Chapter 29

Craniofacial and Neurosurgical Approaches to the Orbit

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Craniofacial and skull base teams formally blend the skills and perspectives of surgeons from the fields of neurosurgery, plastic surgery, otorhinolaryngology, and ophthalmology. This approach has improved the treatment of complex problems that occur at the boundaries of these individual disciplines.[1] The value of multispecialty expertise in the management of specific orbital disorders has also been recognized.[2] The work of these groups has led to numerous clinical advances, among them the evolution of surgical methods that create broad access to the cavities of the skull base. When applied to the surgical management of the orbital neoplasm or vascular anomaly, these methods allow treatment of lesions that are inaccessible when viewed from the perspective of conventional orbitotomy models.

Surgical Osteology of the Orbit

No component is more important to the outcome of surgical treatment of orbital lesions than sufficient osseous exposure. Well-designed approaches surmount the orbit's conical geometry, and limit trauma to its neurovascular tissue. Tessier, in treating congenital malformations of the face and skull, demonstrated that the walls of the orbit might be removed and replaced or reconstructed, in most instances with low complication rates and without appreciable residual deformity. The cavities contiguous to the orbit are frequently included in such procedures.[2]

This section describes patterns of bone removal compatible with effective tissue dissection for specific regions of the orbit. The methods presented are based on cadaver studies, our surgical experiences, and the teachings of pioneers and contemporaries from the aforementioned disciplines, including noted orbital surgeons such as Kronlein, Dandy,[3] Wright,[4] Kennerdell and Maroon,[5,6] McCord,[7] and others.

Exposure planning is approached systematically by subdividing the orbit into three major compartments: anterior, central, and apical (Fig. 29–1). The anterior extends from the orbital margins to the posterior globe, and the central from the globe to the tip of the temporal reflection of the greater wing of the sphenoid. The apical region begins midway between the ethmoidal foramina and spans the remaining area of the posterior orbit. The compartments are further divided into superior and inferior regions by an imaginary horizontal plane bisecting the optic nerve, and into medial and lateral divisions by a vertical plane, also centered on the nerve.

The primary considerations in designing the correct exposure of each compartment are the surgeon's optimal angle of view of the tumor and the area needed for tissue dissecting. The scope of exposure is also influenced by characteristics of a given lesion that cannot always be accurately judged preoperatively. These include tumor vascularity, invasiveness, and precise location relative to vital anatomic structures not clearly defined by preoperative imaging. Therefore, extensibility is also an important feature of the exposure plan, a fact eloquently stated by A. F. Henry[8]: "Exposure ... must be a match for every shift, and therefore have a range, extensile, like the tongue of a chameleon, to reach where it requires." The paranasal sinuses are selectively included in exposure formulations to enhance dissecting space and provide

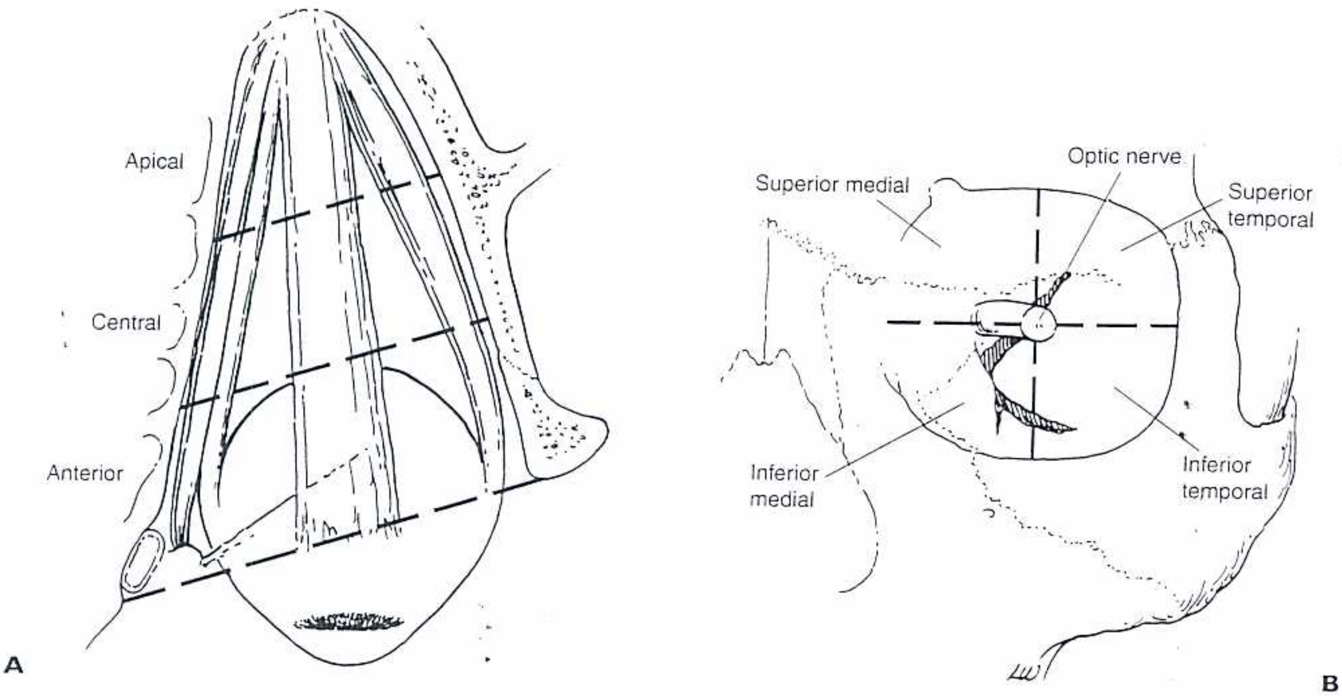


FIGURE 29–1 (A) The orbital cavity is separated into three compartments for the purpose of surgical planning. The anterior extends from the superior orbital rim to the posterior aspect of the eye, the central continues from the eye to a point midway between the anterior and posterior ethmoidal arteries, and the apical spans the remaining area of the posterior orbit. (B) Two perpendiculars, centered on the optic nerve, further divide the orbital compartments into superior, inferior, medial, and lateral quadrants.

drainage of the operative field. Their architecture is discussed below.

SINUS ANATOMY

The air-filled paranasal sinuses surround the orbit on its medial, inferior, and posteromedial, and, in some cases, its superior surfaces. Accordingly, they may be indispensable in supplementing orbital exposure. The features of each sinus that are of surgical importance are outlined below.

The sinuses develop embryologically as diverticulae of the nasal cavities. The maxillary appears first, and is usually present during the third month of fetal life, followed by the ethmoid sinus. The frontal sinus, which is a superior extension of the ethmoid air cells into the frontal bone, is not in evidence until the second or third year of life. It reaches adult dimensions at about 20 years of age. The ethmoid air cells extend into the sphenoid bone, forming the sphenoid sinus.

> **PEARL...** Paranasal sinus anatomy is marked by extreme variability.

Size is the principal variant noted, particularly in the case of the frontal and sphenoidal sinuses. The frontal bone may be completely pneumatized or the sinus may be absent. Similarly, the sphenoid sinus may consist of a single air cell or the central sphenoid bone may be rendered an air cavity with a volume of up to 30 cc.

The Maxillary Sinus

The maxillary sinus is pyramidal in shape and occupies the body of the maxilla. The base of this pyramid forms the majority of the lateral wall of the nose. The apex projects into the body of the zygoma. Its roof forms the central portion of the orbital floor. The anterolateral wall is penetrated by the infraorbital foramen.

> **PEARL...** The posterior wall abuts the infratemporal fossa and is often in contact with the internal maxillary artery.

The thickened portion of the sinus roof, immediately superior to the posterior wall, is an important posterior anatomic landmark upon which bone grafts or implants are positioned during reconstruction of the orbital floor (see Osseous and Soft Tissue Reconstruction, below).

The infraorbital nerve, artery and vein are surrounded by a thin-walled canal that may be absent of bone within either the sinus or the orbit.

> **PEARL... The anterior face of the maxilla and the floor of the sinus are usually penetrated by the roots of the maxillary teeth. These structures may not be covered by bone, and therefore are prone to injury during exposures through the oral mucosa.**

The Frontal Sinus

The floor of the frontal sinus occupies a variable portion of the roof of the orbit. The sinus drains via either the anterior ethmoid air cells or a separate opening into the nose known as the nasofrontal duct. The importance of this sinus in orbital tumor surgery is dependent primarily on its size.[9]

The Ethmoid Sinus

The ethmoid bone is a paired structure that forms the midline floor of the anterior cranial fossa. The sinus consists of a midline perpendicular plate, a horizontal cribriform plate, and the labyrinths. The perpendicular plate descends into the nose to become part of the nasal septum. The pneumatized labyrinths are continuous with the cribriform plate superiorly, and inferiorly are positioned between the lateral wall of the nose and orbital plate of the ethmoid. The anterior articulation of the cribriform plate with the frontal bone creates the foramen cecum.

The nasal surfaces of the labyrinths harbor the superior and middle turbinates. They compose the upper third of the lateral nasal cavity.

The orbital surface, known as the lamina papyracea or lamina orbitalis, forms the majority of the medial wall of the orbit. It articulates anteriorly with the lacrimal bone, inferiorly with the maxillary orbital plate and orbital process of the palatine bone, superiorly with the frontal bone, and posteriorly with the lesser wing of the sphenoid.

The anterior air cells are more numerous and drain into the nose via the middle meatus (with the frontal and maxillary sinuses). The posterior air cells drain into the nose at the superior meatus. The superior aspect of the air cells is crossed by grooves that transmit the ethmoidal neurovascular bundles. They are converted to canals by union with the frontal bone at the frontoethmoid suture. The superior surfaces of some anterior cells are open but are closed by the edges of the ethmoidal notch of the frontal bone.[10] The dual participation of the ethmoid and frontal bones in formation of the roof of the labyrinths has resulted in variety in clinical nomenclature. It has been referred to in the surgical literature as both the cribriform plate and the fovea ethmoidalis.[11]

> **PEARL... The frontoethmoid suture, penetrated by the ethmoidal foramina, marks the level of the lateral roof of the ethmoid sinus.**

The suture is a consistent landmark and is used to maintain orientation during surgical dissection. If followed posteriorly, it leads to the lesser wing of the sphenoid. The medial component of the roof and the cribriform plate lie inferior to the suture in some cases. Its orientation is determined preoperatively by coronal computed tomography (CT) (see Ethmoidectomy, below). All other paranasal sinuses can be reached through the ethmoid sinus, an important anatomic fact in surgical exposure of the orbit and in providing surgical drainage of these central cavities.

The Sphenoid Sinus

The sphenoid sinus may contain a septum, which is only rarely in the midline. Communication between these cavities is unusual. The ethmoid sinus roof is continuous with that of the sphenoid and may be followed posteriorly into the sinus.

The anterior loop of the carotid artery lies in the carotid sulcus at the posterior lateral wall of the sinus, inferior to the cranial aperture of the optic canal. The cavernous sinus is also contiguous to the lateral wall. The bone of the lateral wall may be thin (0.5 mm) or absent over the carotid artery and optic nerve. The thickness of the walls tends to be inversely proportional to the degree of sinus pneumatization.

> **PEARL... Carefully rendered CT scans are essential prior to invasive sphenoid sinus surgery.**

Incision Selection

Adequate bone removal begins with proper selection and judicious positioning of cutaneous incision(s). Visible scarring is minimized by the placement of cutaneous incisions within the relaxed skin tension lines (RSTLs), muscular frown lines, or in concealed locations such as posterior to the hairline and within the oral cavity (Fig. 29–2).[12] Extensibility of the incision is also an important consideration when broad areas of the skeleton are involved in the exposure plan. The critical technical aspects of the incisions commonly employed in orbital exposure are reviewed below.

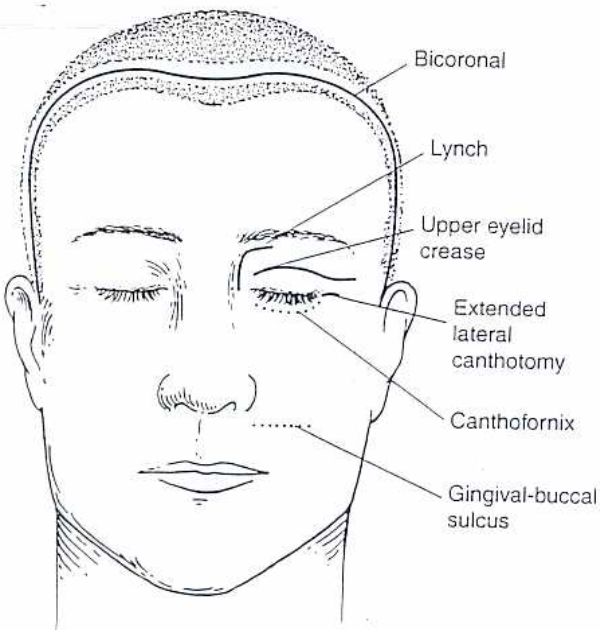


FIGURE 29–2 The soft tissue incisions employed in preparation for removal of the orbital bones include (1) the bicoronal, (2) upper eyelid crease, (3) extended lateral canthotomy, (4) canthofornix, (5) gingival-buccal sulcus, and (6) Lynch.

