Chapter 103 – Endonasal Approach to the Sella and Parasellar Areas

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The evolution of cranial base surgery over the last 2 decades is best exemplified by the evolution of surgical approaches for pituitary tumors. There has been a transition from an open microscopic approach to a “minimally invasive” endoscopic approach. For many years, a sublabial, transseptal microscopic approach was the standard of care. It entailed a sublabial mucosal incision with dissection of the nasal septum in a submucoperichondrial/subperiosteal plane. The septal cartilage was displaced to the side and the vomer was removed. After removal of the sphenoid rostrum, a self-retaining retractor was placed. The main limitations of this approach were the narrow nasal corridor and poor visualization. Postoperative discomfort was significant.

The next stage in pituitary surgery was a transnasal, transseptal approach. The transseptal approach avoided the morbidity of the sublabial incision but provided a smaller surgical corridor. It entailed a hemitransfixion incision in the septal mucosa with disarticulation of the cartilaginous septum and creation of a submucoperichondrial/subperiosteal tunnel. The remainder of the dissection was the same as for the sublabial approach, with placement of a self-retaining retractor in one nostril. The major deficiency of this approach was a narrow surgical corridor with limited visualization and room for instrumentation.

After introduction of the nasal endoscope in the 1980s, a completely endonasal endoscopic approach to the sphenoid sinus and sella was developed.[1] Refinements included the binarial approach, the development of new instrumentation for endonasal skull base surgery, the concept of a modular approach to the skull base with extensions from the sella in the sagittal and coronal planes, and the introduction of septal mucosal flaps for dural reconstruction.[2–4] Advantages of the endonasal endoscopic approach include less soft tissue morbidity and postoperative pain than with the sublabial approach, improved visualization, and increased access.

The endonasal approach to the sella is the starting point for many endonasal surgeries on the ventral skull base. A midline approach to the sphenoid can also be used for other sphenoid sinus pathology such as chronic sinusitis, mucoceles, and meningoceles, especially when normal sinus anatomy is obscured by pathology or previous surgery. A midline approach provides a reliable means of accessing the sphenoid contents and minimizes the risk of inadvertent injury to lateral structures (optic nerve, internal carotid artery [ICA]).

ANATOMY

The sphenoid sinus is geometrically shaped like a cube. The rostrum of the anterior wall is shaped like the prow of a ship and articulates with the vomer bone of the septum in the midline (Fig. 103-1). The sphenoid ostium is located at the superolateral corner of the sinus behind the attachment of the superior turbinate. The roof of the sphenoid sinus is the planum sphenoidale and is bounded by the cribriform plates and the fovea ethmoidalis anteriorly. The posterior wall of the sphenoid sinus is characterized by the bulge of the sella superiorly and the depression of the clival recess inferiorly (Fig. 103-2). The brain stem and vertebrobasilar arteries are situated deep to this bone. The tubercular strut is a thick ridge of bone overlying the superior intercavernous sinus at the junction of the sella and planum sphenoidale. The degree of pneumatization of the sphenoid sinus is variable and can be categorized as presellar, sellar, or postsellar pneumatization patterns.

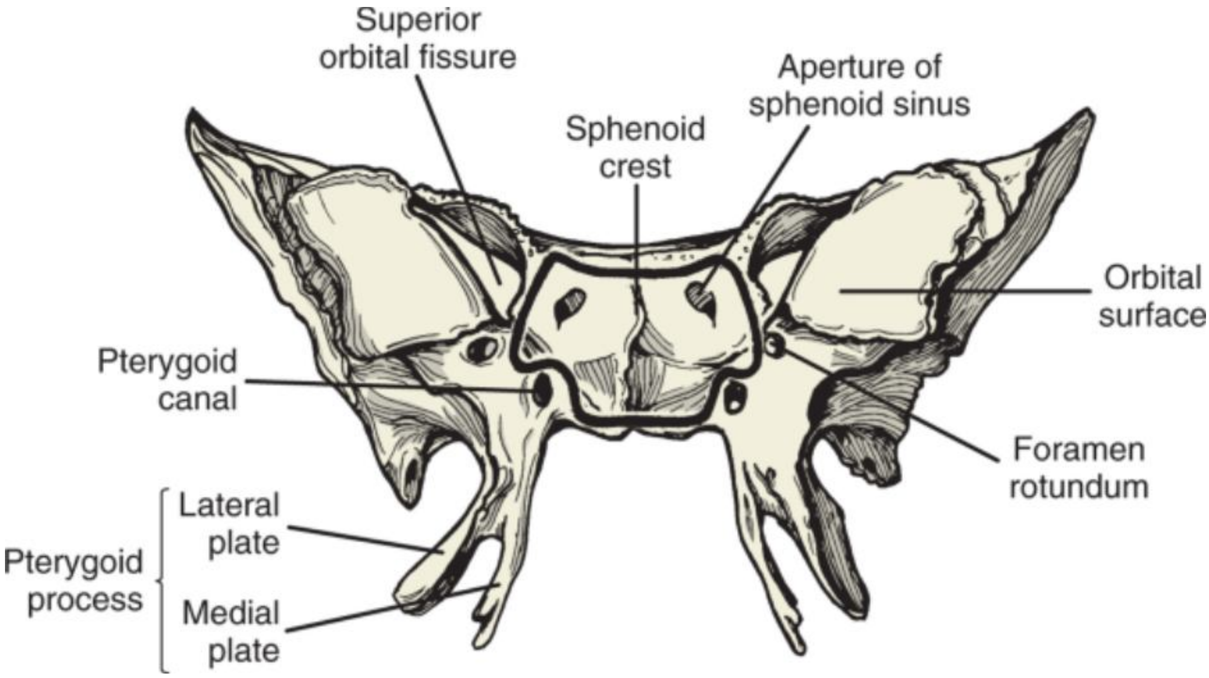

Figure 103-1 Anterior view of the sphenoid bone with bony landmarks identified. The extent of the sphenoidotomy is outlined; it extends between the foramen rotundum and pterygoid canal and includes the lateral recess.

