Images of the Optic Nerve: Anatomic-CT Correlation

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Images of the Optic Nerve: Anatomic-CT Correlation

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The course of the intraorbital part of the optic nerve, as demonstrated on anatomic sections in various planes, is correlated with the appearance of the nerve in computed tomographic (CT) images. Discrepancies between the anatomic and CT appearance are analyzed and discussed. Since the optic nerve has a sinuous course in both the horizontal and vertical planes, no thin axial or sagittal section can be entirely parallel to the nerve. Any section will transsect the optic nerve obliquely, leading to an apparent hypodensity or "thinning" of certain segments as shown on CT. The appearance of the course of the nerve on reformatted CT images depends on the plane of the original CT section. Computed tomograms that are obtained with the eye in primary position do not allow reliable judgments regarding the course and size of the optic nerve.

Authors have indicated that detailed computed tomographic (CT) examination of the optic nerve, particularly in axial sections, is difficult [1–3]. The optic nerve cannot be visualized along its entire orbital course in thin axial sections. It usually appears irregular in caliber and density. The reason for this irregularity has been attributed to its sinuosity and motility within the orbit. We analyzed the appearance of the optic nerve in various axial, coronal, and sagittal anatomic sections, and then correlated the anatomic and CT appearances in corresponding planes.

Materials and Methods

The anatomic part of the study consisted of an analysis of 2–3 mm slices of heads of embalmed human cadavers. The sections were made in various planes using a fine-tooth band saw. The axial planes chosen were those most frequently recommended for CT (fig. 1). In addition, coronal, sagittal, and oblique (through the optic nerve) sections were obtained.

The CT part of the study consisted of scanning a fresh human cadaver using the General Electric 8800 scanner, with the eyes in neutral position, looking straight on. A 1.5 mm collimator was used and sections were obtained at 1.0 mm intervals in the same axial planes described in figure 1. Reformatted views in coronal, sagittal, and oblique planes were obtained from the axial sections performed at an angle of −20° to the orbitomeatal baseline.

Results

Axial Planes

The appearance of the optic nerve is determined by the angulation of the axial plane of section. Sections obtained in an axial plane of −20° to the orbitomeatal baseline first encounter the most distal part of the optic nerve in the superior

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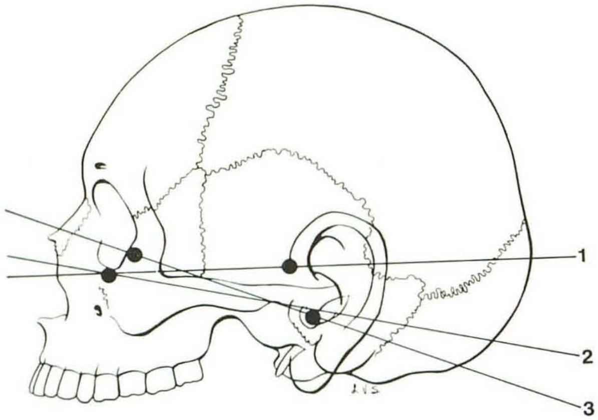
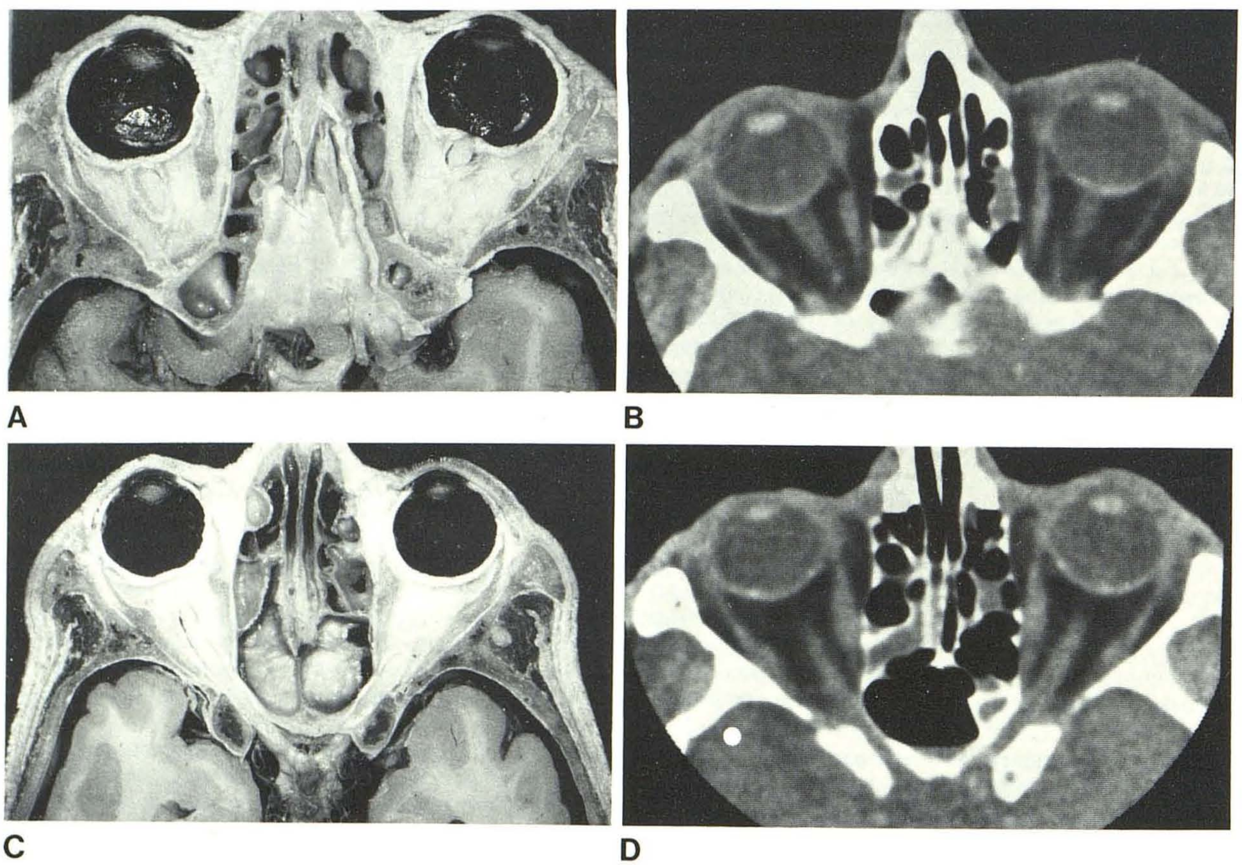