Bicoronal Incision

The lateral, medial, and superior orbital rims are visible through the completely developed bicoronal scalp flap. The medial and lateral orbital apex may also be reached, and this exposure avoids the facial scar of the Lynch procedure in sphenoethmoid surgery. It is our incision of choice for cranio-orbital procedures and when both the medial and lateral orbit must be exposed. Other important advantages of the incision include ample surgical access to the anterior and middle cranial fossae and extensibility, allowing, for example, the harvest of bone grafts for reconstruction without secondary exposure.

Correct positioning of the patient facilitates intraoperative efficiency. In most cases a horseshoe headrest offers adequate stability of the head and creates an open operative field. If self-retaining retraction devices are to be employed, they may dictate the method of head restraint required (see Soft Tissue Techniques and Tumor Resection Methods, below). The lumbar drain is placed prior to positioning the patient on the headrest, if exposure of the anterior or middle cranial fosse is planned. The patient's head is placed at the foot of the operating table, which allows ample room for foot switches and other equipment.

Preinjection of the incision area with epinephrine-containing solution (e.g., 0.5% Xylocaine and epinephrine in a 1:400,000 dilution) minimizes bleeding from the skin edges. The bicoronal incision extends between the anterosuperior attachments of the auricles, shifting gradually toward the hairline over its central span (Fig. 29–2). A 7-mm strip of hair is shaved along the course of the incision and antiseptic (Betadine) gel is applied the hair adjacent to the incision to keep it from the operative field.

The scalp incision is begun over the temporalis muscle and is extended through the galea aponeurotica (Fig. 29–3). Direct coagulation of the superficial temporal artery markedly reduces bleeding from the skin edges as the incision progresses. Low-profile Rayney clips applied to the skin and galeal edges may further limit blood loss by occluding the epigaleal vessels.

The incision continues through the loose areolar fascia, which lies between the galea and the deep temporal fascia. Dissection proceeds on the surface of the deep fascia toward the temporal line, where the fascia and pericranium fuse. This dense condensation is sharply incised below the galea close to the bone to minimize injury to the branches of the facial nerve. Medial to the temporal lines, the flap is elevated in the plane between the galea and pericranium.

The deep temporal fascia is followed (below the temporal fat pad) as the dissection lateral to the temporal line proceeds inferiorly to the zygomatic arch (Fig. 29–3). As the zygomatic process of the frontal bone is approached, the deep temporal vein enters the operative field from the muscle. It is transected after application of bipolar electrocautery. At approximately this point (2.0 cm above the superolateral orbital rim), dissection medial to the temporal lines is converted to a subperiosteal plane and proceeds to the orbital rims, glabella, and nasion.

The lateral aspects of the flap are elevated by extending the dissection to the lateral orbital rim and over the deep temporal fascia to the level of the zygomatic arch. Division of the temporal fat pad (which is continuous with the buccal fat pad) and incision of the periosteum on the posterior surface of the arch protects the temporal branch of the facial nerve (Fig. 29–3).

PEARL... Continued protection of the facial nerve is afforded by maintaining a subperiosteal dissection plane during exposure of the arch's anterior surface.

The supraorbital nerve, when contained within the supraorbital foramen, prevents full inferior development of the flap, unless the inferior margin of the foramen is removed with a small (2.0 mm) osteotome.

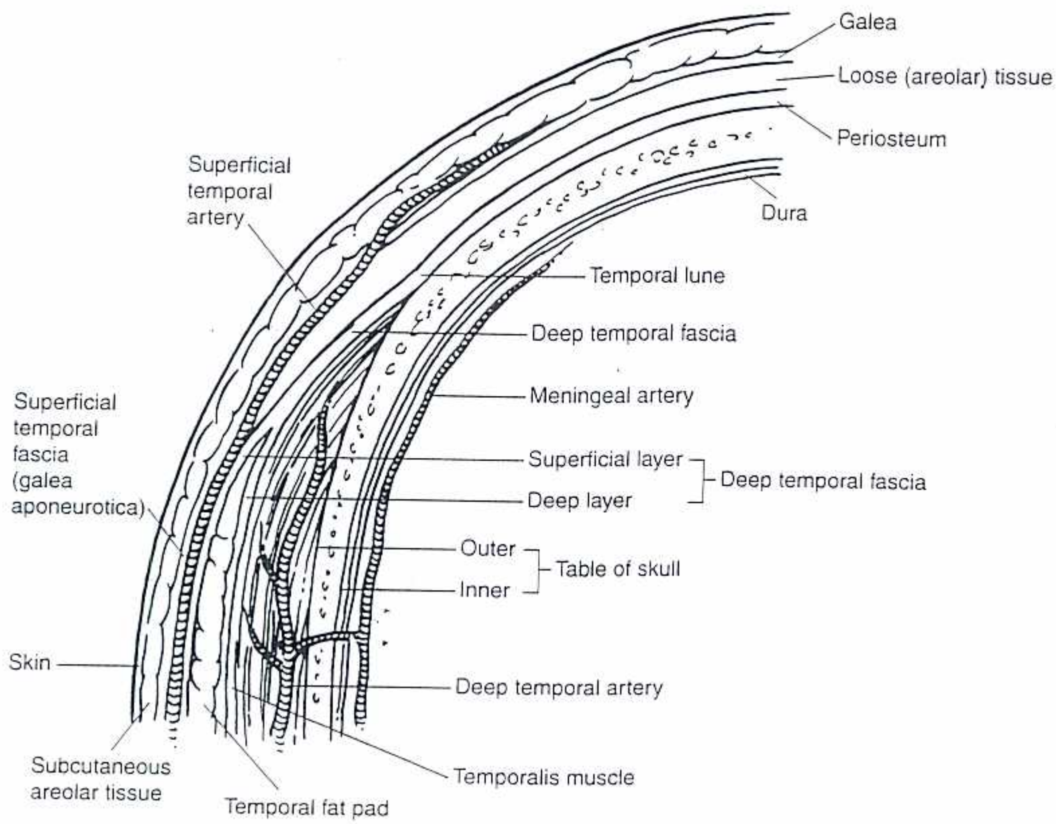


FIGURE 29–3 The anatomy of the temporal segment of the bicoronal scalp flap: (1) superficial temporal artery, (2) temporoparietal fascia (galea aponeurotica), (3) deep temporal fascia, (4) temporalis muscle, (5) superficial layer of deep temporal fascia, (6) temporal fat pad/buccal fat pad, (7) periosteum, and (8) temporal line.

When the neurovascular bundle lies within a notch, a delicate periosteal elevator can release it. Subperiosteal dissection then proceeds over the nasal bone and maxilla to the medial canthal tendon. Elevating the periosteum of the medial orbital wall, beginning at the posterior lacrimal crest, produces an unobstructed view of the orbital plate of the ethmoid. The frontoethmoid suture may be followed to the apex.

Release of the temporal fascia from its orbital margin and reflection of the temporalis muscle from the zygoma and the temporal bone exposes the lateral orbit. The temporalis muscle is separated from the bone by electrodissection to minimize bleeding. A 2.0-cm remnant of the muscle is left attached to the temporal line to simplify its reattachment during closure.

Removal of the lateral rim and outer table of the greater wing of the sphenoid gives access to the superior orbital fissure and lateral apex. In preparation for subsequent soft tissue dissection, the scalp flap is held in position by right-angled retractors, or by self-retaining elastic retractors (DermaHooks, Weck Closure Systems, Research Triangle Park, NC). Closure of the bicoronal incision begins with approximation of the galea with reabsorable suture. A closed suction drain may be used to prevent hematoma formation. Surgical staples are preferred for skin closure for their ease of removal.

Upper Eyelid Crease Incision

The upper eyelid crease incision conforms to the RSTL and provides adequate access to the anterosuperior orbital space and rim (see Anterior Orbital Compartment Surgery, below).[13,14] When used to expose the superior orbital rim, the skin and the orbicularis oculi muscle are divided at the level of the crease, and then reflected from the septum to the rim. The septum is then opened near the rim if the lesion is located within the orbit. For access to a lesion situated between the frontal bone and the periorbita, the periosteum is incised peripheral to the arcus marginalis and a subperiosteal dissection plane is initiated.

Extended Lateral Canthotomy

The so-called extended lateral canthotomy (ELC) offers broad soft tissue exposure of the lateral orbital wall, including the lateral aspect of the superior and inferior orbital rims. The skin incision in the ELC is carried from the lateral canthus in the RSTL for some 2.0 cm. It penetrates to the temporalis fascia and periosteum.

Release of the anterior and posterior crus of the lateral canthal tendon and the septal and muscular attachments of the eyelids to the orbital rim allows sufficient soft tissue mobility to fully expose the lateral, superolateral, and the inferolateral orbit. With the exception of the posterior crus of the lateral canthal tendon, these attachments can rarely be identified visually. Lying deep to the orbicularis oculi muscle, they may follow the rim to the inferior orbit. They are recognized tactilely by palpation with the needle electrocautery tip as firm bands between the lateral eyelid and the orbital rim. Definition of these structures is enhanced by firmly drawing the eyelids away from the lateral rim. Abrupt anterior movement of the lateral eyelids immediately follows their transection.

Canthofornix Incision

The canthofornix incision (CFI) is an alternative to the cutaneous subciliary incision for exposure of the inferior orbital rim and floor. It is, in essence, an ELC with a conjunctival extension.[15] After release of the fascial attachments of the eyelids to the lateral orbital rim, the eyelids are separated at the lateral raphe, exposing the lateral conjunctival fornix.

Delicate rake retractors having sharp teeth are used to hold the eyelid away from the globe to fully reveal the fornix. The conjunctiva and inferior tarsal muscle are incised with needle electrocautery in the depths of the fornix. During the forniceal incision a malleable retractor protects the eyeball. Ragnelle-Davis retractors replace the rakes before the incision is extended to the orbital rim. They are also used for subsequent eyelid retraction.

Restoring the lateral canthus to its anatomic position during reconstruction may prove difficult due to the absence of visible anatomic reference points. If only the inferior eyelid is released, as in an exposure limited to the inferior orbital rim, the superior crus of the canthal tendon provides a landmark that assists in repositioning of the eyelid.

When both eyelids are released, as in lateral orbitotomy, a partial-thickness hole is placed in the zygoma adjacent to the canthus. During closure, the hole is continued through the orbital wall, exiting on the same plane, about 5.0 mm posterior to the rim. A second hole is drilled, exiting at the same point. A double-armed 4-0 Polydek suture, on an ME-2 needle, is directed through the lateral margin of each tarsal plate. Each suture arm is then carried through one of the predrilled holes with a snare, fashioned by folding a short section of 30-gauge surgical wire in half. When the sutures are tied, the canthus is restored to its correct position (Fig. 29–4). Conjunctival closure requires only two buried absorbable sutures.

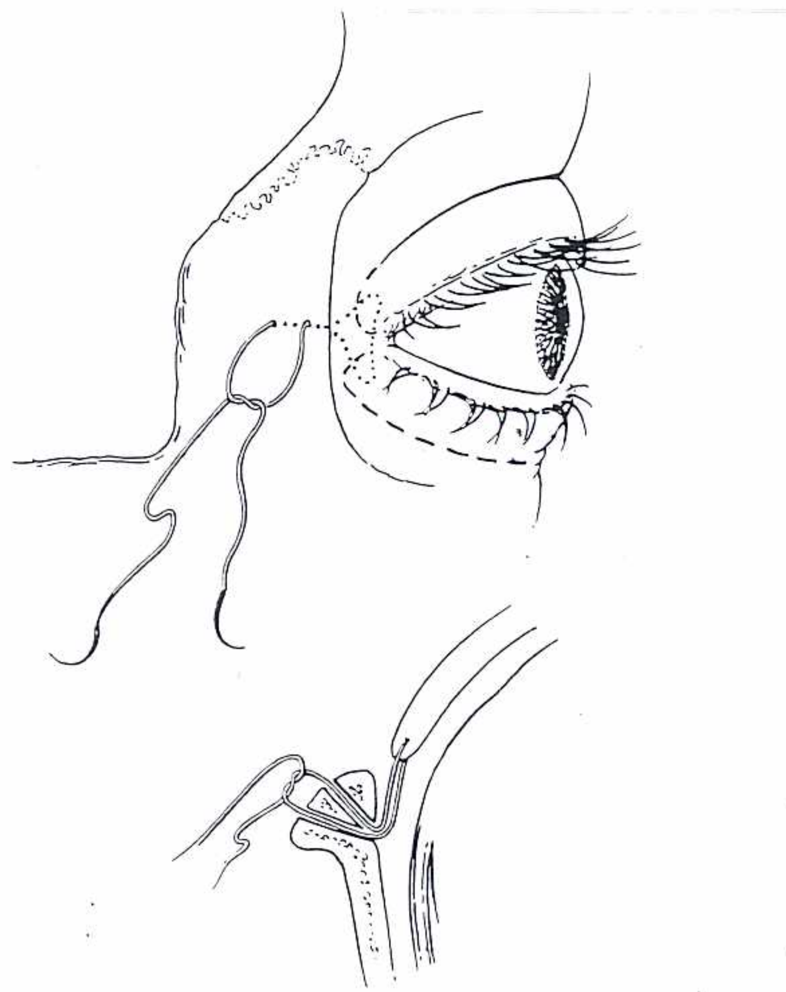


FIGURE 29–4 Marking the position of the drill prior to transection of the posterior crus of the lateral canthal tendon assures restoration of the canthus to the correct position following the canthofornix or extended lateral canthotomy incisions. During reconstruction, holes are extended through the zygoma, exiting 4 to 5 mm posterior to the rim on the plane of the canthus. Sutures attached to the lateral tarsal plates are guided to the surface and tied.