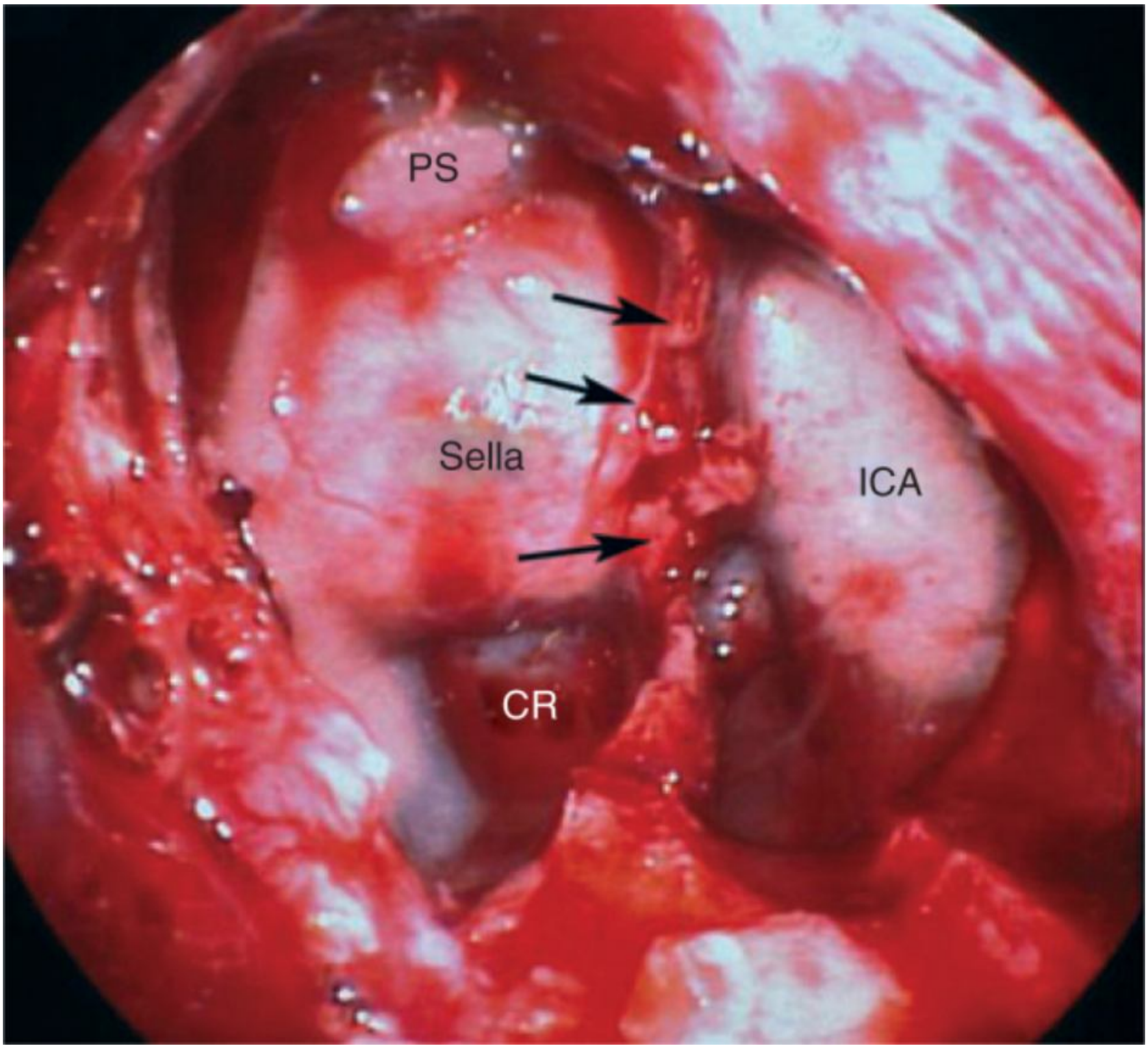

Figure 103-2 Bony landmarks in the sphenoid sinus include the planum sphenoidale (PS), the sella, the clival recess (CR), and the internal carotid artery (ICA) canal. Sphenoid septations *(arrows)* that deviate laterally attach to the carotid canal.

The most important anatomic structures for the surgeon are situated laterally. The ICA courses along the lateral wall from the petrous carotid artery to the ophthalmic artery (Fig. 103-3). The paraclival segment is located at the level of the clival recess; the cavernous segment forms an S-shaped siphon lateral to the sella. The ICA then courses lateral to the optic nerve to become the supraclinoid segment and contributes to the circle of Willis. Deep to the paraclival ICA at the level of the floor of the sella, the sixth cranial nerve courses superolaterally in Dorello's canal. The optic nerves are superomedial to the carotid arteries and converge at the level of the tubercular strut. Laterally, the junction of the ICA and the optic nerve is bounded by the lateral optic-carotid recess (Fig. 103-4). This recess is formed by pneumatization of the anterior clinoid process. The medial optic-carotid junction isless apparent but represents a “danger zone” where the ICA courses medially toward the sella. The pneumatization of the sphenoid sinus may extend laterally into the base of the pterygoid plates. When this occurs, the pneumatized sinus extends between the pterygoid canal (vidian artery and nerve) inferiorly and the foramen rotundum (second division of the trigeminal nerve) superiorly.