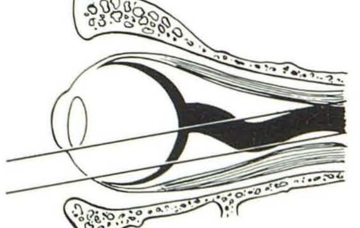
Fig. 1.—Axial planes of section and external landmarks. 1: $-20°$ to orbitomeatal baseline. External landmarks are junction of upper pinna with scalp to inferior orbital point. 2: $-10°$ to orbitomeatal baseline (anthropologic baseline). External landmarks are superior border of external auditory meatus to inferior orbital point. 3: orbitomeatal baseline. External landmarks are center of external auditory meatus to lateral canthus.

sections directly adjacent to the globe (figs. 2A and 2B). The posterior part of the nerve lies below this section and is encountered on the next lower cut (figs. 2C and 2D). Here the nerve appears almost straight within the orbit but is sectioned obliquely as it disappears out of the plane of section anteriorly. The relation of the optic nerve to the plane of section is shown schematically in figure 2E.

With an axial plane angled at $-10°$ degrees to the orbitomeatal baseline, the appearance of the optic nerve is almost straight (figs. 3A and 3B). The optic nerve can be seen in its entire length from the optic canal to its entrance to the globe. However, due to the sinuosity of the optic nerve, the different segments of the optic nerve are not equally included on thin sections (fig. 3C).

