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Orbital Apex: Correlative Anatomic and CT Study

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A detailed analysis of the coronal anatomic and CT appearances of the orbital apex is presented. In cadavers, coronal CT 9800 scans of the orbital apex and precisely corresponding cryomicrotomic sections were obtained. The CT appearance of the optic nerve, annulus of Zinn, and cranial nerves III–VI at the superior orbital fissure and orbital apex were determined. These anatomic structures were also demonstrated in clinical CT studies. Practical applications of the anatomic landmarks in evaluating orbital apex tumors are illustrated.

Although high-quality coronal computed tomographic (CT) images of the orbit may be difficult to obtain, they show some anatomic relations in the orbital apex better than do axial images. Because of the diverging course of the intraorbital muscles and nerves, the anatomic relations in the orbital apex are complex. This correlative study was performed to identify the orbital apex structures demonstrated by CT.

Materials and Methods

Three fresh, frozen cadaver heads were freeze-embedded with a carboxymethyl cellulose gel in a styrofoam box. Contiguous 1.5-mm-thick coronal CT sections of the orbits were obtained with a G.E. CT/T 9800 scanner, and the plane and scanned area were marked on the outer wall of the box with a laser beam indicator. The orbits were sectioned from the cadaver heads with an electric bandsaw and then positioned in a horizontally cutting sledge cryomicrotome (LKB Instruments, Gaithersburg, MD). The surface of each specimen was photographed serially as it was sectioned at 0.1–0.5 mm intervals. This technique has been described in detail [1].

The coronal anatomic sections were correlated with the coronal CT sections of the cadaver heads and of patients. CT studies were performed without evidence of an orbital apex abnormality and in patients with surgically verified tumors at the orbital apex. Most patients had intravenously enhanced (300 ml of 300% iodinated contrast agent) CT scans. The coronal gantry angle was chosen using a lateral localizer image to be as perpendicular as possible to the sellar floor while avoiding dental fillings. CT/T 8800 technical factors included 1.5- and 5-mm-thick sections, 960–1150 mAs, 9.6 sec scan time, and 120 kVp. CT/T 9800 technical factors included 3-mm-thick sections, 200 mA, 3 sec scan time, and 120 kVp.

In the anatomic sections and CT studies of cadaver heads and patients, the optic nerve, annulus of Zinn, cranial nerves III–VI, and the ophthalmic vein were identified at the orbital apex by consulting anatomic and CT references (figs. 1–3) [2–8].

Results and Discussion

The anatomic relations in the cryomicrotomic sections may vary slightly due to freezing. Contrast between fat and nerve or muscle is diminished by freezing. Some crowding of structures in the posterior orbit is anticipated as an artifact of freezing. However, the cadaver CT sections correlated well with clinical studies.

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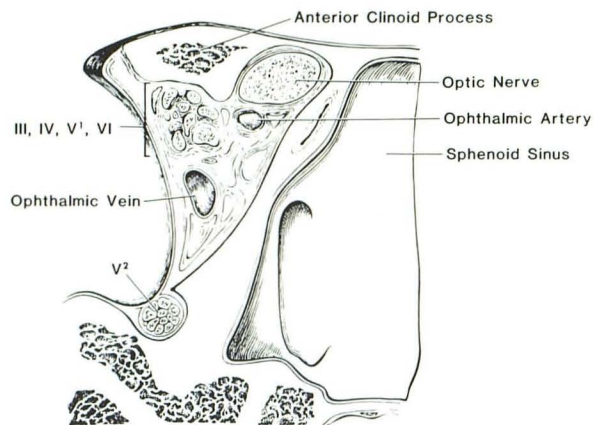


Fig. 1.—Coronal section through cavernous sinus near right orbital apex in coronal plane. Cranial nerves III, IV, V¹, and VI or their branches are above ophthalmic vein and below anterior clinoid process. Cranial nerve V² is in foramen rotundum. Optic nerve is in its canal. (Modified from [2].)