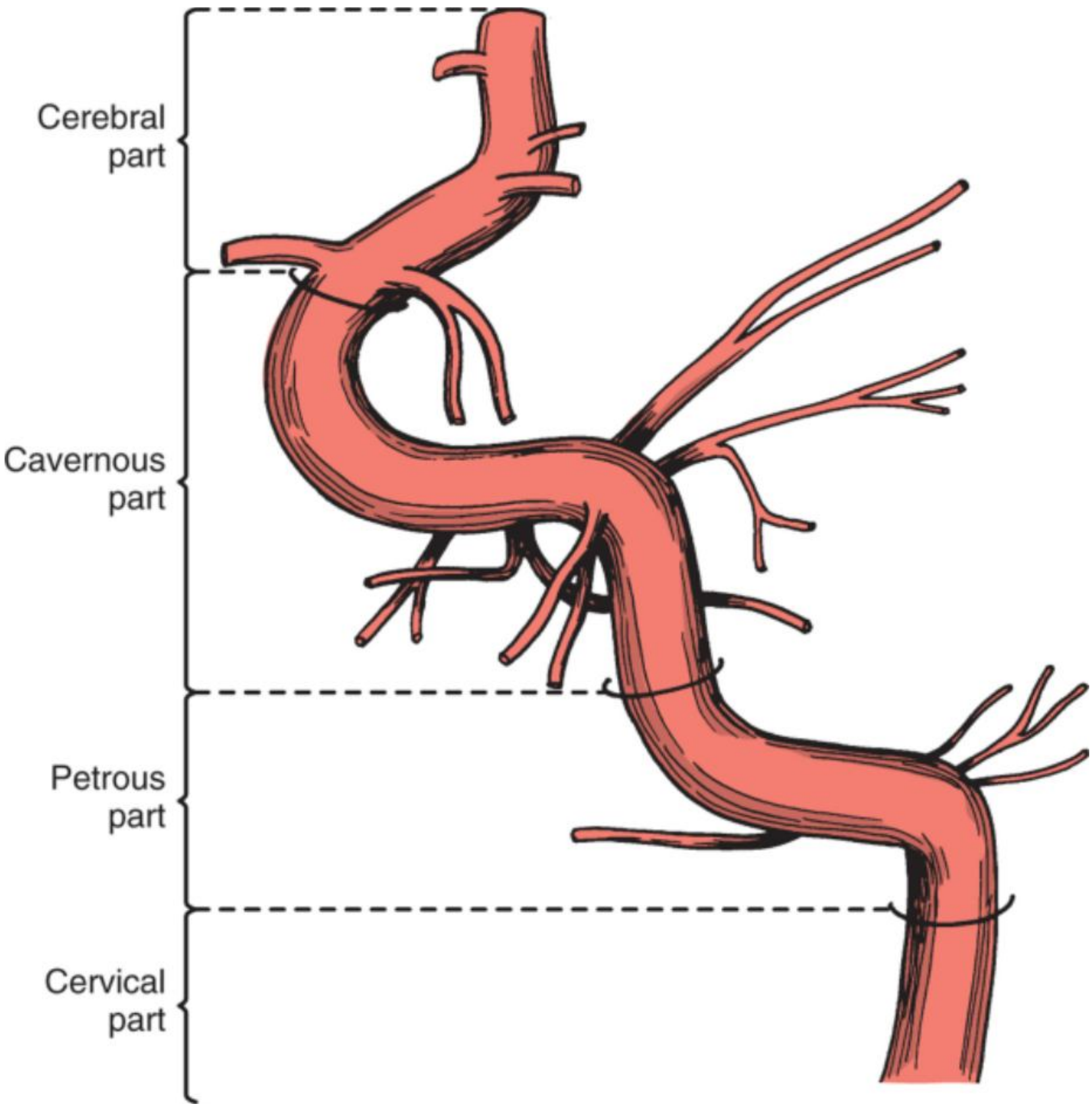

Figure 103-3 Segments of the internal carotid artery.