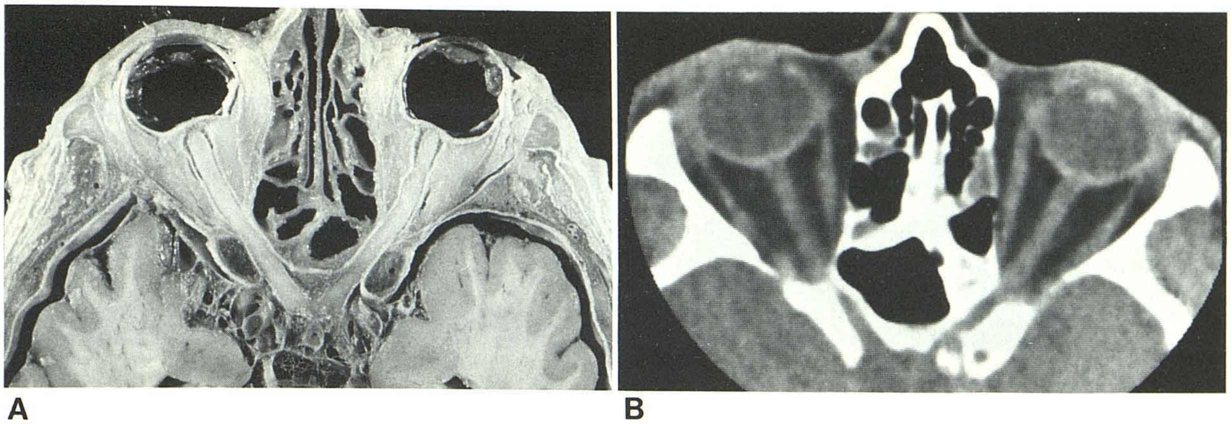
In axial sections obtained parallel to the orbitomeatal baseline, the sinuosity of the optic nerve is most apparent. On the most superior section, only the distal and proximal parts of the nerve are visualized (fig. 4A). The lower sections show the midpart of the optic nerve (figs. 4B and 4C). The relation between the plane of section and the optic nerve is





E

Fig. 2.—Axial sections of optic nerve in primary position of gaze in plane $-20°$ to orbitomeatal baseline. On higher sections (**A** and **B**), only most distal part of optic nerve is encountered. In lower sections (**C** and **D**), posterior part of the optic nerve is sectioned obliquely. **E**, Plane of section through optic nerve.



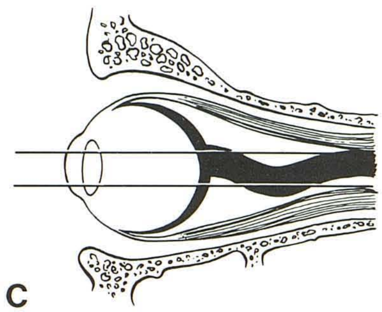


Fig. 3.—Axial sections of optic nerve in primary position of gaze in plane parallel to anthropologic baseline (−10° to orbitomeatal baseline). **A** and **B**, Optic nerve sectioned slightly obliquely along entire orbital course from optic disc to optic canal. **C**, Plane of section through optic nerve.

