring may require special instruments such as a diamond microdrill to remove this dense segment of bone.

The length of the optic canal varied from 5.5 to 11.5 mm, with an average length of 9.22 mm. When viewed from within the sphenoid sinus, the optic canal and the carotid artery produce significant impressions into the sphenoid sinus (Fig. 5). In three specimens (3.6%), bone was missing over this region, leaving the optic nerve and its dural sheath covered only by sphenoid sinus mucosa. This variant has also been previously described.

The thickest portion of the optic canal was the lateral wall, the roof, and the optic ring. In 25% of the specimens, ethmoidal air cells completely surrounded the optic canal, making the wall of the canal uniformly thin throughout. This variation in anatomy is significant in intracranial decompression of the optic canal, because two layers of thin bone must be removed instead of the single layer that normally forms the canal roof.

In the orbit, the anterior and posterior ethmoidal neurovascular bundles were studied (Fig. 6). The dacyron is the anatomical point where the frontal, maxillary, and the lacrimal bones meet at the upper end of the lacrimal fossa. The distance from the dacyron to the anterior ethmoidal neurovascular bundle averaged 11.7 mm. The average distance between the anterior and posterior ethmoidal neurovascular bundles was 12.25 mm. The posterior ethmoidal bundle and optic ring were separated only by an average distance of 6.78 mm. These measurements are crucial to successful surgery for cranioorbital disorders. Optic nerve injury is avoided by keeping orbital dissection and osteotomies distal to the posterior ethmoidal neurovascular bundle.

Of the 22 optic canals studied in formalin-fixed whole cadaver heads, the average length of optic canal decompression via the transorbital-ethmoidal route was 7.3 mm. When examined by the method of evaluation described above, the length of decompression was found to be adequate in 21 of these 22 optic canals.

Summary

The microanatomy of the optic canal and its nearby structures has been described. Pertinent measurements and anatomical observations as they apply to the clinical and surgical setting have been noted. The transorbital-ethmoidal route of optic canal decompression has been performed in a laboratory model. The adequacy and completeness of canal decompression was evaluated from both the intracranial approach and medially from the sphenoid sinus. Based on
this study, the transorbital-ethmoidal approach to the optic canal as simulated in the laboratory appears to be a suitable alternative approach to the medial aspect of the optic canal.

References


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