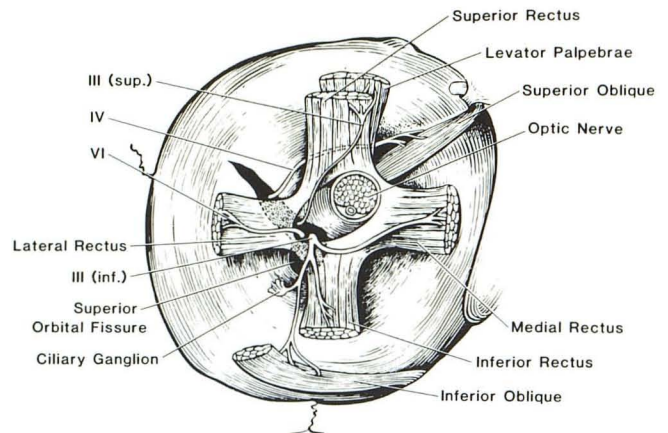


Fig. 3.—Location of cranial nerves III, IV, and VI. Cranial nerve IV extends medially along back of orbit to superior oblique muscle. Cranial nerve VI extends to lateral rectus muscle. Inferior branch of III extends to inferior oblique and rectus and medial rectus muscles. (Modified from [2].)

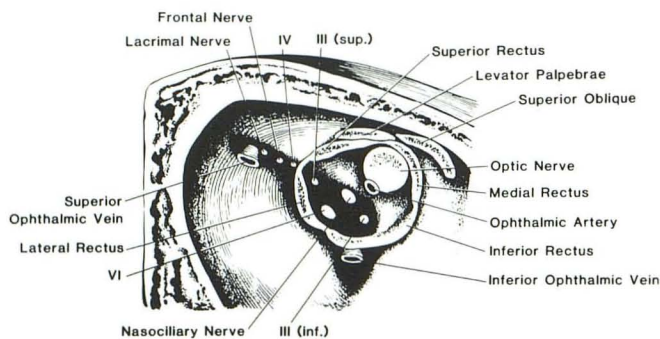
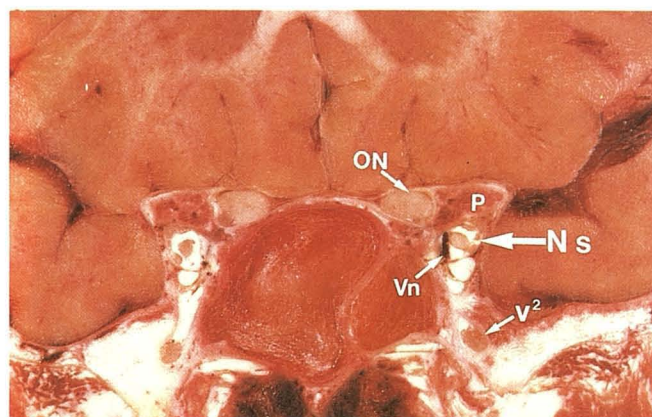


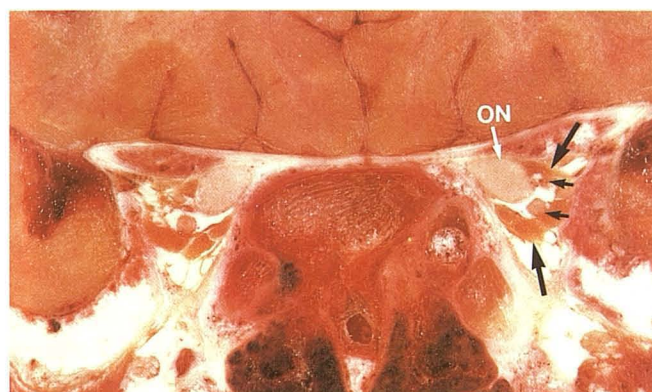
Fig. 2.—Frontal view of right orbital apex. Anulus of Zinn, from which four rectus muscles originate, encircles optic foramen. Cranial nerves III (inferior branch) and VI pass through anulus of Zinn. (Modified from [3].)