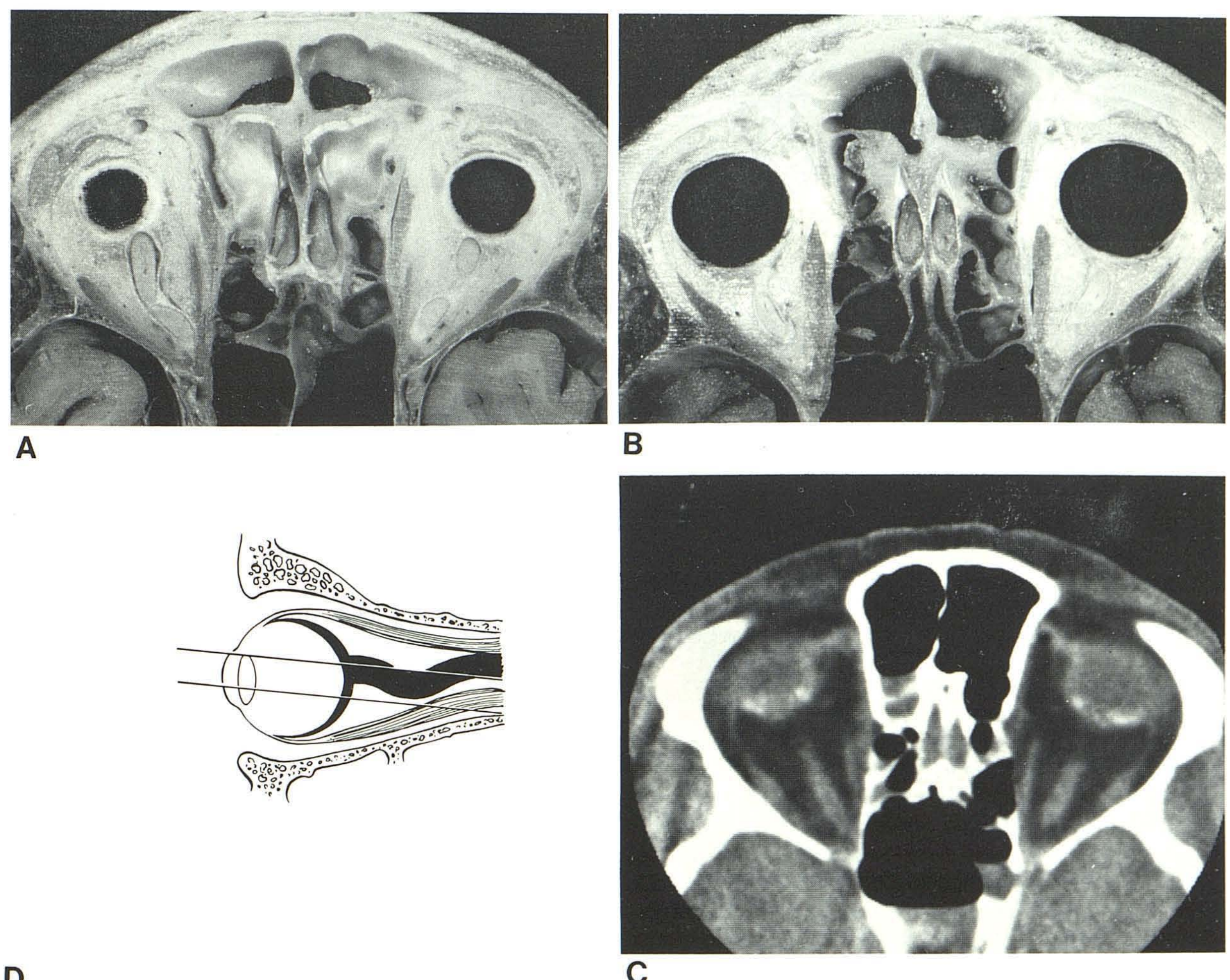
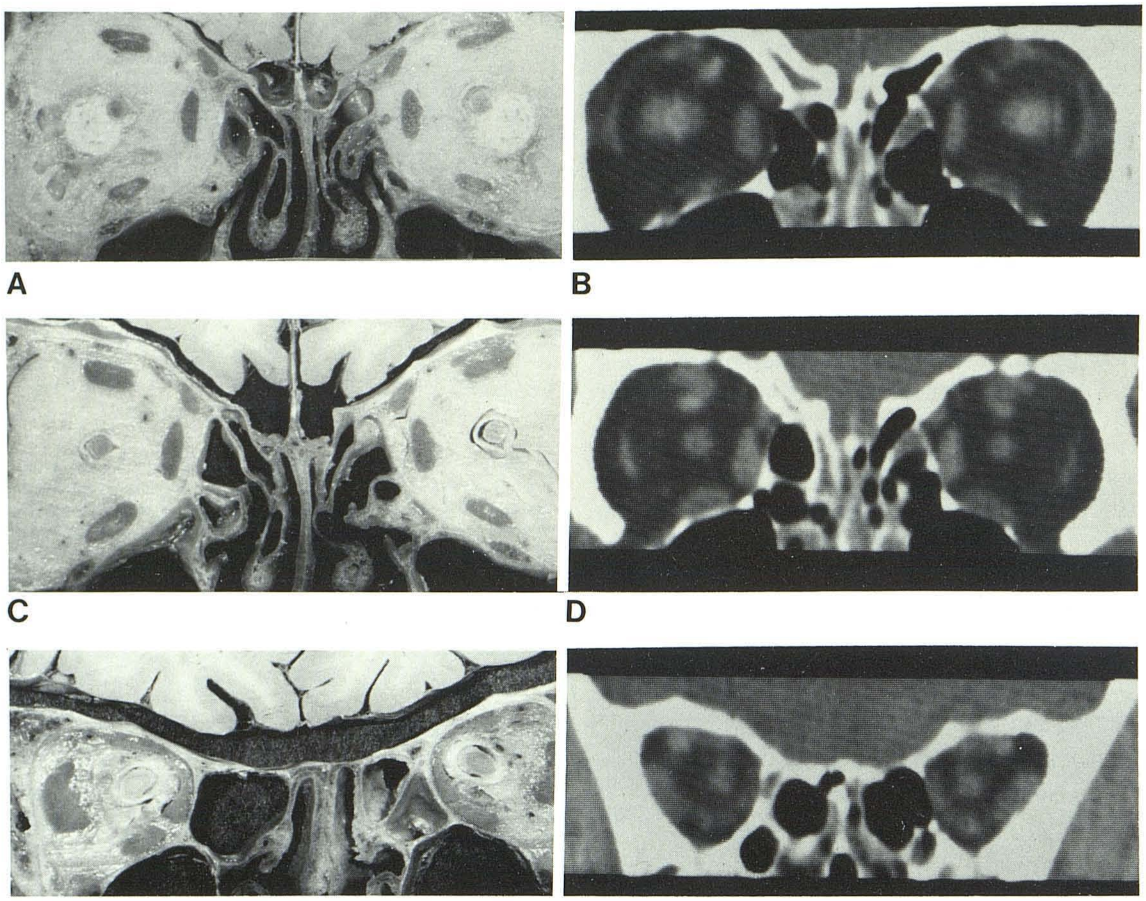