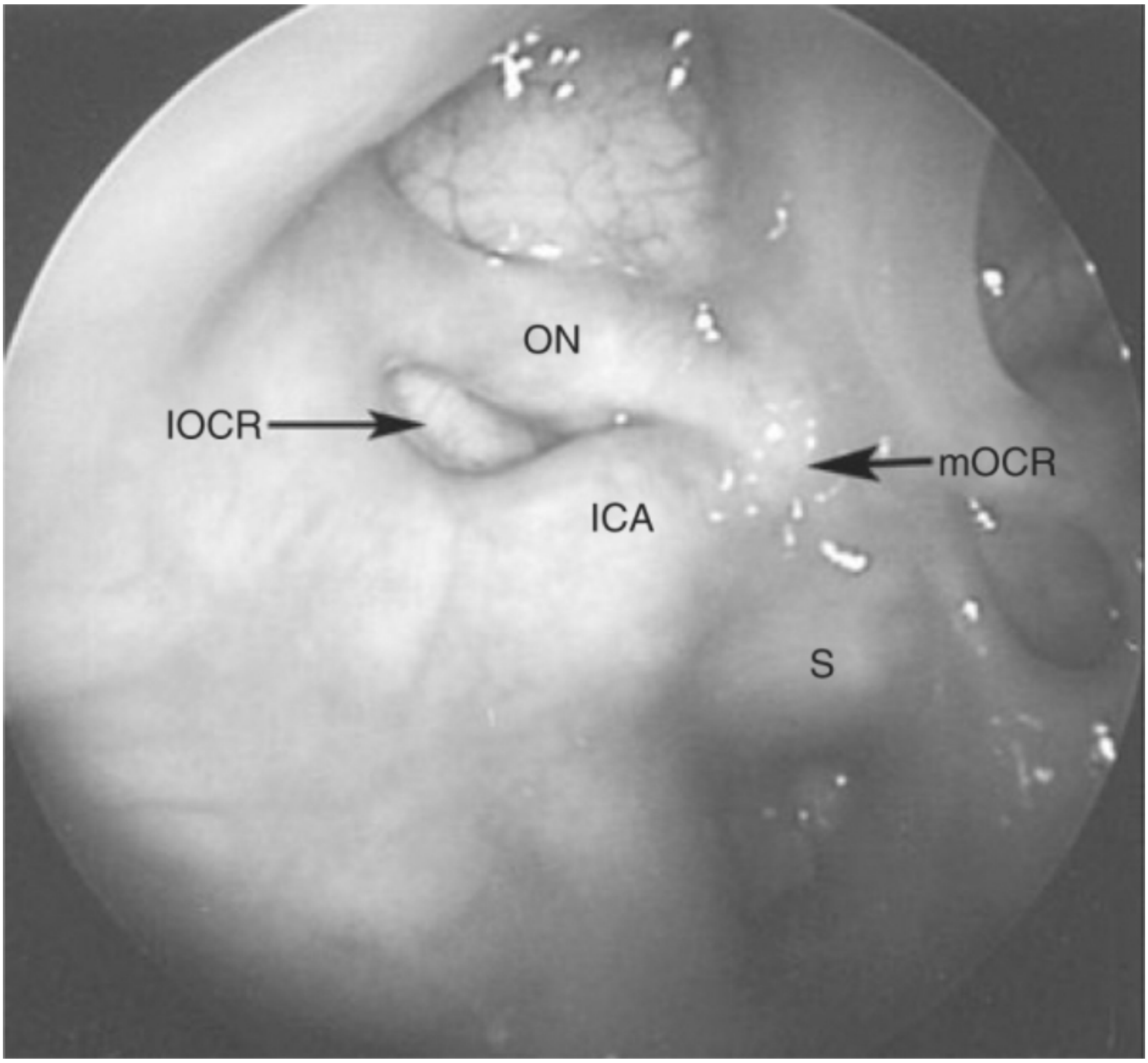

Figure 103-4 Cadaveric dissection with a view of the right optic nerve (ON) and internal carotid artery (ICA). The pneumatization of the anterior clinoid forms the lateral optic-carotid recess (lOCR). The medial junction of the ON and ICA is the medial optic-carotid recess (mOCR).

Anatomic variations of the sphenoid are common and may increase the risk for inadvertent injury to structures bordering the sphenoid sinus. The sphenoid sinus often contains multiple septations. Lateral septations always attach to the carotid canal (see Fig. 103-2). The prominence of the carotid canal is quite variable and it may be dehiscent in approximately 10% of patients (Fig. 103-5). Tortuosity of the carotid arteries is pro nounced in patients with acromegaly. The prominence of the optic canals depends on the degree of pneumatization of the sinus; the optic nerves may be at risk in patients with posterior extension of the ethmoidal air cells (Onodi cell). An Onodi cell may be recognized on preoperative radiographs by horizontal septations within the sphenoid sinus on a coronal view or by an oblique anterior sphenoid wall on an axial view.

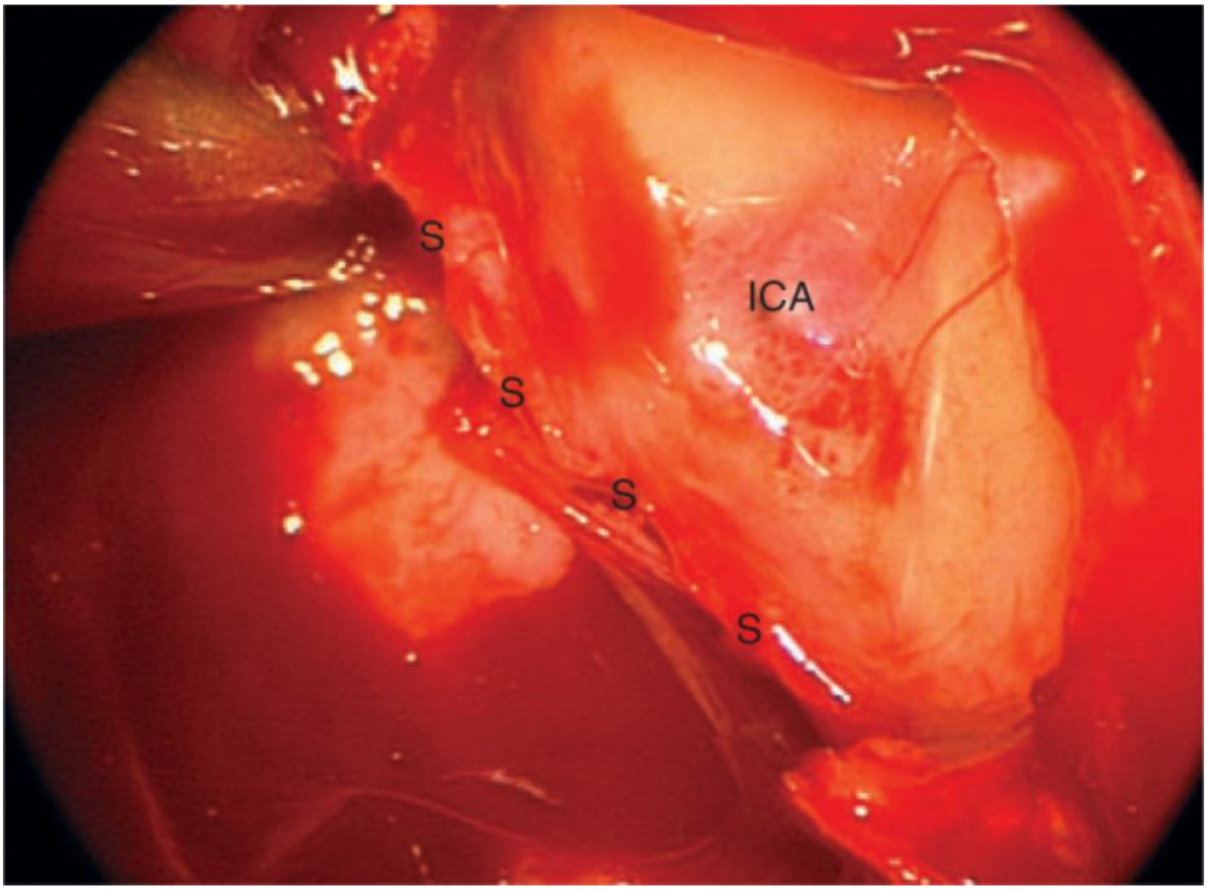

Figure 103-5 The left cavernous segment of the internal carotid artery (ICA) is dehiscent and susceptible to injury. A lateral sphenoid septation (S) attaches to the carotid canal.