Structures in the orbital apex have complex anatomic relations. The four rectus muscles originate from the anulus of Zinn, a tendinous ring that encircles the optic foramen and the medial end of the superior orbital fissure (fig. 2). Passing through the anulus of Zinn via the optic canal are the optic nerve and ophthalmic artery and via the superior orbital fissure are cranial nerves III (superior and inferior branches) and VI and the nasociliary nerve (branch of cranial nerve V¹). The superolateral part of the superior orbital fissure contains the frontal and lacrimal nerves (branches of cranial nerve V¹), cranial nerve IV, and the superior ophthalmic vein. The superior and inferior ophthalmic veins form the ophthalmic vein, which drains into the cavernous sinus. Within the orbit, cranial nerve IV extends medially to the superior oblique muscle; cranial nerve VI, to the lateral rectus muscle; and the inferior branch of cranial nerve III, to the inferior oblique and inferior and medial rectus muscles (fig. 3).

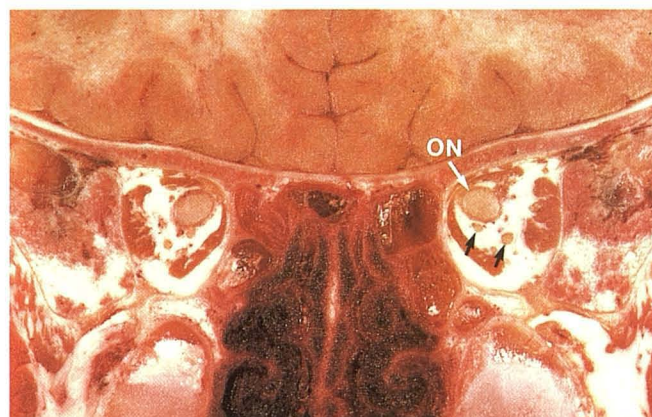
Many of the orbital apex structures were identified on coronal CT/T 9800 scans of cadavers. Although cranial nerves III–VI or their branches are just inferior to the anterior clinoid process and above the ophthalmic vein, they could not



A

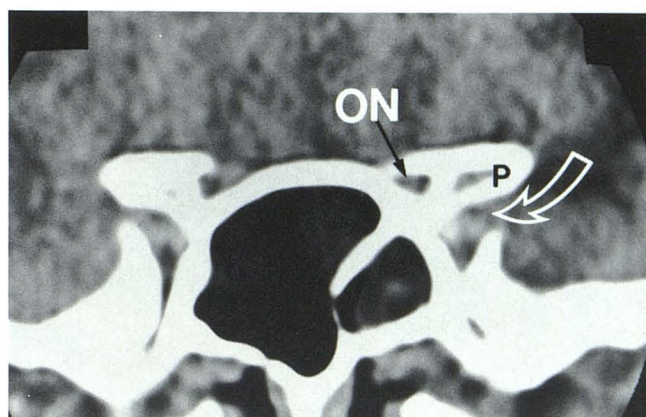


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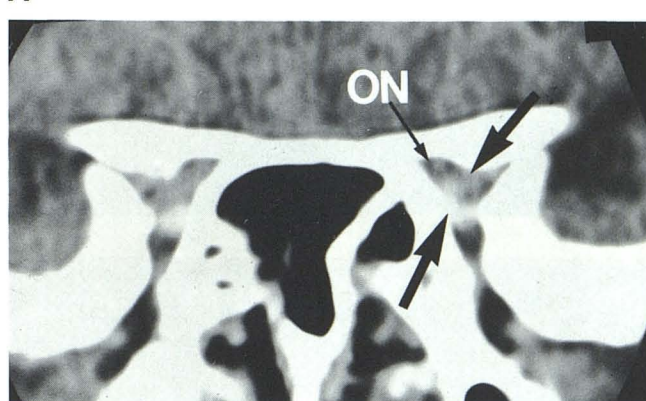