Fig. 4.—Axial sections of optic nerve in primary position of gaze in plane parallel to orbitomeatal baseline. On superior section (**A**), only most distal and proximal parts of optic nerve are visualized (**A**). On lower section (**B** and **C**), middle segment of optic nerve is sectioned. **D**, Plane of section through optic nerve.



A B C D E F

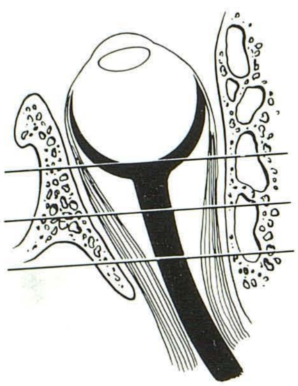


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Fig. 5.—Coronal planes of optic nerve in primary position of gaze. **A** and **B**, Cross-sections through optic nerve at entrance into globe. Optic nerve lies slightly medial to and above posterior pole. **C** and **D**, Cross-section through midpart of optic nerve. Optic nerve has rounded appearance. **E** and **F**, Section through posterior part of optic nerve. Optic nerve appears obliquely sectioned. **G**, Planes of section through optic nerve.

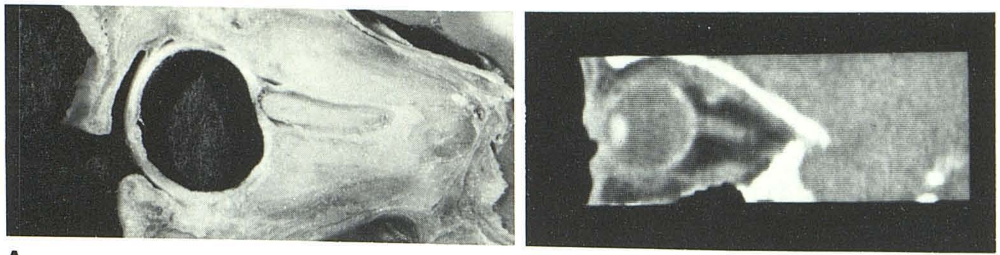
shown in figure 4D.

Coronal Planes

The optic nerve can be demonstrated from its entry into the orbital to the optic disc in coronal sections (fig. 5). A section through the posterior pole of the globe shows that the optic nerve enters the globe medially and slightly above the posterior pole (fig. 5A). On CT sections, this part of the optic nerve appears as a rounded area of higher density along the medial aspect of the posterior globe (fig. 5B). The optic nerve has a rounded appearance in its midpart (figs. 5C and 5D). More posteriorly the optic nerve has a more oval appearance, indicating a more oblique course within the posterior orbit (figs. 5E and 5F).

Sagittal Planes

The optic nerve is only partly visualized on sagittal sections, due to its lateral convexity. Only the anterior part of the optic nerve is visualized in a sagittal section through the optic nerve at the level of the optic disc, since the posterior