PATIENT SELECTION

Indications for an endonasal approach to the sphenoid sinus include inflammatory disease, benign and malignant neoplasms, congenital malformations, and trauma. Inflammatory conditions include acute and chronic sinusitis, invasive fungal sinusitis, mucocele/mucopyocele, nasal polyposis, and cholesterol granulomas of the petrous apex. Neoplasms may arise from the mucosal lining of the sinus or the underlying bone or may extend into the sinus from the nasal cavity or cranial cavity. Pituitary tumors are among the most common neoplasms and may be confined to the sella or extend superiorly to the suprasellar region, laterally to the cavernous sinus, or anteriorly to the sphenoid sinus. Tumors arising from bone encountered in this region include fibrous dysplasia, chordoma, and chondrosarcoma. Meningiomas frequently involve the planum sphenoidale and petroclival regions. Sinonasal neoplasms that can involve the sphenoid include inverting papilloma, squamous cell carcinoma, adenocarcinoma, adenoid cystic carcinoma, and sinonasal undifferentiated carcinoma. Congenital malformations include meningoceles of the lateral sphenoid recess. Rarely, traumatic injuries may result in a cerebrospinal fluid (CSF) leak within the sphenoid sinus or compression of the optic nerve.

PREOPERATIVE EVALUATION

Symptoms of sphenoid disease are often nonspecific and patients may remain asymptomatic or attribute their minor symptoms to “sinus disease.” When headaches occur, they are poorly localized and may be experienced in a frontal or occipital location. Neoplastic disease may be associated with mild epistaxis or nasal obstruction. Patients should be queried about associated symptoms from involvement of adjacent structures, such as visual loss, diplopia, and facial hypoesthesia. Neoplastic invasion of the sella may result in symptoms of hypopituitarism.

Physical examination of a patient with suspected sphenoid sinus pathology should include nasal endoscopy to look for intranasal pathology and assess the patency of the sphenoid ostia. Assessment of cranial nerve function includes visual acuity, motility of the extraocular muscles (cranial nerves III, IV, and VI), and midfacial sensation (V2). A complete ophthalmic evaluation by a neuro-ophthalmologist is indicated if there is evidence of orbital involvement.

A computed tomography (CT) scan of the sinuses is essential to establish a differential diagnosis and determine the extent of disease. Magnetic resonance imaging (MRI) provides complementary information and is helpful in narrowing the diagnostic possibilities. It is especially helpful for visualizing tumor involving the dura and perineural extension and in differentiating soft tissue from obstructed secretions.

PREOPERATIVE PLANNING

Preoperative consultation with specialists in other disciplines may include ophthalmology, endocrinology, and neurosurgery, depending on the initial symptoms and findings. Complete evaluation of visual function may establish the urgency of surgery in patients with visual loss and their potential for recovery. Testing of pituitary function determines the need for hormonal replacement, especially perioperative coverage with stress steroids. Collaboration with a neurosurgeon is recommended for surgeries that involve the cranial base.

Radiologic imaging with CT of the sinuses or skull base is used to plan the best approach (laterality) and to look for variations in normal anatomy (pneumatization, lateral sphenoid septations, Onodi cell, course of the ICA) that may create technical problems during surgery. Intraoperative image guidance is very helpful in surgical approaches to the sella and is used routinely with an image guidance protocol consisting of detailed scanning of the skull base. A CT angiogram provides bony detail with visualization of the ICA. When normal anatomy is obscured, image guidance can help direct the trajectory to the sella and avoid one that is too high and risks a CSF leak. It is also helpful in identifying anatomic structures beneath the bone surface, such as the ICA and optic nerves, and delineating the margins of pathology. Tumors that have a significant soft tissue interface (intracranial, orbital, or infratemporal skull base extension) are also imaged with MRI, and a fusion image is created for intraoperative guidance.

SURGICAL APPROACHES

The sella and surrounding areas may be approached unilaterally when disease is very limited. A bilateral or binarial approach is preferred in most cases because of improved visualization and increased room for instrumentation. The basic approach to the sella may be expanded in any direction, depending on the pathology, and may include a transplanum approach for su-prasellar lesions,[2] a transclival/transodontoid approach for lower clival lesions, and a transpterygoid approach for access to the lateral recess of the sphenoid and middle fossa.[5]

Techniques

The patient is positioned in a supine position and registration with an image guidance system is instituted. If immobility of the head is desired, the head is fixed in position with a Mayfield clamp, and the image guidance registration is transferred to the head holder; otherwise, a mask or tracker secured to the skull is used to track the position of the head. The nasal cavity is decongested with pledgets soaked in oxymetazoline, and the anterior nares are prepared with povidone-iodine solution.