> **PEARL** **Advantages of the CFI include reduced bleeding from the conjunctival incision compared to the transcutaneous subciliary incision and near-total concealment.**

Complications include potential injury to the globe, entropion, and canthal dystopia, as just discussed. A hard plastic lens and a malleable retractor are used to protect the globe during the fornix incision. Postoperative entropion may be more likely when the incision is positioned at the inferior tarsal border rather than in the conjunctival fornix.

Gingival-Buccal Sulcus Incision

The buccal sulcus incision completely exposes the inferior body of the zygoma, the maxilla, and the lateral nasal wall. The mucosa is infiltrated with epinephrine-containing anesthetic solution. The oral incision is placed well above the attached gingiva, at the approximate level of the apices of the maxillary teeth. If the incision is made in the gingiva close to the teeth, the wound will be difficult to close. The parotid salivary duct is protected as it enters the oral cavity adjacent to the maxillary molars.

After vasoconstriction, the mucosa is incised with a scalpel and then extended to the maxilla with a needle cautery. Degloving of the face of the maxillary antrum is performed with a periosteal elevator, or a surgical sponge, to the level of the infraorbital nerve (see The Maxillary Sinus, above). A periosteal elevator is used to release the periorbita and muscle from the orbital rim, joining the oral incision with the CFI.

OSSEOUS EXPOSURE TECHNIQUES

Anterior Orbital Compartment Surgery

Anterior orbital lesions are contiguous to the globe and, if confined to this compartment, are often accessible with little or no bone removal. However, the roof of the orbit ascends from the rim into the anterior cranial fossa, creating the superior "vault." This space is difficult to visualize when the eye is proptotic or highly myopic and bone removal may be required (Fig. 29–5).

Superior Lesions

The upper eyelid crease incision provides access to the superior spaces of the anterior orbit. If the superior rim obstructs visualization of lesions that lie within the orbital "vault," it is removed by an osteotomy that extends from the supraorbital foramen to the zygomatic process of the frontal bone (Fig. 29–5). A saw or osteotome may execute it.

After tumor removal or biopsy the rim is replaced and stabilized by absorbable miniplate fixation. If the lesion cannot be totally removed and is producing a functional mass effect, reconstruction may be deferred to decompress the area. A visible deformity rarely results.

Extension of the lesion into the central orbital space requires more extensive bone removal if the objective is complete excision. Conventional hemifrontal craniotomy in conjunction with removal of the entire superior orbital rim, the fronto-orbital craniotomy, provides exposure for the removal of an anterior lesion with centromedial extension. Centrolateral extension of an anterior lesion is exposed by superolateral orbitotomy (Fig. 29–5). The bicoronal incision is usually preferred for exposure of this orbital quadrant.

An extracranial approach to the anterocentral and anteromedial orbit may be used if the frontal sinus extends over the operative area. In this technique the anterior wall and floor of the sinus are removed. A Caldwell view of the frontal sinus is obtained and a template defining the boundaries of sinus is made from clear x-ray film. It is sterilized and placed on the exposed frontal bone in the anatomic position of the sinus. A sterile lead pencil is used to inscribe the outline of the sinus on the bone (Fig. 29–6).

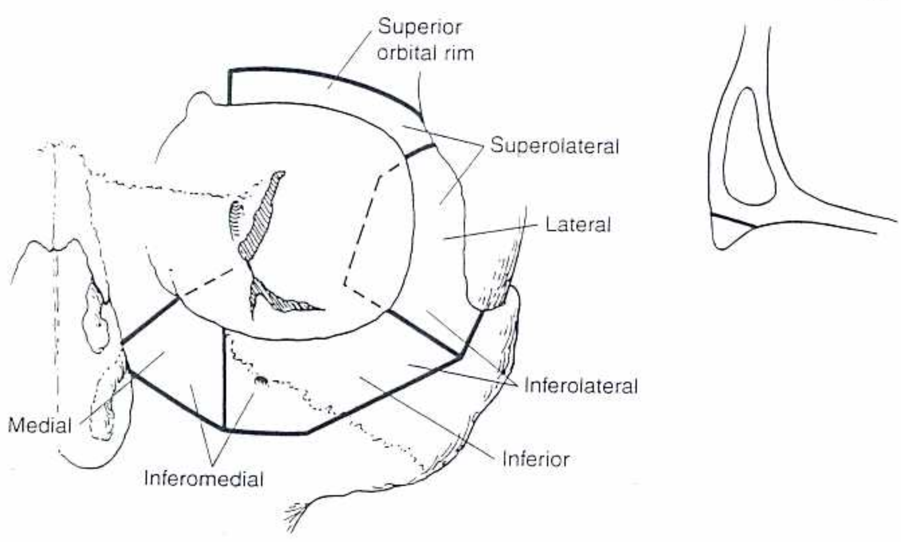


FIGURE 29–5 The basic extracranial orbitotomies include (1) the superior orbital rim, (2) superolateral, (3) lateral, (4) inferolateral, (5) inferior, and (6) inferomedial. The drawing on right illustrates cross-sectional view of the superior orbital rim.

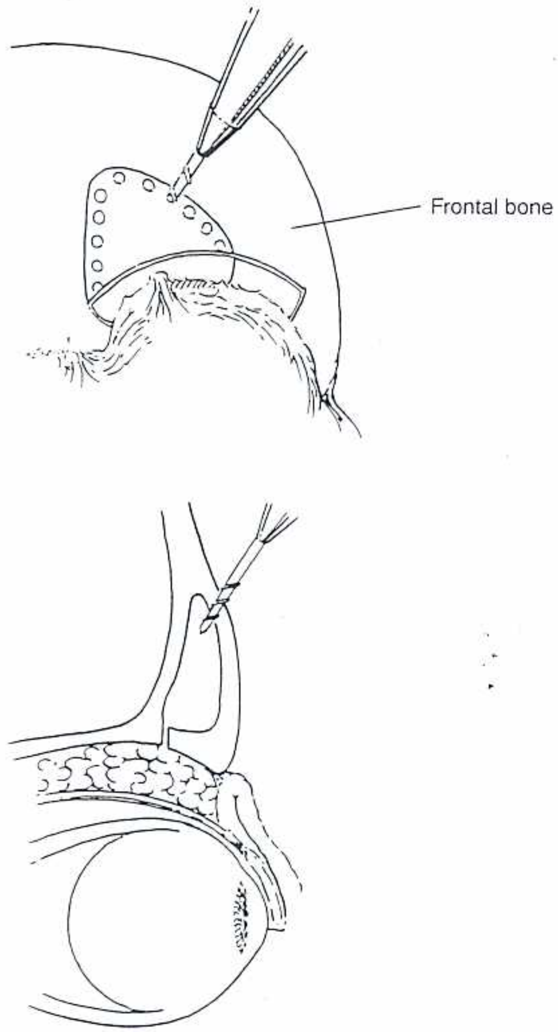


FIGURE 29–6 If the frontal sinus is extends over the central orbital compartment, a transsinus approach to the compartment may be used. The shape of the sinus is first inscribed on the frontal bone using a template. Pilot holes are then placed internal to the outline and joined with a side-cutting burr or saw (top). The anterior wall of the sinus and the roof of the orbit are removed (bottom).

The inferomedial frontal sinus is entered with a 3-mm cutting burr at the nasofrontal angle. The opening is enlarged with a small rongeur and the osteotomy is extended along the anterior floor of the sinus. The sinus interior is in view.

A series of pilot holes are drilled in the frontal bone 2.0 mm internal to the inscribed outline of the sinus (this maneuver minimizes the chance of intracranial penetration during the subsequent osteotomy). The holes are connected by side-cutting burr. The anterior wall of the frontal sinus is removed followed by the floor, exposing the anterior and central orbital spaces.

During reconstruction the anterior wall of the sinus and orbital roof are stabilized by fixation with miniplates. The osteotomy gaps are filled with hydroxyapatite if necessary (Norian, Cupertino, CA).

Lateral Lesions

The upper eyelid crease incision offers excellent exposure for lateral lesions that lie above the canthal tendon, as in the case in dermoid tumors at the frontozygomatic suture.[14] However, if the lesion descends into the inferior orbit, the ELC provides better exposure.

Inferolateral Lesions

Biopsy or removal of anteriorly placed inferior lesions rarely requires bone removal because the soft tissues can be displaced into the superior vault, which in most cases provides adequate surgical access to this space. The inferior orbital compartment is reached via the CFI, which also permits removal of the inferior rim, should increased exposure of the inferior orbital compartment be needed.

Inferomedial Lesions

A 180-degree, fornix-based conjunctival flap and disinsertion of the medial rectus tendon provides access for biopsy or tumor removal. Alternatively, a transcaruncular approach to the anteromedial compartment may be employed if the lesion is medial to the muscle. Neither approach, however, affords excellent visibility or room for dissection, due to the presence of the medial orbital wall.

PEARL... Visibility of the medial orbital compartment can be improved by removal of the lateral orbital wall, which allows lateral translocation of the globe.[7]

Removal of the inferior rim in conjunction with the lateral wall further enhances exposure of inferior anterior compartment (Fig. 29–5).

Central Orbital Compartment Surgery

The central orbit is a common site of tumor origin or extension. Large lesions of the lateral, inferior, and medial quadrants can usually be removed by extracranial orbitotomy because dissection may be carried between quadrants with reasonable safety. During dissection three-dimensional awareness of the position of the optic nerve is maintained and the soft tissues are protected. Lesions of the superomedial quadrant, however, are rarely accessible by purely extracranial bone removal.

Superolateral Lesions

Lateral orbitotomy, executed through either the bicoronal or ELC incision, exposes the centrolateral orbital spaces. The ELC is the preferred incision if bone removal may extend to the inferolateral orbit, because it offers better exposure of this region. Following canthotomy, the temporalis muscle is separated from the zygoma and sphenoid and the periorbita is separated from the orbital surface of the lateral wall.

Orbitotomy is initiated with a bone incision that first traverses the zygomatic process of the frontal bone and, turning inferiorly, follows the zygomaticosphenoid suture to the inferior orbit (Fig. 29–7). An assistant protects the orbital tissues with a malleable retractor.

A second osteotomy is carried through the inferior lateral orbital wall and anterior zygomatic arch, joining the previous bone incision. Removal of the lateral wall is continued with the resection of the dense triangular mass of the greater wing of the sphenoid. Initiated with a curette or rongeur, final resection is completed with a fine cutting burr, aided by loupe magnification, to facilitate recognition of the inner table of the middle cranial fossa. The Aesculap reciprocating saw, actuated by foot switch, is preferred for orbital osteotomy because it is easily manipulated in the limited confines of the orbit and it destroys minimal bone during the incision (Aesculap South San Francisco, CA).