A B

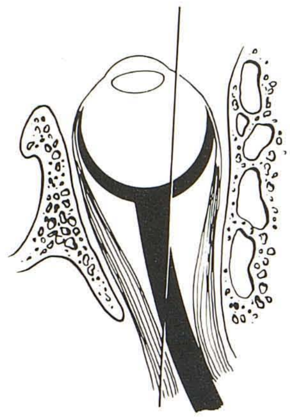


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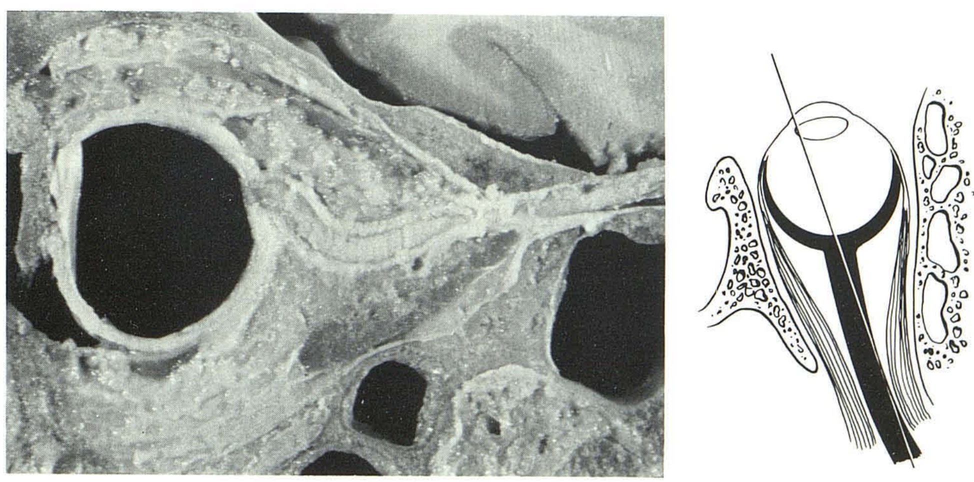
Fig. 6.—Sagittal plane through optic nerve in primary position of gaze in midorbit. **A** and **B**, Only anterior and midpart of optic nerve are included in section. **C**, Plane of section through optic nerve.



A B

Fig. 7.—Paraaxial sections through optic nerve in plane parallel to orbital course in primary position of gaze. **A**, Curved course of optic nerve in vertical plane. **B**, Plane of section through optic nerve.

part of the nerve lies outside of the plane of section (fig. 6). The visualized part of the optic nerve appears relatively straight.

Oblique Planes through Optic Nerve

The optic nerve can be demonstrated in its entire length on sections obtained parallel to a line extending between the optic disc and the orbital opening of the optic canal (fig. 7). In this projection, the downward bending of the midpart of the nerve and its upward curve to insert into the posterior globe are well demonstrated.

On oblique CT sections, the appearance of the optic nerve on computer reformatted views depends on the segment of the nerve being reformatted (fig. 8). With computer reformatted images obtained in a plane extending between the intraorbital opening of the optic canal and the optic disc, the different segments of the optic nerve have a variable density and thickness (fig. 8A). Reformatted views through various segments of the optic nerve show that the optic nerve actually has a uniform density and thickness (figs. 8B–8D).