The potential need for a reconstructive flap must be considered at the beginning of the surgery.[4] If exposure of the ICA or dura is anticipated, a septal mucosal flap is elevated at the beginning of surgery. It is elevated opposite the side that requires greater exposure. The inferior aspect of the middle turbinate on one side (right side for a right-handed surgeon) is resected to provide additional room for the endoscope during the later stages of surgery (see Video 103-1). The inferior turbinate is lateralized and the sphenoid ostium is visualized (see Video 103-2). A needle-tip electrocautery is used to incise the mucosa and perichondrium/periosteum of the nasal septum while leaving a 5-mm margin at the skull base and nasal vestibule (see Video 103-3). The incision extends along the junction of the nasal septum and nasal floor to the inferior surface of the sphenoid sinus. A vascular pedicle containing the posterior nasal artery and extending from the sphenoid os to the inferior sphenoid surface is preserved. The flap is elevated deep to the perichondrium/periosteum and displaced into the oropharynx for later reconstruction (see Video 103-4).

The posterior septum is incised with a Cottle elevator at its attachment to the sphenoid rostrum, and mucosa is elevated from the contralateral sphenoid surface and resected (see Video 103-5). If bleeding from the contralateral posterior nasal artery is encountered, it is controlled with monopolar or bipolar electrocautery. The bone of the rostrum is removed in the midline with bone rongeurs to create an opening into both sphenoid sinus air cells. The posterior 1 to 2 cm of the transected septum is resected with back-biting rongeur to enhance binarial exposure (see Fig. 103-2) (see Video 103-6). The anterior face of the sphenoid sinus is then resected with Kerrison rongeurs to maximize the sphenoidotomy (see Fig. 103-1). Laterally, bone is removed to the edge of the pterygoid (vidian) canal, which is located inferolateral to the lateral recess of the sphenoid sinus. Superiorly, bone is removed to the planum sphenoidale. This may require opening the posterior ethmoid air cells for visualization. Resection of soft tissue and bone anterior to the planum sphenoidale in the midline is minimized to avoid injury to olfactory nerves and possible CSF leak. Additional room for instrumentation can be gained by removing thick bone along the floor of the sphenoid sinus with a drill (4-mm diamond hybrid bit).

Both nasal passages can now be used for instrumentation. The sphenoid sinus is inspected to confirm the location of the sella, carotid arteries, and optic nerves (Fig. 103-6). The relationship of sphenoid septations to these structures is determined, and the septations are carefully removed with rongeurs or a drill (see Video 103-7). Aggressive removal of lateral septations that attach to the carotid canal can result in vascular injury. Although sinus mucosa can be preserved when removing small pituitary tumors, it is usually stripped from the sinus to improve visualization of bony landmarks and to prepare the surgical bed for reconstruction with the septal mucosal flap or fat grafts.

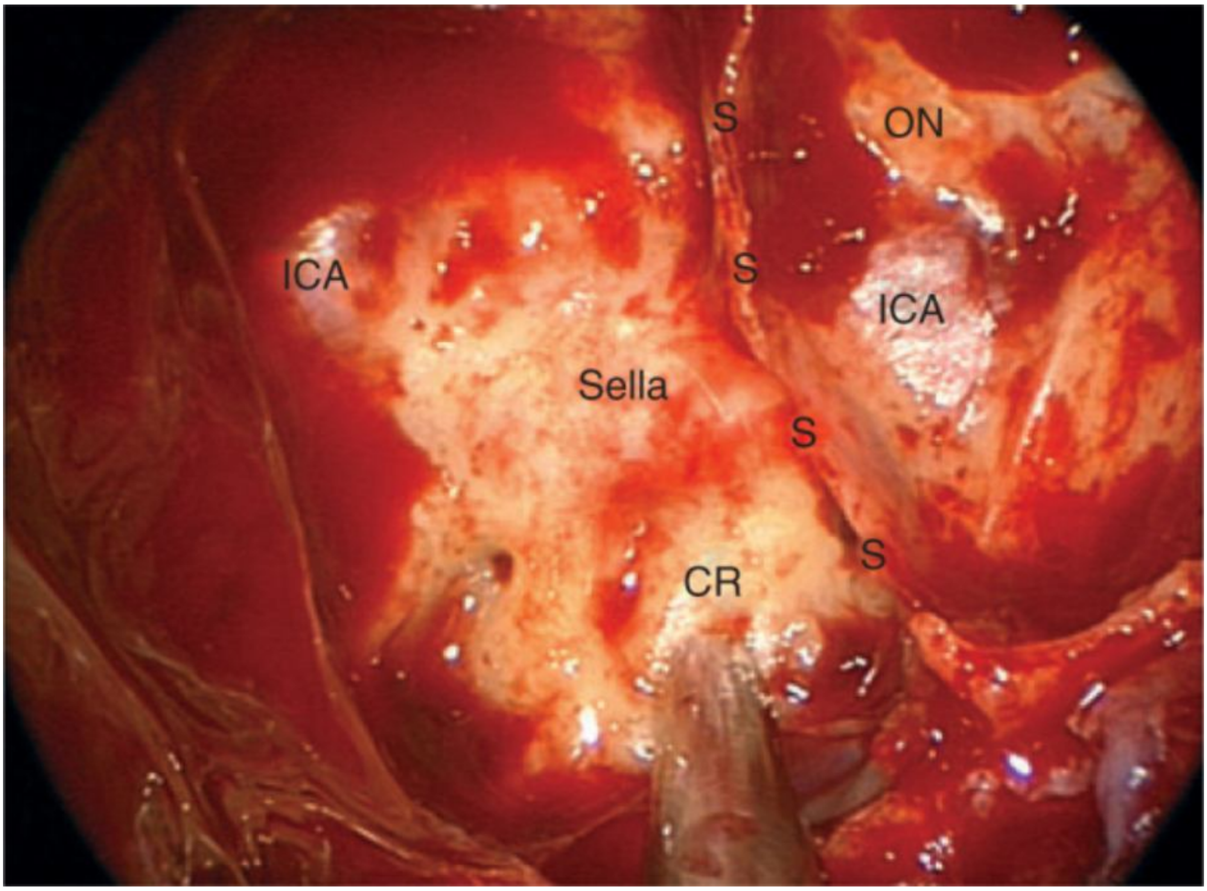

Figure 103-6 Endoscopic view of the sphenoid sinus and bony landmarks after bilateral sphenoidotomy and resection of the posterior nasal septum. CR, clival recess; ICA, internal carotid artery; ON, optic nerve; S, lateral sphenoid septation.