A relatively large lesion may be removed through this exposure if it is peripheral to the muscle cone and well demarcated from orbital tissue, for example, pleomorphic adenoma of the lacrimal gland (Fig. 29–8). In the removal of such lesions, soft tissue

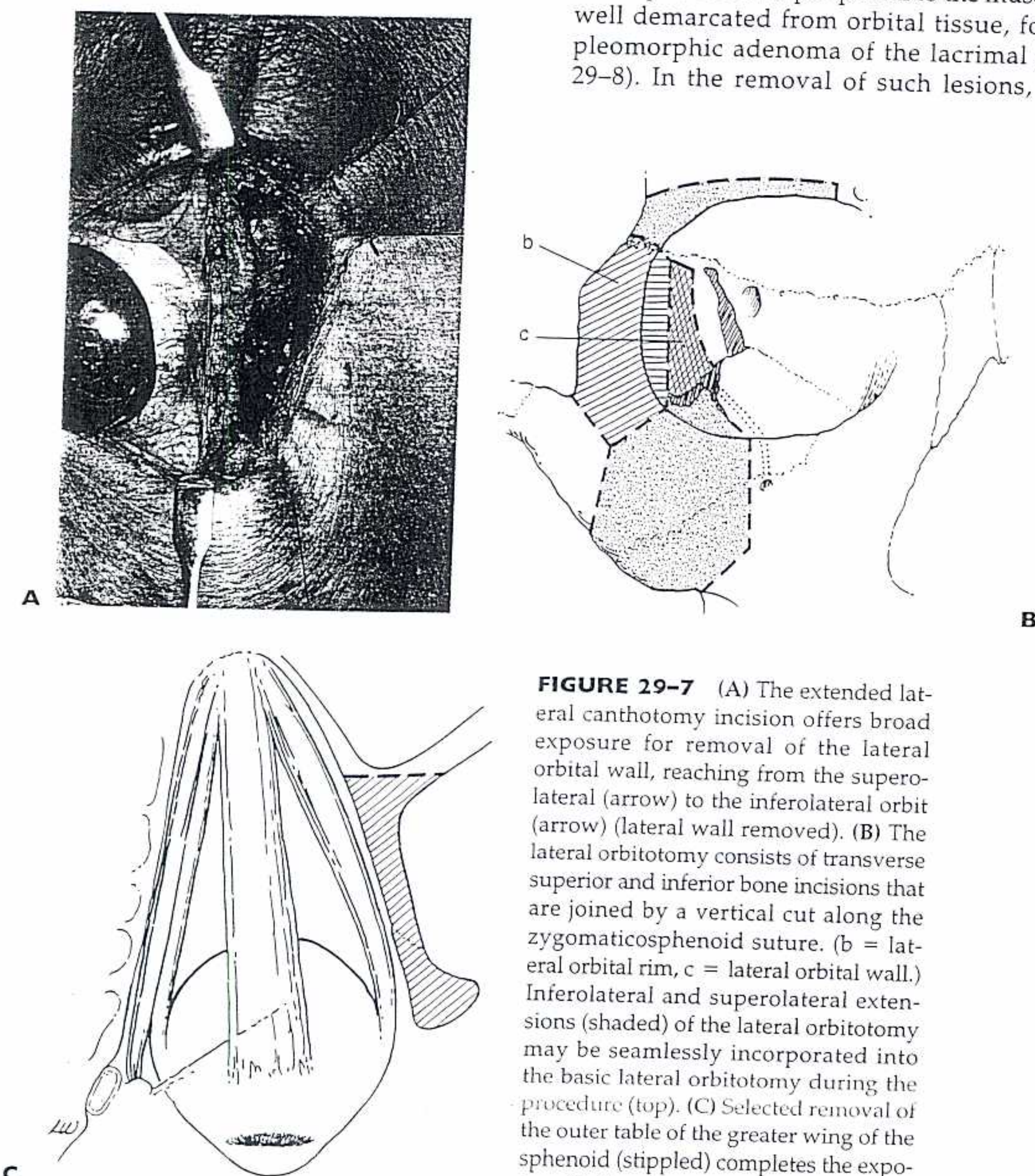


FIGURE 29–7 (A) The extended lateral canthotomy incision offers broad exposure for removal of the lateral orbital wall, reaching from the superolateral (arrow) to the inferolateral orbit (arrow) (lateral wall removed). (B) The lateral orbitotomy consists of transverse superior and inferior bone incisions that are joined by a vertical cut along the zygomaticosphenoid suture. (b = lateral orbital rim, c = lateral orbital wall.) Inferolateral and superolateral extensions (shaded) of the lateral orbitotomy may be seamlessly incorporated into the basic lateral orbitotomy during the procedure (top). (C) Selected removal of the outer table of the greater wing of the sphenoid (stippled) completes the exposure (bottom).

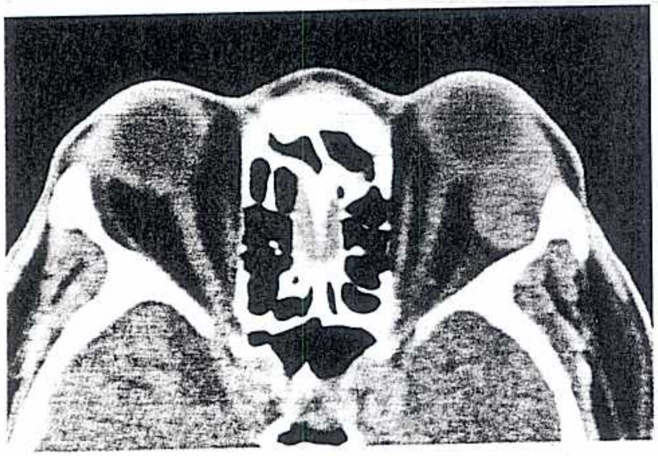


FIGURE 29–8 Superficial lesions of the lateral orbital compartments that are well demarcated from the orbital soft tissue, for example, pleomorphic adenoma of the lacrimal gland, are efficiently removed via lateral orbitotomy alone.

dissection begins anteriorly. As the tumor is displaced laterally from the orbit, normal medial tissues can be seen and protected.

> **PEARL** The lateral orbitotomy alone may offer insufficient exposure if the lesion is within the muscle cone and apposed to the globe and optic nerve because the medial surface of the tumor cannot be visualized (Fig. 29–9). An inferolateral orbitotomy that permits displacement of the lesion inferiorly into the maxillary sinus may surmount this barrier (Fig. 29–10).

Concomitant disinsertion of the lateral rectus may also be necessary. If dissection superior and medial to the tumor still cannot be performed under direct view with this added exposure, a frontozygomatic craniotomy is recommended (see Fig. 29–18). We feel that a tumor extending to the midline of the orbit is more effectively exposed by the frontozygomatic approach that is depicted in Figure 29–18.

Inferolateral Lesions

Inferior lateral quadrant exposure is achieved by combining the lateral orbitotomy described above with the removal of the inferior orbital rim lateral to the infraorbital foramen. The CFI and the gingival-buccal sulcus incisions are used to obtain necessary exposure of the zygoma, maxilla, and orbital rim and floor.

Following removal of the lateral orbital wall, as described above, inferolateral orbitotomy is initiated through the oral incision by placing a burr hole inferolateral to the infraorbital foramen (Fig. 29–10). Using the microreciprocating saw blade (Aesculap, MD988—13 mm), an osteotomy extends from the hole across the upper maxilla and through its zygomatic process. A perpendicular cut, lateral to the inferior orbital foramen, is then made through the rim and a second cut separates the body of the zygoma from the arch. Through the conjunctival incision, a bone incision is continued through the orbital floor to the inferior orbital fissure, paralleling the infraorbital canal. A metal ribbon retractor, controlled by the assistant, protects the globe and other orbital tissues. A 3.0-mm osteotome is used to complete release of the lateral wall of the maxillary sinus (Fig. 29–10). The anterior sinus wall, orbital rim, and floor are removed as a unit through the oral incision.

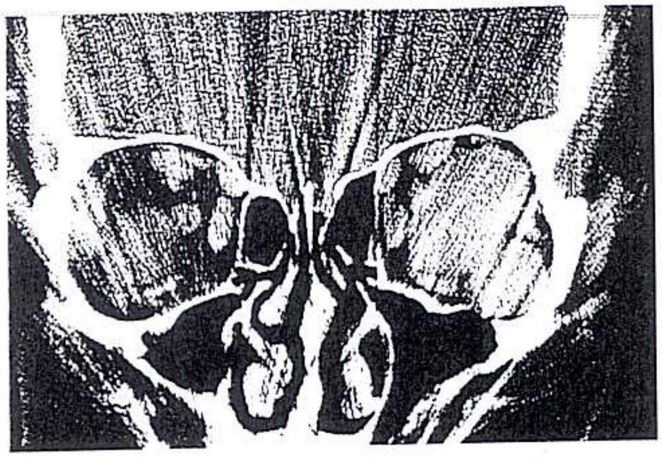


FIGURE 29–9 Lesions that occupy the lateral compartment abutting the optic nerve and globe are most safely removed by two-quadrant exposure, which allows displacement of the lesion and a direct view of the tumor and optic nerve during dissection. Optimal exposure of such lesions is provided by the frontozygomatic craniotomy (see Fig. 29–18).

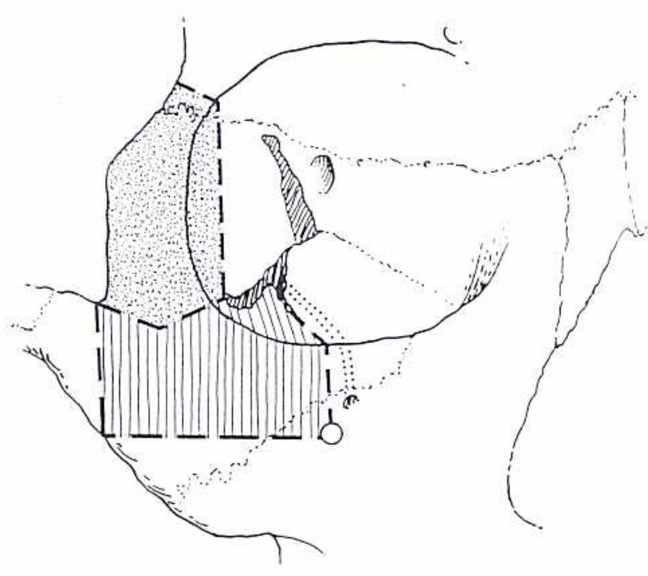


FIGURE 29–10 The inferolateral orbitotomy provides two-quadrant exposure for removal of inferolateral and inferocentral lesions.

Two-quadrant exposure allows the surgeon to see the tumor and the normal tissue superior and medial to it, as the lesion is displaced inferolaterally. The exposure of the maxillary sinus expands the area available for surgical manipulation. The sinus also provides drainage of the operative field, further improving visibility.

Inferomedial Lesions

The inferomedial orbitotomy includes removal of the medial inferior orbital rim and floor, the anterior wall of the maxillary sinus, the upper pyriform aperture, and the inferior aspect of the frontal process of the maxilla, and exposes the inferomedial quadrant (Fig. 29–11). It is executed through the CFI and gingivobuccal sulcus incisions. Ethmoidectomy may supplement the exposure.

A burr hole is placed in the maxillary face inferolateral to the infraorbital foramen, and the microreciprocating saw blade is placed into the sinus. An incision is carried medially across the face of the antrum and through the pyriform rim (coursing anterior to the nasolacrimal duct and superior to the root of the canine tooth). A lacrimal probe is placed within the nasolacrimal duct prior to osteotomy.

The next cut is made perpendicular to the infraorbital foramen and extended through the orbital rim. It then follows the infraorbital canal to the posterior limit of the floor. The canal is unroofed and the neurovascular bundle is atraumatically displaced, allowing division of the inferior wall of the canal by delicate osteotome. The posteroinferior margin of the canal is also transected by osteotome. The anteroinferior aspect of the foramen is removed by delicate cutting burr (Fig. 29–11).

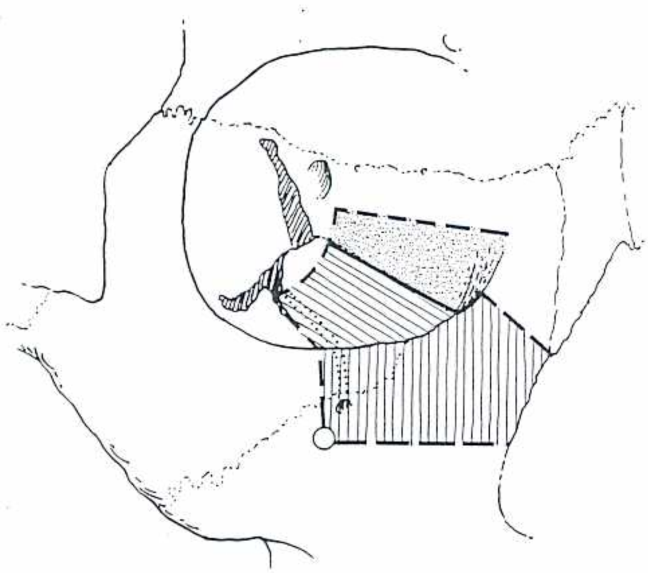


FIGURE 29–11 The inferomedial orbitotomy provides a satisfactory viewing angle for removal of most central, inferomedial, and selected apical orbital lesions. The maxillary sinus provides expansion and drainage of the operative field. Ethmoidectomy may provide supplemental exposure (shaded) and may be executed endoscopically or through the orbital exposure.