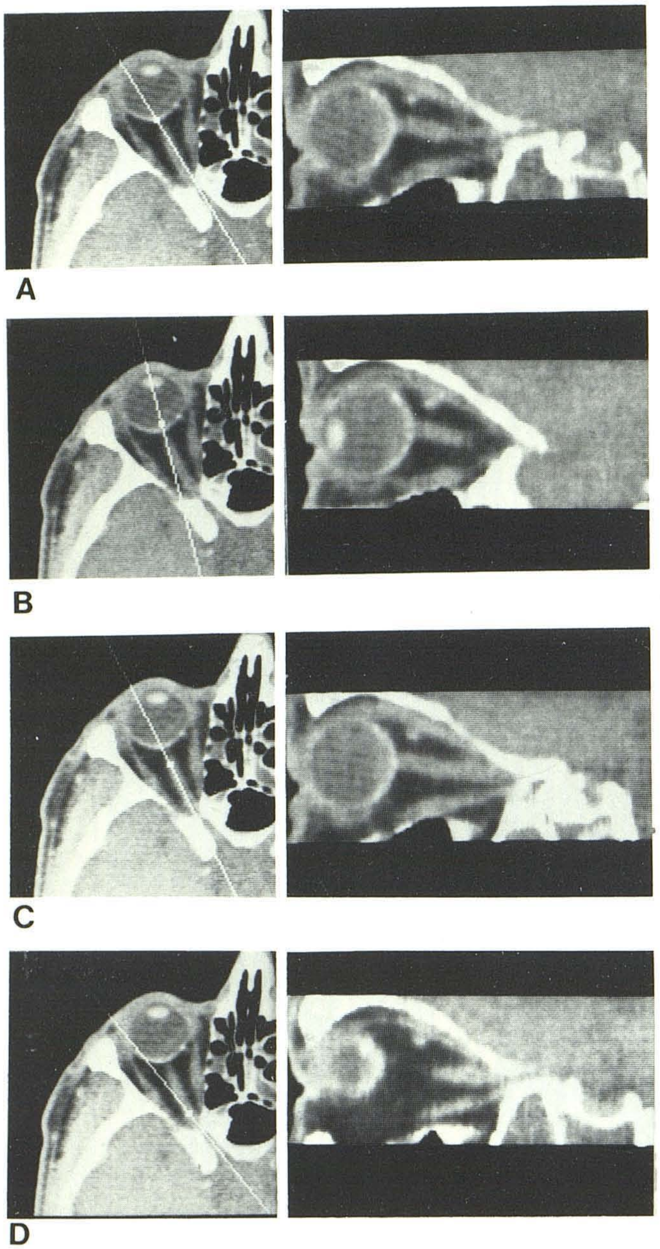


Fig. 8.—Paraaxial CT reformatted views of different segments of optic nerve from axial sections at $-20°$ to orbitomeatal baseline. **A**, Parallel to line through optic disc and intraorbital opening of optic canal. Optic nerve demonstrated in entire course but anterior and posterior segments are slightly thinner and of lower density. Images through anterior (**B**), midpart (**C**), and posterior parts (**D**) of optic nerve show true caliber and density of optic nerve segments.

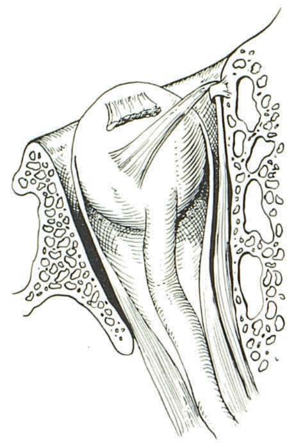


Fig. 9.—Course of optic nerve shown from behind and above.

Discussion

The two factors that primarily influence the appearance of the optic nerve on anatomic and CT sections are the plane of sections chosen and the sinuosity of the optic nerve in the horizontal and vertical planes.

The horizontal lateral bending of the optic nerve is best shown on axial sections parallel to the orbitomeatal baseline (fig. 4). This curvature can also be derived indirectly from an analysis of coronal and sagittal sections or from reformatted views in the coronal and sagittal planes by analyzing the shape and course of the obliquely sectioned segments of the nerve (figs. 5 and 8). For instance, sections through the posterior segments of the optic nerve have an oval appearance with an axis that is obliquely oriented both in the horizontal and vertical planes when sectioned coronally (fig. 5E). The appearance of this oblique section indicates that the optic nerve is bent both in the horizontal and vertical planes.

The vertical bending of the course of the optic nerve is best demonstrated on paraaxial sections along the optic nerve (figs. 7 and 8). On these sections parallel to a line passing through the optic disc and the orbital opening of the optic canal, the nerve can be followed along its entire orbital course. However, the nerve is sectioned somewhat obliquely, resulting in a thinner and hypodense appearance of the optic nerve anteriorly and posteriorly where it runs out of the plane of section (fig. 8A). This appearance is the result of its bending in the horizontal plane.

The different segments of the optic nerve may be compared in the axial and sagittal views (fig. 9). This analysis reveals that the most proximal part of the optic nerve has a relatively straight course, running slightly laterally and downward as viewed from the optic canal. The two more distal parts of the optic nerve form a knee, bending into both horizontal and vertical planes. The proximal limb of the knee is directed laterally in the horizontal plane and downward in the vertical plane. Therefore, the apex of the bend faces obliquely downward and outward. The most distal segment of the optic nerve courses medially and upward (fig. 9).

The appearance of the optic nerve on CT depends both on the plane and thickness of the section. Relatively thick sections (8 mm) result in volume averaging (fig. 10). Therefore, the optic nerve appears of uniform density with a relatively straight course. Thinner sections (5 mm) tend to include only a smaller part of the optic nerve (fig. 10B). In this situation, the midpart of the optic nerve appears hypodense because of volume averaging with orbital fat. If a very thin section (1.5 mm) is obtained in a plane extending through the entire length of the optic nerve obliquely, the optic nerve will appear as a straight isodense structure on CT (fig. 10C). This assumes that the slice of section is considerably thinner than the optic nerve. The same phe-