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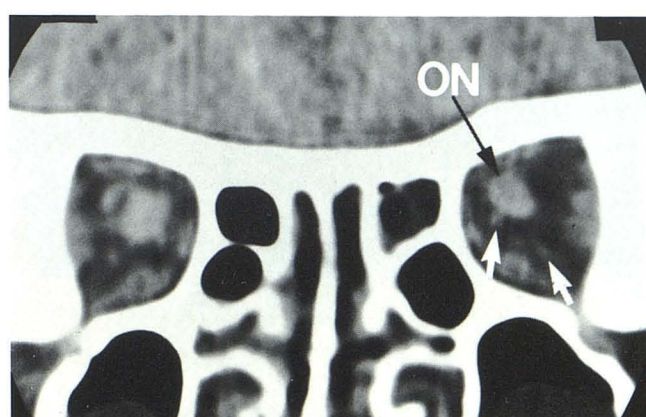
Fig. 4.—Coronal cryomicrotomic sections through orbital apex from posterior to anterior. **A**, Posteriorly, cranial nerves III, IV, V¹, and VI (Ns) are inferior to anterior clinoid process (P); optic nerve (ON) is in its canal; and cranial nerve V² is in foramen rotundum. **B**, Slightly more anteriorly. Optic nerve enters orbit superomedial to muscular ring (*large arrows*). Nerves (*small arrows*) to ocular muscles are encircled by muscular ring. **C**, Most anterior section. Rectus muscles diverge within orbit. Nerves (*arrows*) can be traced to their muscular insertions. Vn = ophthalmic vein.



A



B



C

Fig. 5.—Coronal CT sections of cadaver head sections illustrated in fig. 4. **A**, Section corresponding to fig. 4A. Cranial nerves cannot be identified at superior orbital fissure (*curved arrow*). **B**, Optic nerve in orbit is seen superomedial to muscular ring (*arrows*). **C**, Nerves (*arrows*) are identified after rectus muscles diverge from optic nerve. ON = optic nerve; P = anterior clinoid process.