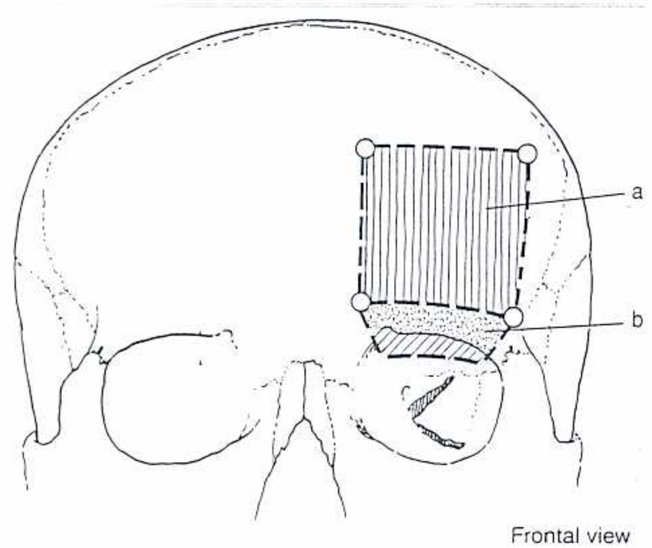
A medial osteotomy is next extended from the upper pyriform aperture through the frontal process of the maxilla to the lacrimal bone using the microreciprocating saw. Pilot holes may be placed along the intended incision, making the osteotomy easier to perform with the delicate saw blade. Resuming at the posterior lacrimal crest, the bone incision is continued by osteotome along the maxillary-ethmoid suture. The posterior attachments of the orbital floor are severed. Bone around the lacrimal sac and upper nasolacrimal duct is removed with delicate forceps and the entire osseous segment is removed through the conjunctival incision. The lacrimal probe is replaced by silicone tubing, which is retained during the early postoperative period to minimize the likelihood of lacrimal stenosis. Additional exposure is obtained by adjacent ethmoidectomy and/or lateral orbitotomy (Fig. 29–11).

Superomedial Lesions

The frontal sino-orbitiotomy offers extracranial exposure of the superomedial central orbital space if the frontal sinus is of sufficient size (Fig. 29–6). Otherwise, fronto-orbital craniotomy is required to achieve visualization of the superomedial surface of the tumor and protect the optic nerve during dissection. The frontal bone and superior orbital rim are removed, allowing retraction of the frontal lobe to expose the floor of the frontal fossa.

Using the bicoronal incision, the scalp is reflected to the canthal tendon medially and to the zygomatic arch laterally. Medial and lateral frontal burr holes are placed 3.0 cm above the orbital rim and anterior to the coronal suture (Fig. 29–12). Mannitol is given and/or cerebrospinal fluid is released via a lumbar drain to relax the dura before the craniotomy is performed. After removal of the frontal bone, the dura is reflected from the floor of the frontal fossa and protected by cottonoids and a retractor.

Osteotomy of the orbital rim, or frontal bar, is begun at the inferomedial burr hole using the Aescalap reciprocating saw. A companion osteotomy is extended from the inferolateral burr hole to the lateral orbital rim. A 3.0-mm burr hole is centered in the anterior floor of the frontal fossa about 1 cm posterior to the rim, and a transverse osteotomy using the microreciprocating saw completes release of the orbital rim (Fig. 29–12). The remaining floor of the frontal fossa is removed and saved for subsequent reconstruction. The roof of the ethmoid sinus and air cells may be removed to further broaden the operative field.



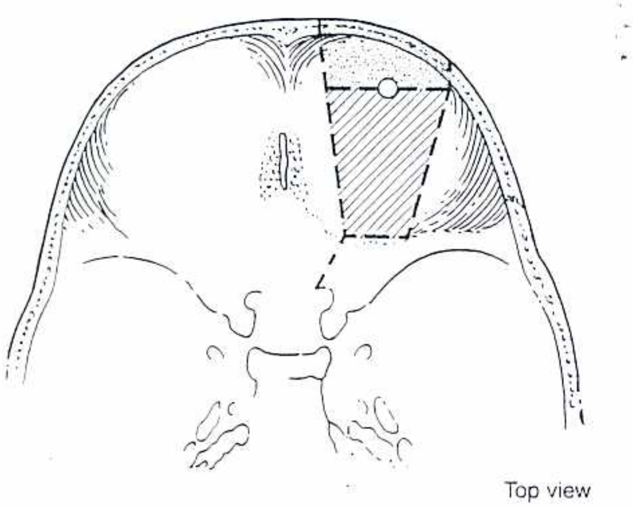


FIGURE 29–12 Frontal craniotomy (a) alone rarely offers adequate space for tumor dissection. Removal of the superior orbital rim (b) widens the operative field and permits execution of the techniques required in the removal of deeply positioned lesions of the centromedial, lateral, and anterior apical compartments.

Removal of the frontal bone provides an unobstructed view of the superomedial quadrant of the orbit with ample room for surgeon and assistant to maneuver. The exposure allows use of self-retaining retractors and the operating microscope.

Apical Compartment Surgery

Only that of the neighboring cavernous sinus rivals the density of the neurovascular structure within the orbital apex. The surgeon's view of the dissecting area is more severely limited by the osseous architecture than in other compartments, which renders the apex, in particular its medial quadrants, the most challenging of the surgical orbital regions.

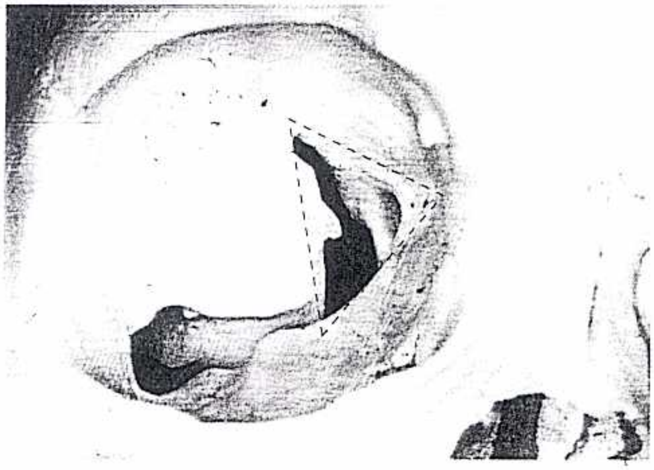


FIGURE 29–13 From the frontal perspective the form of the apex resembles an acute triangle whose apex points to the optic foramen.

The functional outcome of tumor excision within the apex improves with wide bone exposure, the design of which is facilitated by a thorough understanding of its three-dimensional osseous anatomy.[16] The union of the frontal bone and lesser wing of the sphenoid marks the roof of the extreme posterior orbital apex. When this area is observed from the frontal perspective, the inward slope of the lateral margin of the superior orbital fissure and medial wall produces a shape that resembles an acute triangle. The base is formed by the lateral margin of the superior orbital fissure and the apex points toward the optic foramen (Fig. 29–13).

When viewed from a perspective that is frontolateral and coaxial with the long axis of the optic canal, the shape of the apex resembles an isosceles triangle (Fig. 29–14). The apparent change in form occurs

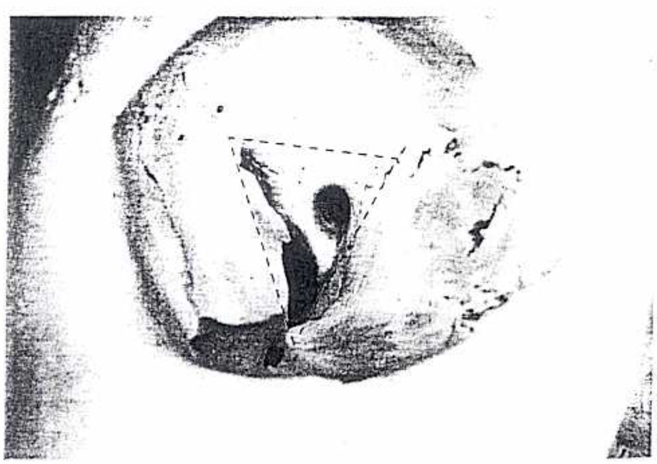


FIGURE 29–14 From a frontolateral perspective coaxial with the optic canal, the apical form resembles an isosceles triangle.

because the maximum lateral projection of the orbital plate of the ethmoid lies some 9.0 mm anterior to the inferior limit of the superior orbital fissure (approximately at the posterior medial maxillary sinus). Posterior to this coordinate, the inferomedial wall of the apex shifts slightly toward the midline.

Medial Lesions

The shortcomings of extracranial approaches to the posterior orbital apex have been noted.[17–19] Adequate room for soft tissue manipulation is difficult to achieve by these methods, most of which are modifications of the inferomedial orbitotomy that has been previously described.[7,20] The lateral projection of the posterior medial wall prevents direct visualization of lesions in the posteromedial apex during extracranial approaches that follow the medial wall (Fig. 29–15). Methods to improve visualization of the region include transnasal endoscopy.[21] Dailey et al[22] developed the LeForte 1 orbitotomy to improve visualization of the inferonasal apex. The most critical limitation of these methods, however, is the absence of a direct view of the posterior, superior, and lateral margins of the tumor, which hinders protection of the optic nerve during dissection and the control of orbital tributaries of the internal carotid artery.

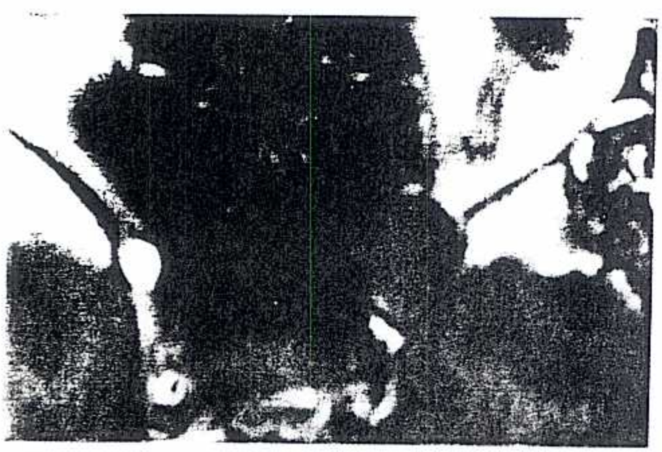


FIGURE 29–15 Inferomedial apex lesion with visual loss. Preoperative imaging indicated possible dural origin in the anterior middle cranial fossa. The lesion extended medially into the ethmoid and sphenoid sinuses and possibly into the anteromedial cavernous sinus. Angiography failed to demonstrate direct supply of the lesion by the internal carotid artery. The exposure, illustrated in Fig. 29–17, included partial unroofing of the optic canal and intracranial exposure of the adjacent carotid artery, prior to orbital dissection to permit rapid access in the event of unexpected supply to the tumor (Wayne Villanevua, M.D.). The tumor proved to be a cavernous hemangioma.

PEARL... Transfrontal orbitotomy offers an unobstructed view of the superomedial apex, facilitating atraumatic development of a plane separating the tumor from the optic nerve and the nerves of the superior orbital fissure.

Even a transcranial approach noted above, however, does not completely overcome the limited posteroinferior operative field created by lateral protrusion of the posterior medial wall. A solution to this anatomic barrier lies in the conversion of the triangular form of the posterior apex to a rectangle by transcranial sphenoethmoidal orbitotomy (Fig. 29–16).

Bone incisions to enlarge the surgical field are first inscribed with a sterile pencil. The posterior orbital plate of the ethmoid and contiguous air cells is removed first, followed by the ethmoid notch of the frontal bone. A delicate rongeur or the microreciprocating saw may remove the bone (use of the saw may allow the roof, and at times the lateral wall of the sinus, to be reused in reconstruction). A cottonoid protects the dura covering the olfactory bulb during removal of the ethmoid roof.

Sphenoidotomy opens this sinus, allowing removal of its roof under direct vision. The operating microscope may be used during the bone incisions. If the tumor extends to the cavernous sinus or middle fossa or if it enters the orbit from these locations, removal of the anterior clinoid and additional lateral exposure of the middle cranial fossa may supplement this approach (Fig. 29–17).[23]

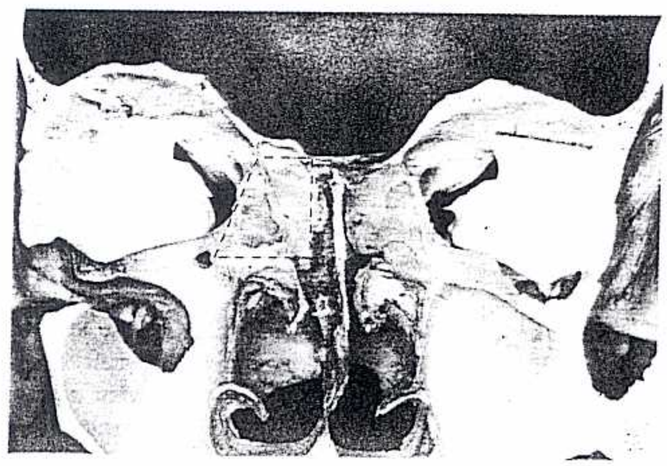


FIGURE 29–16 The triangular form of the posterior orbital apex may be converted to a rectangular one by use of the contiguous ethmoid and sphenoid sinuses.