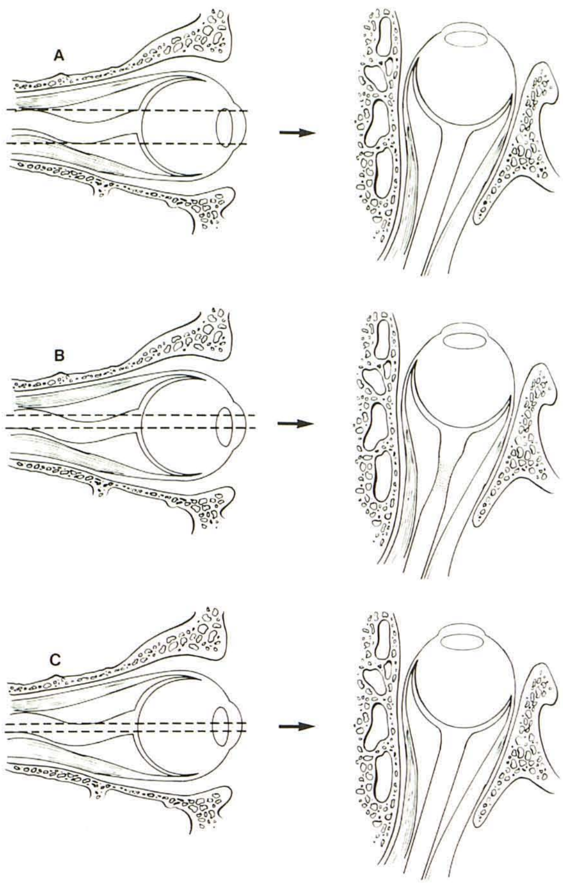


Fig. 10.—Effect of varying slice thickness on CT appearance of optic nerve in axial planes.

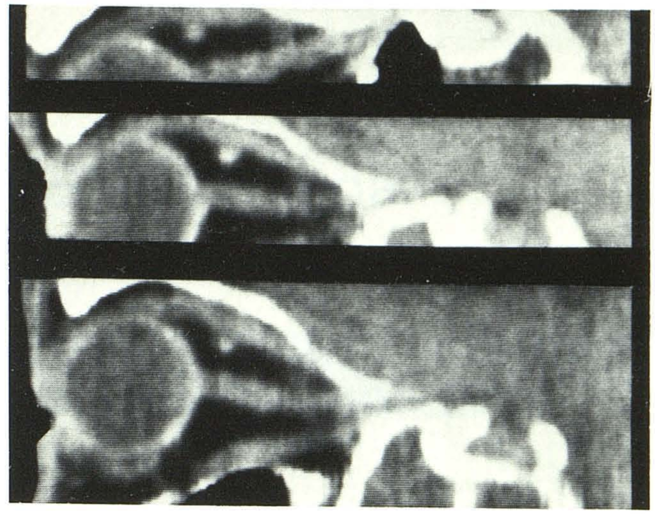


Fig. 11.—Sagittal reformatted images of same optic nerve in primary position of gaze in three different axial planes were obtained by tilting gantry and leaving head and eye position unchanged.

nomenon can be demonstrated on sagittal reformatted view in a more elegant manner. Figure 8A shows an oblique reformatted view of the optic nerve in a plane parallel to a line through the optic disc and the intraorbital opening of the optic canal. The nerve can be seen along its entire orbital course. However, it appears thinner and hypodense in both its proximal and distal parts where it runs partly out of the plane of section. Reformatted views parallel to the anterior, middle, and posterior segments of the optic nerve more accurately demonstrate its true caliber (figs. 8B–8D).

The appearance of a structure in a sagittal reformatted view depends on the angulation of the axial plane from which the data were obtained. The horizontal plane of the reformatted sagittal image corresponds to the plane of the original axial section. This fact explains why the optic nerve on sagittal reformatted views from different axial planes appears to have a different course. In a positive angulation (fig. 11A), the optic nerve appears to course downward, while with a negative angulation (fig. 11C), it seems to course upward. The relations of orbital structures to each other is, of course, maintained.

From the above discussion, it becomes evident that no single plane of section or reformatted projection is ideal for the visualization of the optic nerve obtained in the primary position of gaze. Any single plane of section will always extend through the nerve obliquely. Judgments regarding the caliber and actual course of the nerve within the orbit are therefore difficult if not impossible. Hypodense or thin segments of the optic nerve in primary gaze position should not be considered pathologic unless similar changes can also be demonstrated on reformatted views parallel to the segment in question.

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