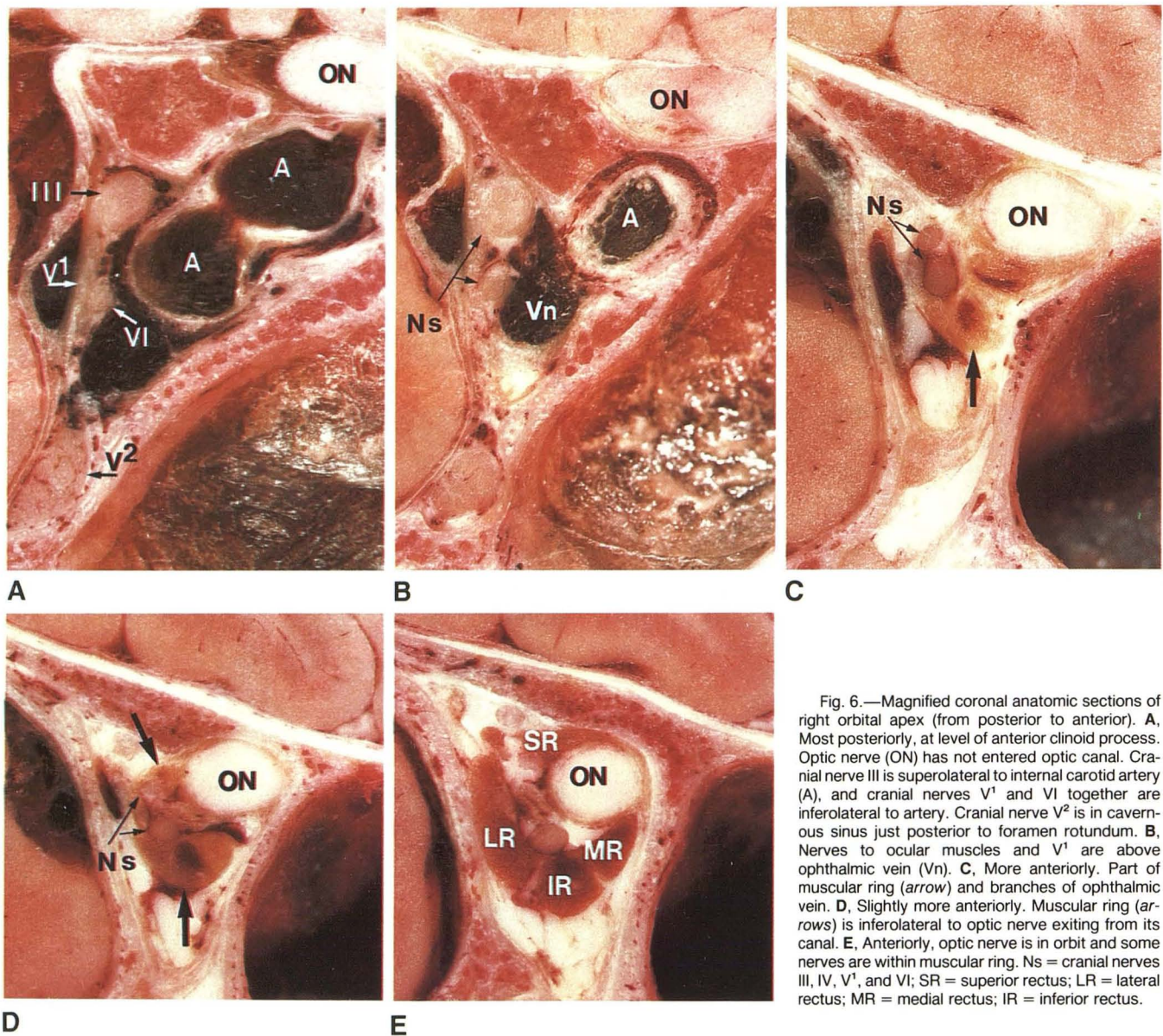


Fig. 6.—Magnified coronal anatomic sections of right orbital apex (from posterior to anterior). **A**, Most posteriorly, at level of anterior clinoid process. Optic nerve (ON) has not entered optic canal. Cranial nerve III is superolateral to internal carotid artery (A), and cranial nerves V¹ and VI together are inferolateral to artery. Cranial nerve V² is in cavernous sinus just posterior to foramen rotundum. **B**, Nerves to ocular muscles and V¹ are above ophthalmic vein (Vn). **C**, More anteriorly. Part of muscular ring (arrow) and branches of ophthalmic vein. **D**, Slightly more anteriorly. Muscular ring (arrows) is inferolateral to optic nerve exiting from its canal. **E**, Anteriorly, optic nerve is in orbit and some nerves are within muscular ring. Ns = cranial nerves III, IV, V¹, and VI; SR = superior rectus; LR = lateral rectus; MR = medial rectus; IR = inferior rectus.

be identified on the precisely corresponding CT image (figs. 4 and 5). The optic nerve could be identified within its canal on these sections and on progressively more anterior coronal CT sections; the optic nerve was demonstrated within the orbit first superomedial to and then encircled by the muscular ring. Cranial nerve VI and the inferior branch of cranial nerve III were traced to their insertions in the lateral and inferior rectus muscles, respectively. The frontal, lacrimal, and nasociliary nerves and cranial nerves III (superior branch) and IV

could not be identified with certainty on CT images due to their proximity to the orbital roof or medial wall.

Orbital apex nerves and muscles were also identified on progressively more anterior enhanced coronal CT images in patients (figs. 6–8). First, at the level of the anterior clinoid processes, cranial nerves III, IV, V¹, and VI or their branches together appeared as a low-density area above the enhancing ophthalmic vein. Next, a part of the muscular ring appeared as an enhancing structure near the top of the superior orbital