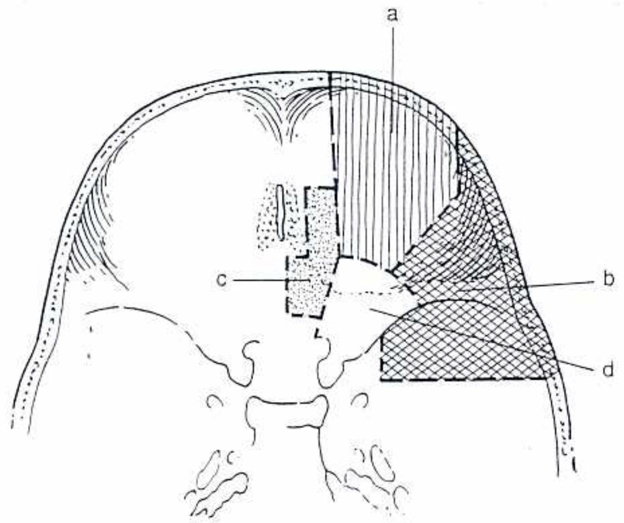


FIGURE 29–17 Transcranial sphenoethmoidal orbitotomy. Visualization of tumors located inferiomedial to the optic nerve and in close proximity to the internal carotid artery is provided by combined frontal cranio-orbitotomy (shaded) and sphenoethmoid orbitotomy (a, c) (see Figs. 29–15 and 29–16). The approach permits effective soft tissue dissection within the posterior, inferior apex with minimal traction on the optic nerve. It can be readily extended to include exposure of the internal carotid artery (d). Addition of a pterional bone flap (b) provides access to the cavernous sinus.

Transcranial sphenoethmoidal orbitotomy expands the surgical field, allowing a direct view of the inferomedial apex (Fig. 29–16). This ability to see the posterior and lateral margins of a tumor located in this region improves the safety and efficiency of soft tissue dissection compared to extracranial methods. It permits the surgeon to direct the majority of the force of dissection to the lateral tumor margin and away from vital normal tissues as the tumor is displaced into the sinus cavity. Devices that assist soft tissue retraction can be used, and drainage of the operative field is excellent.

Ethmoidectomy

The external ethmoidectomy has been described many times and may be reviewed in standard texts of sinus surgery. Some general points pertinent to its use in both extracranial and intracrainal exposures of the orbit are discussed here.

The frontoethmoid suture marks the roof of the ethmoid sinus; however, the medial limit of the cribriform plate may lie on or below this plane and its location must be determined from preoperative CT. Beginning the ethmoidectomy at the superior border of the lacrimal bone in extracranial procedures allows a direct view of the roof of the ethmoid throughout the procedure. This improved view permits the ethmoidectomy to be carried safely to the posterior ethmoid and into the sphenoid if necessary.

The anterior and posterior ethmoidal arteries exit through the frontoethmoid suture and lie on the ceiling of the sinus with or without a covering of bone. The anterior foramen, posterior foramen, and optic canal lie, respectively, 12, 24, and 30 mm posterior to the anterior lacrimal crest. Anatomic variation is common in and around the ethmoid sinus, as previously mentioned, and the positions of the ethmoidal foramina frequently do not conform to these guidelines. A middle ethmoidal foramen has been reported.[24] The arteries may also be inconstant, and multiple posterior foramina may be found.[25,26]

The roof of the ethmoid sinus is continuous with that of the sphenoid sinus, allowing the surgeon to follow the bone safely into the sphenoid as noted above. The medial wall of the optic canal may lie within the posterior ethmoid air cells.

Cottonoids, soaked in a vasoconstricting agent, placed between the lateral wall of the nose and the nasal septum protect the septum during creation of the drainage window after sphenoethmoidectomy, and serve as a surgical landmark.

Lateral Lesions

There are numerous effective options for exposure of the lateral orbital apex. Due to the generous operative field created by removal of the lateral orbital wall, extracranial exposures are more often suitable than in the medial apex.[27] This is especially true for large lesions that extend to the apex from the anterior and central spaces. In such cases, dissection of the tumor is begun anteriorly and, as it is laterally displaced, a direct view of the contiguous normal tissue is obtained. If the lesion lies in the inferolateral quadrant between the lateral and inferior rectus muscles, subtotal removal of the zygoma and lateral maxilla greatly expands the operative area. Viewing angle and the drainage of the field via the maxillary sinus are improved by this extension of the osseous exposure (Fig. 29–10).

Successful exposure of tumors positioned deep within the lateral apex, including those with limited cavernous sinus extension, has been reported via the lateral approach combined with partial removal of the lateral mass of the greater sphenoidal wing.[28,29] If the tumor is concealed and extends to or beyond the midline, lateral orbitotomy does not allow direct view of the critically important adjacent normal tissue. Frontal craniotomy provides an alternative approach that improves the view of this area, but substantial pressure must be exerted on adjacent tissue to displace the lesion from the orbit to frontal fossa. Two-quadrant exposure can be obtained by combining the lateral orbitotomy with frontal craniotomy, the frontozygomatic approach, and has been shown to improve the functional outcome of lesion removal in this area (Fig. 29–18).

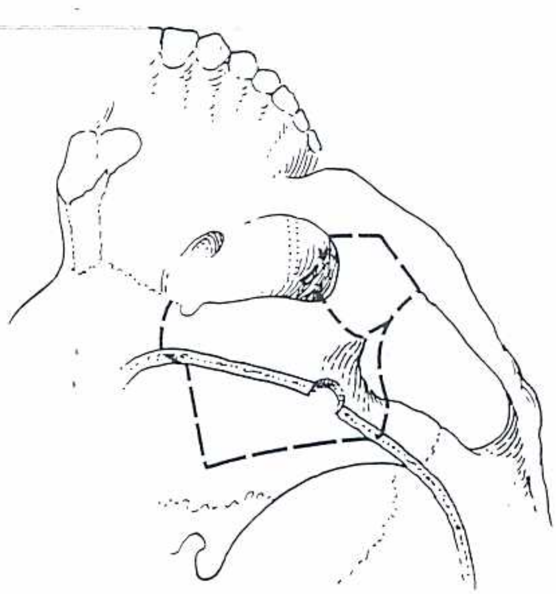


FIGURE 29–18 Frontozygomatic orbitotomy.

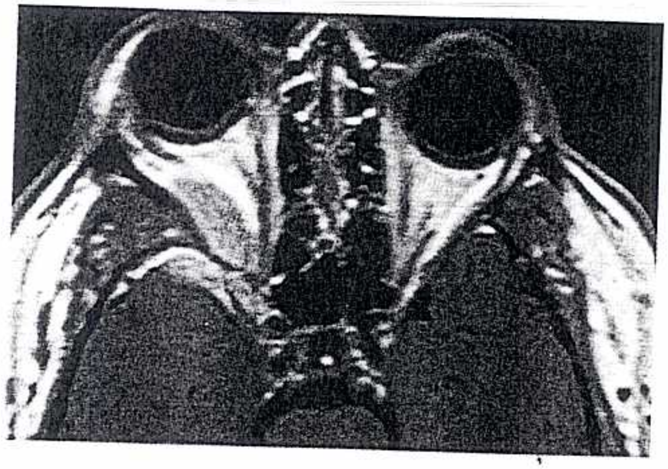


FIGURE 29–19 Cranio-orbital meningioma.

The operative field created by this method permits dissection between the tumor and normal tissue under direct vision. Dissection forces can be directed laterally or superolaterally away from the optic nerve and superior orbital fissure. The operating microscope and self-retaining retraction devices can be employed, and there is ample room for the surgeon and assistant to work efficiently. A pterional bone flap supplements the fronto-orbital exposure if the lesion occupies both the orbit and the middle cranial fossa (Figs. 29–19 and 29–20).[30] If the lesion extends into the lateral orbit from cavernous sinus, Dolnec's exposure is used.[22]

Cranio-Orbital and Sino-Orbital Lesions

Further discussion of exposures designed for tumors that enter the orbit from the cavernous or paranasal sinuses can be found in recent volumes devoted to skull base surgery.[31,32]

SOFT TISSUE TECHNIQUES AND TUMOR RESECTION METHODS

Successful tumor removal begins with properly designed bone exposure. This exposure creates an advantageous operating position for the surgical team that includes a direct view of both the lesion and vital contiguous normal tissue (or the immediate area of such tissue), and adequate room for the performance of surgical maneuvers. Techniques that promote efficient tumor removal with minimal trauma to normal tissue are highlighted in this section.

The aim of soft tissue dissection is the gradual displacement of the lesion from the orbit to a contiguous cavity that is created by the excision of bone. As tumor removal proceeds, an ever-improving view of normal soft tissues adjacent to the tumor should be obtained. If this is not the case, the osseous exposure is extended.

Superficial lesions displace normal tissue toward the midline of the orbit. A plane between them is usually readily established as the leading edge of the tumor is maneuvered from the orbit. Deeply positioned tumors, however, must be reached by dissection through normal tissue, preferably in areas devoid of neural structure when possible (e.g., beneath the lateral and medial recti rather than over their superior margin).

Techniques that minimize soft tissue trauma during this phase of the procedure include the use of loupe magnification (4.0×) and coaxial lighting or an operating microscope. Gentle blunt dissection, precise retraction, and tissue protection by the use surgical patties (cottonoids) are additional means of reducing trauma during tumor isolation (Johnson and Johnson, Raynham, MA).

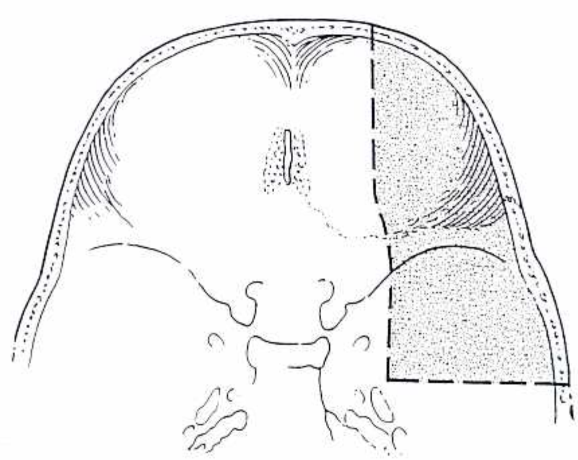


FIGURE 29–20 Cranio-orbital tumors extending from the middle cranial fossa to the lateral orbital compartments require modified pterional and frontolateral approaches.

The orbital adipose tissue conceals both tumor and vital neural tissue. Its resilience propels it into the surgical field as pressure is applied during dissection. Control is established by delicate entry into the fat, initiated with blunt dissectors, such as the Penfield elevators (numbers 3 and 4), and, as the surgical plane is developed, cottonoids are inserted to atraumatically restrain the fat (see below).

As dissection advances, periodic saline irrigation and suction (applied to cottonoids, not the orbital tissue) helps to identify hemorrhagic points and maintain a clear surgical field. Wetfield cautery is delivered through delicate, insulated bayonet forceps. When the tumor is reached, it is grasped and gently displaced from the orbit as counterdirectional forces are ap-plied to contiguous orbital tissue. Cottonoids are inserted into the void that is created between the tumor and the adipose tissue. Blood supply to the tumor is interrupted by first skeletonizing the feeding vessels. Bipolar coagulation is then applied to the vessels close to the surface of the lesion. This process is continued until the tumor is completely isolated from neighboring tissue.

Effective retraction is critical during tumor removal, and must be capable of rapid and repeated alteration of position. Retraction instruments are applied to the cottonoids rather than unprotected normal tissues. There is no substitute for the four hands of an experienced surgeon and cosurgeon as a retraction system. The retractionist's role is equal to that of the surgeon, executing maneuvers that maintain exposure and advance tumor resection by coagulation, suctioning, and strategic application of countertraction. A self-retaining retraction system is a valuable adjunct to this process, and the Budde Halo retractor system (OMI Surgical Products, Cincinnati, OH) provides delicate retractor blades that are suitable for orbital tissue. To preserve tissue perfusion, retraction is relaxed when maximum exposure is not required.

Cystic lesions pose unique technical difficulties during dissection, particularly those containing irritative material such as the dermoid and epidermoid (Fig. 29–21). Being thin-walled, they are prone to rupture during dissection and may require more generous bone exposure to permit optimal view and manipulation of the lesion. Adjacent tissues frequently adhere to one of the orbital surfaces of the dermoid cyst, due to microfistulization of its contents, and development of a satisfactory plane of dissection is challenging.

When dense adherence to normal tissues is encountered, aspiration of the cyst contents may be preferable to uncontrolled rupture during attempts to isolate it. Aspiration is followed immediately by irrigation of the entire field to remove material that may have been released. The free wall of the cyst is then resected and the irrigation is repeated. This maneuver creates space for dissection, reducing the area of bone removal required, and permits direct traction on the remaining wall, resulting in easier separation from adjacent orbital tissue.