In patients undergoing pituitary surgery, the bone over the sella is thinned with the drill and fractured with an elevator. The bone fragments are elevated from the dura of the sella and removed. Removal of bone continues to the margin of the cavernous sinus with a 1-mm angled Kerrison rongeur (Fig. 103-7) (see Video 103-8). The tip of the rongeur should be directed parallel to the cavernous ICA to avoid perforating the vessel. The ICA is especially prone to injury at the medial optic-carotid recess, where the ICA deviates medially before passing lateral to the optic nerve. Opening of the dura and removal of pituitary pathology are then performed in conjunction with a neurosurgeon. The otolaryngologist maintains visualization with the endoscope while the neurosurgeon uses two hands to dissect the tumor. For tumors that have suprasellar extension, a transplanum approach is combined with a transsellar approach (Fig. 103-8). The bone of the planum sphenoidale over the dura is thinned with a drill (3- to 4-mm hybrid diamond bit) until it is thin enough to fracture and elevate from the dura. Drilling should be limited to the midline initially until the course of the optic nerves is well visualized. Continuous irrigation when drilling is essential to prevent thermal injury to the optic nerves. Once the bone of the sella and posterior planum is removed, the remaining strut of bone along the tuberculum sellae is thinned laterally adjacent to the middle clinoid (medial optic-carotid recess). The strut of bone can then be fractured and elevated from the superior intercavernous sinus. Bleeding from the sinus is controlled by gentle application of hemostatic material. The dura can now be opened in the midline to avoid injury to the optic nerves, and the superior intercavernous sinus is transected to provide maximal visualization.

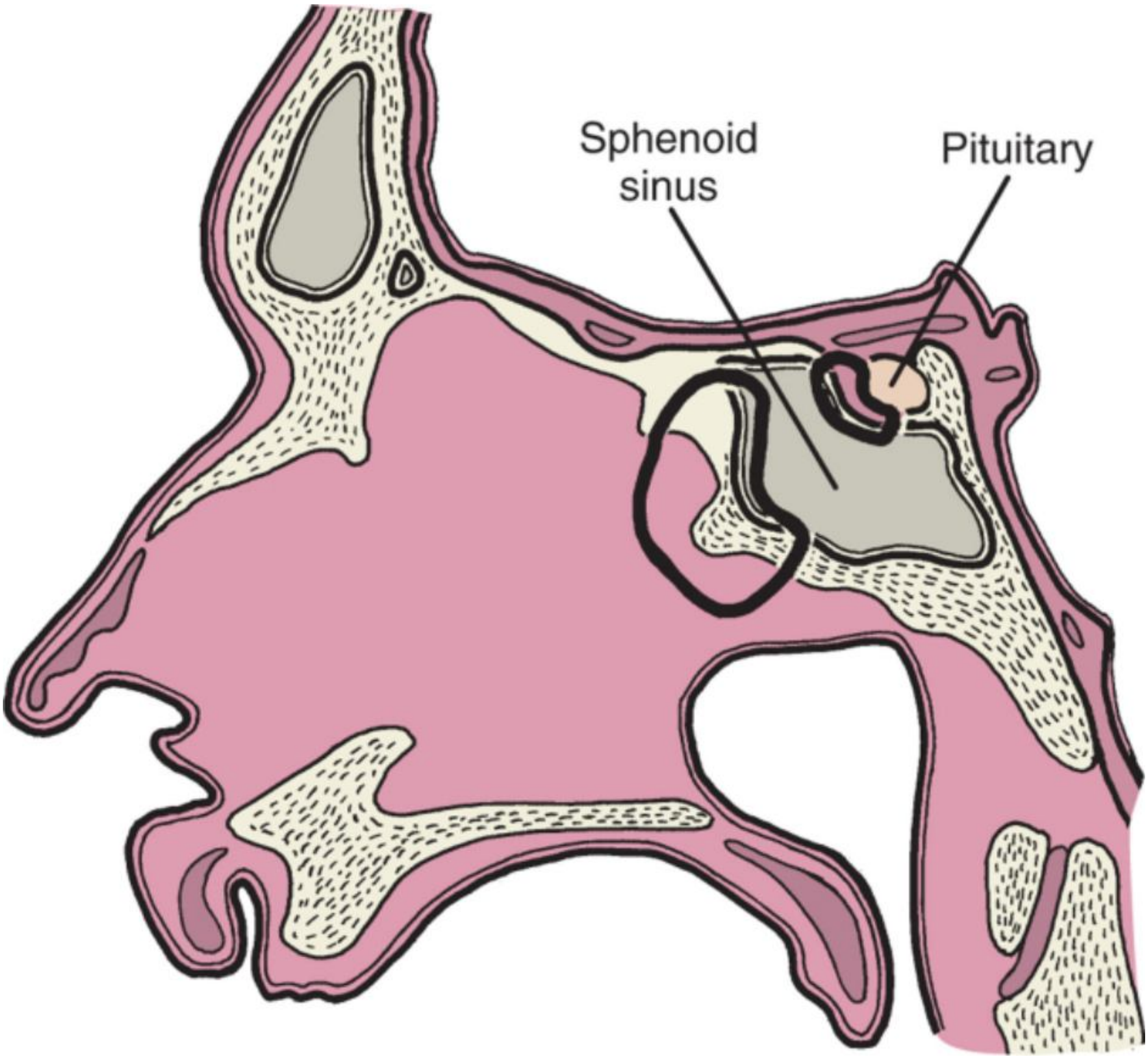

Figure 103-7 The extent of resection of the anterior face of the sphenoid sinus, posterior nasal septum, and sella is outlined.