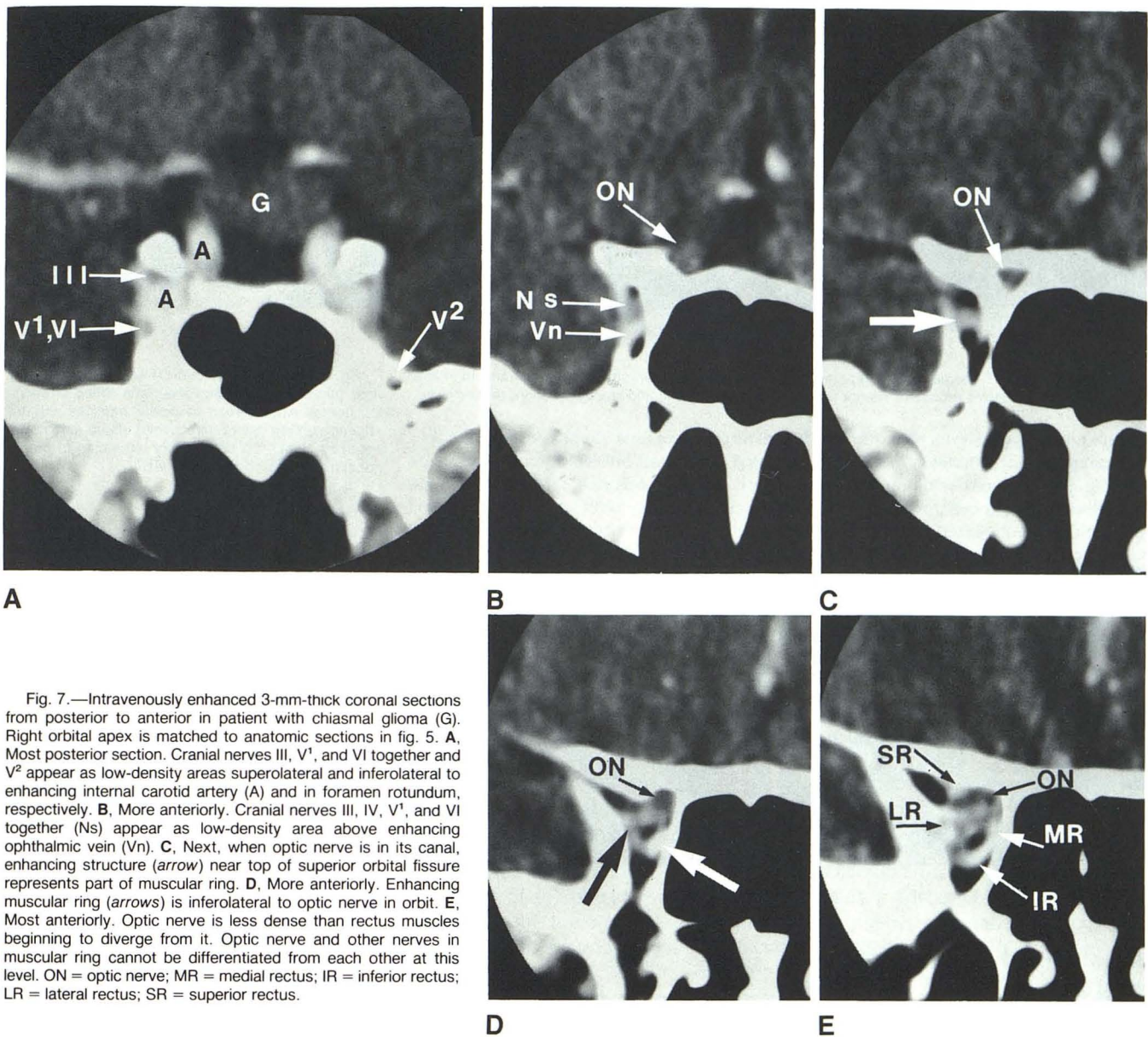


Fig. 7.—Intravenously enhanced 3-mm-thick coronal sections from posterior to anterior in patient with chiasmal glioma (G). Right orbital apex is matched to anatomic sections in fig. 5. **A**, Most posterior section. Cranial nerves III, V¹, and VI together and V² appear as low-density areas superolateral and inferolateral to enhancing internal carotid artery (A) and in foramen rotundum, respectively. **B**, More anteriorly. Cranial nerves III, IV, V¹, and VI together (Ns) appear as low-density area above enhancing ophthalmic vein (Vn). **C**, Next, when optic nerve is in its canal, enhancing structure (arrow) near top of superior orbital fissure represents part of muscular ring. **D**, More anteriorly. Enhancing muscular ring (arrows) is inferolateral to optic nerve in orbit. **E**, Most anteriorly. Optic nerve is less dense than rectus muscles beginning to diverge from it. Optic nerve and other nerves in muscular ring cannot be differentiated from each other at this level. ON = optic nerve; MR = medial rectus; IR = inferior rectus; LR = lateral rectus; SR = superior rectus.

fissure. More anteriorly, the complete muscular ring enhanced to a greater degree than the optic nerve exiting from its canal superomedial to the ring. The optic nerve and other nerves in the muscular ring could not be differentiated with CT. Further anteriorly, the rectus muscles diverged from the optic nerve, which was identified on CT at the superomedial aspect of the orbit as a structure less dense than the muscles. Between the diverging rectus muscles, cranial nerves III (inferior branch) and VI appeared as thin, soft-tissue structures extending to

the inferior and lateral rectus muscles, respectively.