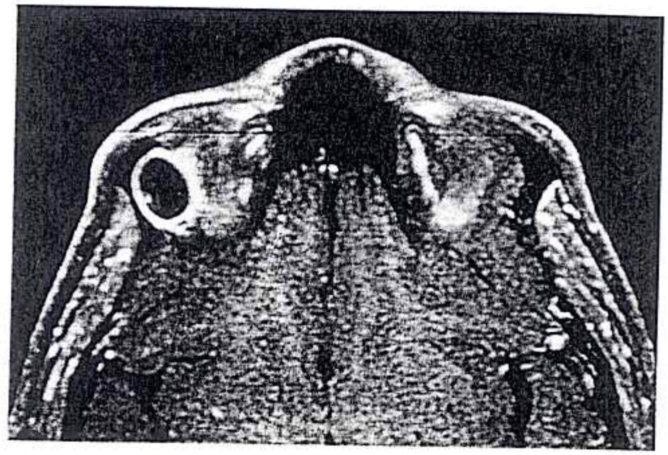


FIGURE 29–21 Thin-walled cystic tumors may require added exposure and/or special dissection methods, as they are prone to rupture.

OSSEOUS AND SOFT TISSUE RECONSTRUCTION

Successful and efficient osseous and soft tissue reconstruction is guided by basic craniofacial tenets. Bone is not discarded for the sake of expedience during the exposure phase. Fragmentation of the orbital walls is avoided whenever possible. Leaving rims and roof or floor fragments in continuity expedites reconstruction by avoiding protracted efforts to restore contour. Shaping and positioning miniplates and predrilling the bone for subsequent application of these devices during the exposure phase consistently shortens total operating times.

When bone must be discarded during exposure, split calvarial grafts that are shaped to match the original thickness and contour of the area being reconstructed replace it. The use of iliac crest and rib grafts is less desirable due to their high rates of reabsorption. If craniotomy was performed, grafts are readily obtained by expanding the ostectomy and removal of the inner table from the calvarium. The outer table is replaced, restoring skull contour. Following extracranial approaches, suitable grafts are obtained from the outer table lateral to the midline and posterior to the hairline. Harvesting of split calvarial grafts should not be attempted without substantial experience under the supervision of a surgeon who is expert in the technique.

PEARL... Alloplastic materials such as acrylic, polyethylene sheeting, and hydroxyapatite may suffice for reconstruction of the orbital floor if sufficient bone is not available. These materials may also be chosen for cranial reconstruction under similar circumstances.

The principles of orbital floor reconstruction apply regardless of the material used: the orbital bilge posterior to the orbital rim is restored and the upward slope and medial cant of the orbital floor is re-created. Two-point fixation by resting the graft or implant on the preannular shelf and securing it to the anterior orbital rim by miniplates and/or lag screws assures stability. A smooth surface is placed toward the orbital tissues. Exposed mesh is avoided because soft tissue ingrowth makes repeat dissection difficult and fibrous tissue adherence to the mesh may interfere with ocular motility.

Several plating systems are currently available and none has a clear advantage over the other in orbital reconstruction. Absorbable systems are attractive because plate removal is obviated when relatively short-term stability is needed. For this application only the BioSorb FX modular system, at present, offers plates that can be shaped without heating to adjust contour (Bionix Implants, Blue Bell, PA) (Fig. 29–22).

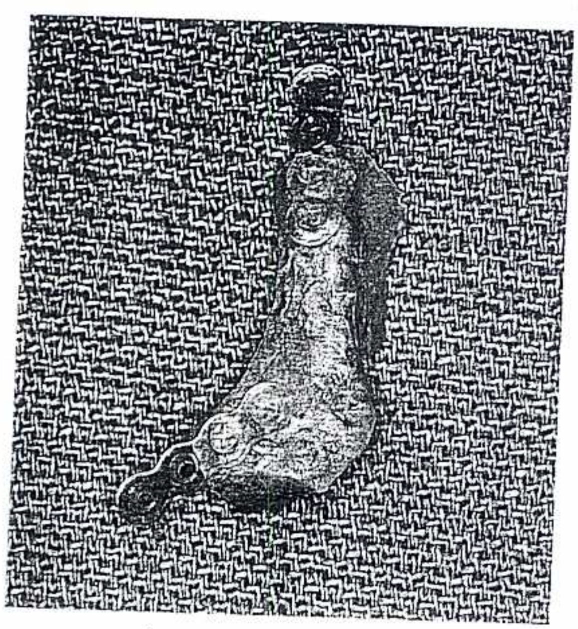


FIGURE 29–22 Absorbable miniplates are used to stabilize orbital segments not subject to muscular forces.

Following intracranial approaches the integrity of the dural interface between the cranial cavity and the orbit is established by suture and/or replacement with autogenous or alloplastic materials if dura was resected. To help establish a watertight seal, the dural surface may be coated with fibrin glue (Baxter Healthcare, Deerfield, IL). Fascia or muscle may also be placed over the reconstituted floor of the frontal fossa to further stimulate formation of a fibrous seal. Intermittent drainage of cerebrospinal fluid (CSF) via a lumbar drain is employed in selected cases.

Removal of the roof of the ethmoid and sphenoid sinus requires that communication between the cranium and the nasal cavity be sealed with split calvarial grafts, if the original bone is not available. Prior to reconstruction of the sinuses, however, sinus drainage into the nasal cavity must be established. Diseased or injured mucosa is removed along with damaged air cells to provide unobstructed gravity drainage. If the ostia have been damaged, a generous window in the lateral nasal wall may be necessary. Middle turbinectomy is not recommended because it is an important anatomic landmark, and nasal crusting often follows its complete removal.

A pericranial flap, harvested from the deep surface of the bicoronal flap, is placed over the roof of the reconstructed sinuses to further isolate the cranium from the nasal cavity.[33] A fat graft may be placed within the sinus to reduce the risk of pneumocephalus. Bone edges are tightly apposed over the frontal sinus when the superior orbital and frontal bone are replaced to prevent leakage of air into the cranial cavity. Gaps remaining at the osteotomy sites may be filled by hydroxyapatite.

If there is concern that postoperative tissue edema may compress the optic nerve, posterior medial wall reconstruction may be waived to provide decompression. Similarly, in the case of benign but unresectable apical tumors, apical decompression may forestall further visual loss for several years.

IMAGING

Preoperative Imaging

Computed tomography in both axial and coronal planes provides adequate information for the preoperative planning of orbital tumor exposure. Magnetic resonance imaging (MRI) is also employed in the evaluation of lesions of the optic nerve and of lesions at the interface of the orbital and cranial cavities. The absence of bone signal may create false positives and negatives in this region. MRI is especially valuable in delineating tumors of the cavernous sinus, which is poorly imaged by CT. A carotid angiogram is obtained if the lesion is thought to be an arteriovenous malformation or if the relationship of the lesion to the carotid artery must be known to plan the exposure (Fig. 29–15). If a varix is suspected, its vascular nature may not be demonstrated unless jugular compression is performed during the venous phase of the angiogram.

Intraoperative Imaging

Most orbital lesions can be localized by dissection during surgery. However, deeply situated cystic lesions, because of their compressibility, may be difficult to isolate. In this rare case intraoperative MRI may play a useful role for this purpose if available.

COMPLICATIONS

The potential for morbidity in the surgical management of orbital tumors exists because of the close proximity of neural tissue and neoplasm, and unpredictable anatomic variations. Lesions in the apex and those occupying both the cranial cavity and orbit pose the greatest risk of postoperative neurologic deficit.

The methods described in the preceding pages have been used in the management of 81 orbital lesions. Complications to date include transient motor neuropathy (ten), permanent sensory neuropathy (five), transient optic neuropathy (two), facial contour abnormality and/or enophthalmos requiring secondary repair (three), sinusitis (two), CSF leak (two), CSF leak requiring repeat craniotomy (one), and pneumocephalus (one). Potential complications include superior orbital fissure syndrome with permanent paralysis of the muscles extrinsic and intrinsic to the eye, blindness, meningitis, intracranial hemorrhage, and stroke.

Transient optic neuropathy was associated following extracranial removal of a large inferior apical schwannoma and after intracranial removal of a sphenoorbital fibrous dysplasia. Postoperative edema and/or optic nerve traction during dissection was suspected in both cases. Vision returned to preoperative levels following treatment with high-dose corticosteroids.

Following this experience, the transcranial sphenoethmoid orbitotomy was developed for removal of tumors from the medial apical quadrants. The broad operative field enables dissection vectors to be directed toward the midline, minimizing pressure on the ophthalmic artery and optic nerve, as previously noted. The cavities also provide drainage of fluids during tumor removal, which improves visibility.

Intraoperative steroids are employed during removal of tumors from the orbital apex, and the operative field is decompressed if dissection around the optic nerve has been prolonged. Relatively large steroid dosages (e.g., dexamethasone 10 mg every 6 hours) and close visual monitoring are continued for 48 hours after surgery and rapidly tapered thereafter. As a further precaution against delayed compressive optic neuropathy, postoperative drainage of the sphenoid and ethmoid sinuses is assured by creating a window in the lateral nasal wall near the superior meatus. These methods have been used in five patients with preoperative optic neuropathy due to an apical neoplasm. Postoperative vision was either improved or maintained at preoperative levels in all.

Transient neuropathy of the extrinsic muscles of the eye is common after intraorbital dissection. The levator palpabrae superioris is prone to postoperative dysfunction following even brief retraction. These occurrences should be presented to the patient as expected outcomes of tumor removal from the central and apical compartments.

Recovery of upper eyelid function may require several months, but no patient has required subsequent ptosis repair. Extraocular muscle function is typically recovered within 6 months, but may take longer. Surgical repair should be deferred until the degree of ocular deviation is stable for at least 3 months, but not earlier than 6 months unless the muscle has been denervated. Nerve grafting may be attempted in such cases if a sufficient residual segment of motor nerve remains.

ORBITAL EXENTERATION

Invasive lesions arising at the skull base, for which the primary therapy is surgical, may require exenteration of the orbital contents. Orbital exenteration methods are described in chapter 25. In this section a method of exenteration will be presented that preserves the eyelids, conjunctiva, and lacrimal drainage apparatus.

If the neoplasm spares the anterior orbit, complete resection of the involved tissue without sacrifice of the eyelids is possible. Retention of the lids allows rehabilitation by a conventional ocular prosthesis and subsequent ptosis repair by fascia-lata suspension. This approach may produce an aesthetic result that exceeds that attained through the use of a silicone facial prosthesis.

This technique may be performed entirely through the bicoronal incision during craniotomy. Following removal of the abnormal tissue from the posterior orbit, the posterior surface of the globe is exposed by blunt dissection. Dissection is then carried to the corneal limbus in the quadrants between the rectus muscles. Posterior traction is then placed on the globe and the rectus muscles are detached. Ciliary artery bleeding is controlled by bipolar cautery. A transtenon peritomy is performed at the corneal limbus. The levator is transected near the origin of its aponeurosis. The globe is then removed.

If a craniotomy was performed, the orbital rims are reconstructed after cranial reconstitution and transfer of the temporalis muscle to the orbit. The muscle will only rarely reach the midline. Dividing it into two components with preservation of the deep temporal artery allows the section contiguous to the orbit to reach to the medial orbital wall in many cases.

A dermis fat graft may be used to supplement the orbital volume provided by the temporalis muscle. A pericranial flap or temporoparietal flap may be placed over the anterior face of the graft, providing an additional source of blood supply.[34] The volume deficit created by translocation temporalis muscle is then reconstructed with an acrylic or polyethylene implant. If temporalis muscle resection is required due to tumor invasion, a free flap is used to restore orbital and temporal soft tissue volume, followed by osseous reconstruction (Fig. 29–23).

Prosthetic rehabilitation is delayed until soft tissue healing is complete, usually 6 to 12 months. Additional supplementation of the orbital tissue volume may be required. When volume is satisfactory, the prosthesis is crafted.

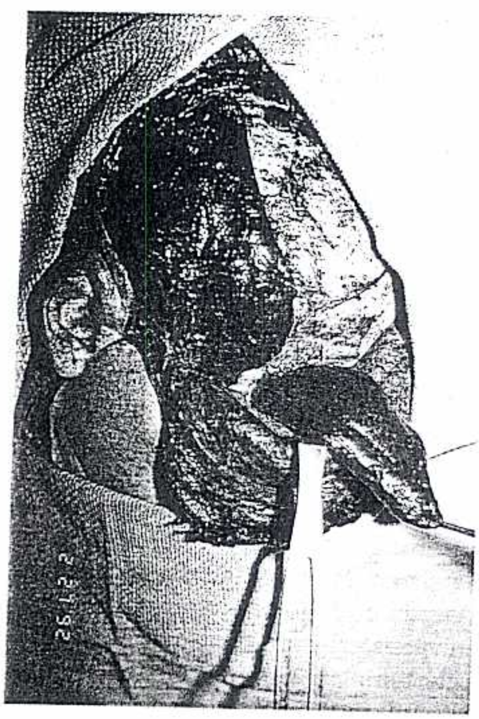
Reconstruction is completed by ptosis repair, using autogenous fascia lata to suspend the upper eyelid from the frontalis muscle (Fig. 29–24). If the frontal branch of the facial nerve is dysfunctional, ptosis repair is deferred until the eyebrow is returned to its anatomic position. The fascia is fixed to the periosteum during the subsequent ptosis correction.