Anatomic relations in the orbital apex are altered when tumor is present (figs. 9 and 10). If orbital fat is obliterated or cranial nerve V¹ and nerves to the ocular muscles are obscured above the ophthalmic vein at the level of the anterior clinoid process, a lesion is suspect. Normal orbital apex structures such as the muscular ring should not be confused with tumor.

Thin, high-resolution coronal CT scans can be used to

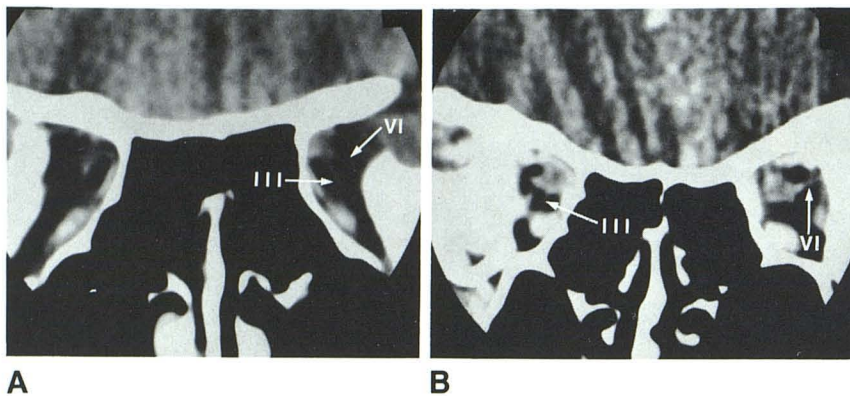


Fig. 8.—Coronal CT images illustrating cranial nerves III and VI. Thin structures extending to inferior and lateral rectus muscles represent inferior branch of cranial nerve III and cranial nerve VI, respectively.

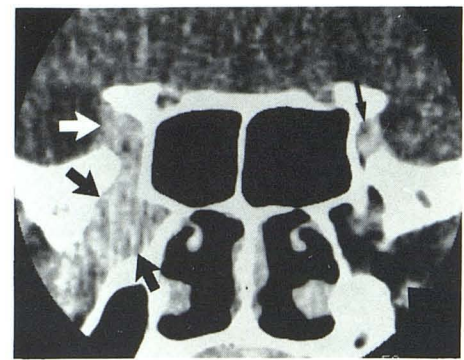


Fig. 9.—Enhanced coronal CT scan in patient with right parasellar paraganglioma (thick arrows). On normal side, nerves to ocular muscles and V¹ appear as filling defect (thin arrow) above enhancing ophthalmic vein. On right, tumor extending to pterygopalatine fossa obscures nerves.

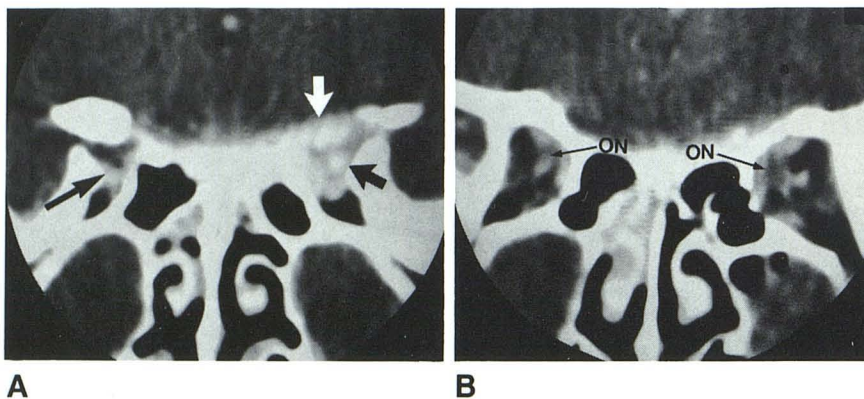


Fig. 10.—Enhanced coronal CT scans in patient with a suprasellar meningioma (arrows) extending into left orbital apex and obliterating orbital fat. **A**, More posterior section. Enhancing structure in right orbit represents part of muscular ring rather than tumor. **B**, Just anterior to meningioma. Normal optic nerves (ON) can be identified.

identify some of the small and complex structures at the orbital apex.

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