The foregoing method of eyelid preservation cannot be used if postoperative adjuvant radiation of the orbit is required. The radiation damages the conjunctiva, which results in forniceal contracture, and a prosthesis cannot be comfortably worn. In these cases conventional exenteration with preservation of only eyelid skin and orbicularis muscle is suggested.

TREATMENT OF CONGENITAL MICROPHTHALMIA

Conventional treatment of congenital microphthalmia may take many forms, but usually consists of replacement of the vestigial eye with a fixed volume orbital implant that is periodically replaced by progressively larger implants. Conjunctival conformers of increasingly larger size are concurrently applied to the growing conjunctival fornices. This process achieves noticeable improvement but is protracted, and eyelid and facial skeletal growth is dysmorphic in many cases.[35]

A



B

FIGURE 29–23 (A) Following orbital exenteration in the treatment of a recurrent sphenoid wing meningioma the temporalis muscle was resected. (B) The orbital walls were reconstructed and a gracilis muscle free flap reconstructed the soft tissue deficits created by posterior orbital exenteration and resection of the temporalis muscle (John Derr M.D./Joe Banis M.D.). The eyelids, conjunctiva, and lacrimal drainage system were preserved.

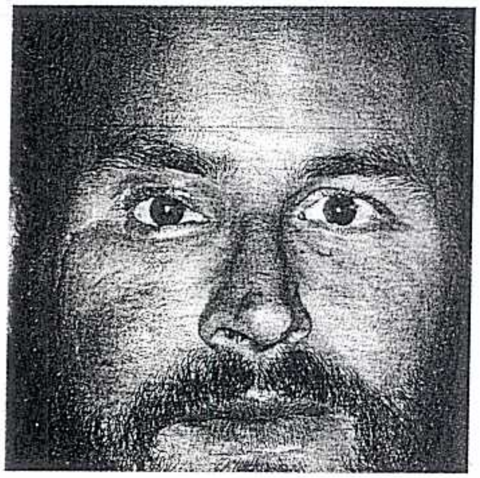


FIGURE 29–24 Postoperative appearance of the patient shown in Fig. 29–23 after supplemental orbital dermis fat graft, fitting of an ocular prosthesis, brow lift, and autogenous fascia lata tarsofrontalis suspension.

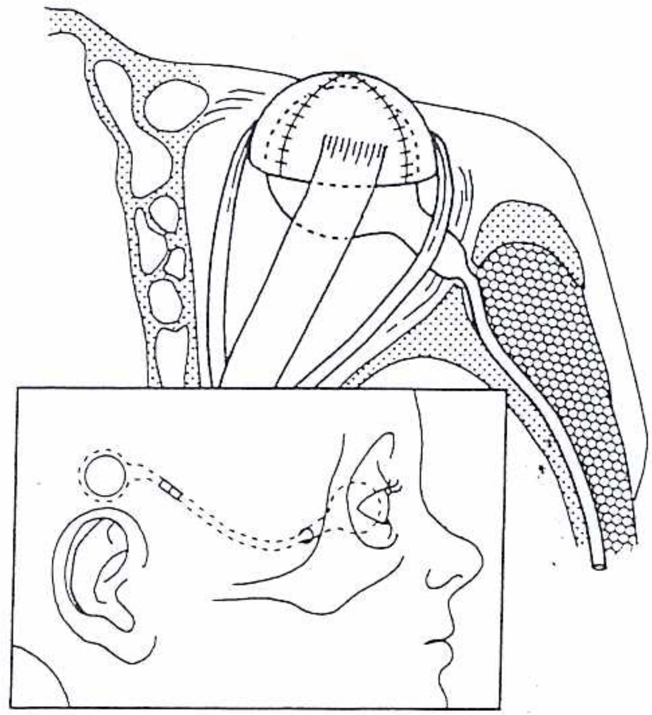


FIGURE 29–25 Expansion of the micro-ophthalmic orbit is achieved by an expander system inserted into the muscle cone of the orbit and connected via subtemporalis tunnel to an infusion port, positioned over the temporoparietal skull. (Used with permission, Gossman.[37])

The use of a tissue expander in unilateral microphthalmia has been shown experimentally and in clinical practice to induce eyelid, orbital, and contiguous facial skeletal growth that closely approaches the normal hemiface.[36] The process is completed over a 10- to 12-month period and requires two outpatient surgical procedures.

Patients with significant facial deformity without visual potential are candidates for orbital expansion. Antibiotic prophylaxis is administered intravenously prior to the procedure. Evisceration is performed under general anesthesia and all uveal tissue is removed. The sclera is divided into four sections that are separated from the optic nerve. A rectus muscle remains attached to each section.

An abbreviated lateral canthotomy incision is used to expose the temporal fascia, which is detached from the zygoma. The temporalis muscle is separated from the area of the zygomaticosphenoid suture. A 3.0-mm round window is placed in the lateral orbital wall anterior to the suture, to allow the expander's inflation tubing to exit the orbit.

A vertical temporoparietal scalp incision is carried to the periosteum about 5.0 cm above the ear. The temporalis fascia is separated from the skull at the temporal line and a submuscular tunnel is created to the lateral orbit for subsequent passage of the inflation tubing (Fig. 29–25).

The integrity of a custom-made expander (PMT, Chanhassen, MN) is evaluated by inflating it with saline. Residual air is evacuated and the precise volume of saline required to reach a diameter of 22.0 mm is determined. A silk ligature is placed around the distal end of the inflation tubing and the expander is inserted into the orbit, beginning with the silk tie. The suture is guided to the lateral orbital osteotomy with a hemostat, passing under the inferior border of the lateral rectus muscle. The suture and tubing are withdrawn from the orbit and the expander is guided to the desired position within the muscle come by tension on the tubing.

The scleral sections are joined over the collapsed expander with interrupted 6-0 polydioxanone sutures (sutures are tied on the anterior scleral surface to prevent rupture of the expander during inflation) and the conjunctiva is closed with the same suture. An acrylic conformer is shaped to fit snuggly into the conjunctival fornices. A complete temporary tarsorrhaphy is created to allow the subsequent increases in orbital pressure to be transmitted to the eyelids, without extrusion of the expander or conformer.[37] The inflation tubing is guided through the submuscular tunnel and joined to an inflation port. All connections are secured with silk ligatures. Residual air and saline are evacuated from the expander and the scalp and canthotomy are closed with absorbable suture.

Inflation of the expander is begun 3 months after placement. The volume of saline to be injected is apportioned into 10 to 12 equal fractions that are injected monthly. The ocularist is involved when the injections are begun. A prosthesis is fashioned when the socket will accommodate one of satisfactory size. The prosthesis is enlarged every 3 to 4 months as needed.

Three months after the final injection, the expander and its pseudocapsule are removed through a conjunctival incision. The tubing is removed through the scalp incision. A hydroxyapatite or other perforated implant is inserted and is typically 22.0 mm in diameter. The sclera is closed over the implant and the conjunctiva is closed. Prosthesis fitting follows in 4 weeks.

Ten patients ranging in age from 6.0 months to 6.0 years have been managed by this method without serious complication. In this group, the preoperative eyelid dimension deficit ranged from 12% to 26%, which was reduced to a range of 0% to 5.0% after expansion. The preoperative orbital dimension deficit range for the group was 8.0% to 25%. The postoperative the range was 0.5% to 7.3%. The duration of the inflation period correlated inversely with the magnitude of reduction of the dimension deficit. Inflation periods of 10 and 12 months produce the best result. If additional eyelid growth is desired, removal of the expander may be deferred and additional saline injections added empirically.

CONCLUSION

Surgical teams will continue to be challenged during the treatment of orbital tumors by inherent limitations of imaging technology, dissection methods, and anatomic variation among individual patients. Minimally invasive procedures, especially those based on endoscopic techniques, offer the potential for reduced morbidity and quicker postoperative recovery. However, in areas of critical neurovascular structure, safety and functional outcome are improved by wide osseous exposure that permits rapid shifts in the angle of view, dissection orientation, and instrumentation. The approaches presented in this chapter can be executed efficiently with low risk by surgical teams possessing neurosurgical, craniofacial, and ophthalmologic expertise, and may be combined or modified to suit the exposure a given lesion may require. (Fig. 29–26).

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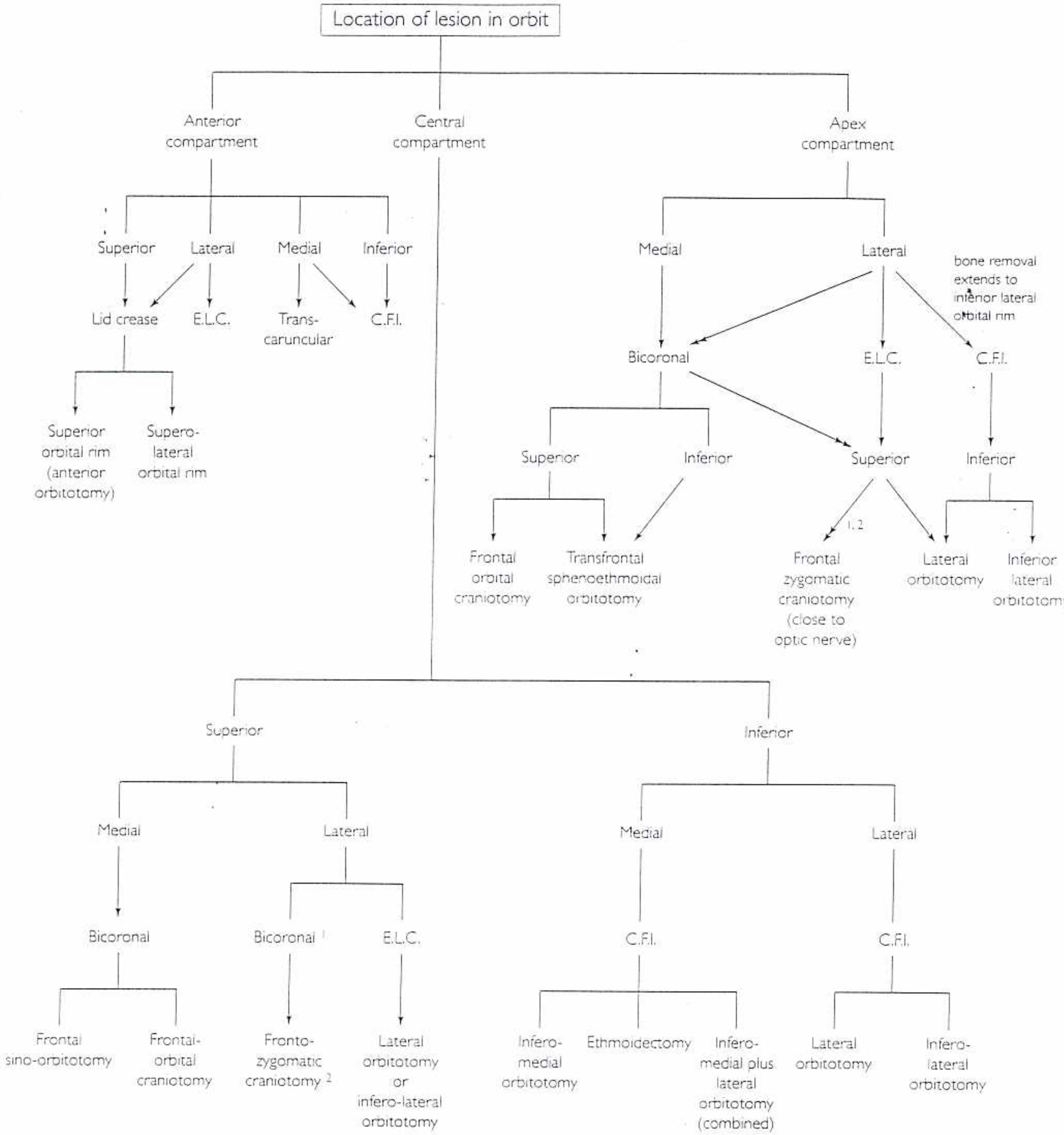

[1] When removal of superior orbital rim or frontal bone is indicated.

[2] Lesion within muscle cone or an extraconal lesion extending to optic nerve.

E.L.C., extended lateral canthotomy; C.F.I., canthal-fornix incision.

FIGURE 29–26 Craniofacial and neurosurgical approach to the orbit: clinical pathway.

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