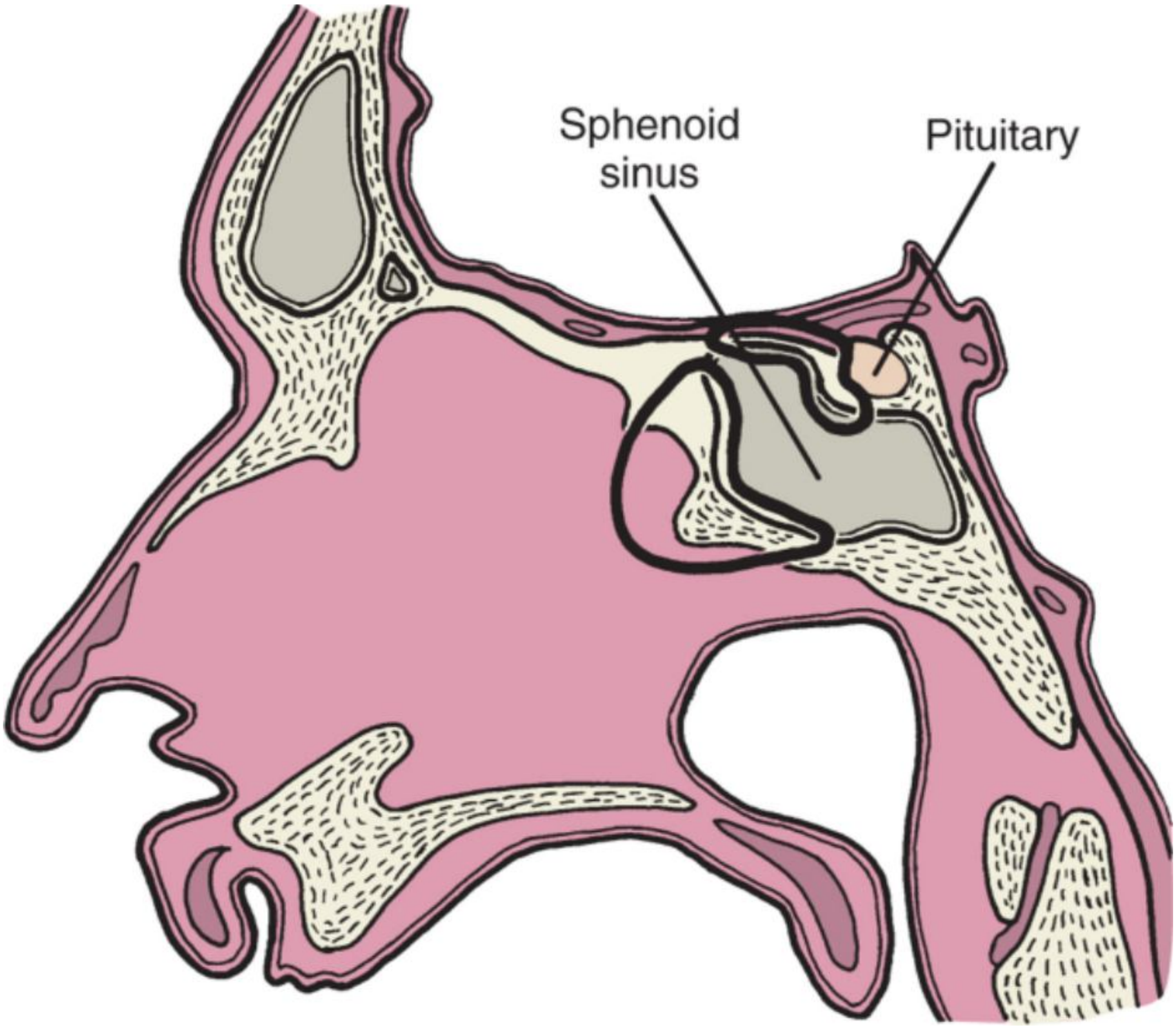

Figure 103-8 The planum sphenoidale and sella may be removed in continuity to provide access to tumors with suprasellar extension.

Pathology that extends into the lateral recess of the sphenoid sinus requires a transpterygoid approach if the sinus is well pneumatized.[5,6] A middle meatal antrostomy is performed on the side of the pathology, and the sphenopalatine foramen is identified (see Video 103-9). The overlying bone is removed with a 1-mm angled Kerrison rongeur to expose the contents of the pterygopalatine space (Fig. 103-9) (see Video 103-10). The vessel is cauterized with bipolar electrocautery and transected. The soft tissues of the pterygopalatine space are elevated from the underlying pterygoid bone medi ally and displaced laterally. The vidian artery and nerve are identified at the point where they exit the pterygoid canal, and additional bone superolateral to the pterygoid canal is removed to open the lateral recess (Fig. 103-10). The lateral recess is bounded superolaterally by the foramen rotundum (second division of the trigeminal nerve) and the floor of the middle cranial fossa (Fig. 103-11). Wide exposure requires sacrifice of the vidian artery and nerve. The vidian artery courses su-perolateral to the ICA and is a key landmark for identification of the second genu of the ICA (Fig. 103-12).[7] The surrounding bone is drilled to the plane of the petrous ICA, starting with removal of bone inferiorly from the 3-o'clock to the 9-o'clock position (see Video 103-11). This avoids injury to the ICA until the depth of the artery can be ascertained. Identification of the course of the petrous ICA is a prerequisite for additional dissection of the petrous apex and parasellar region.[8]

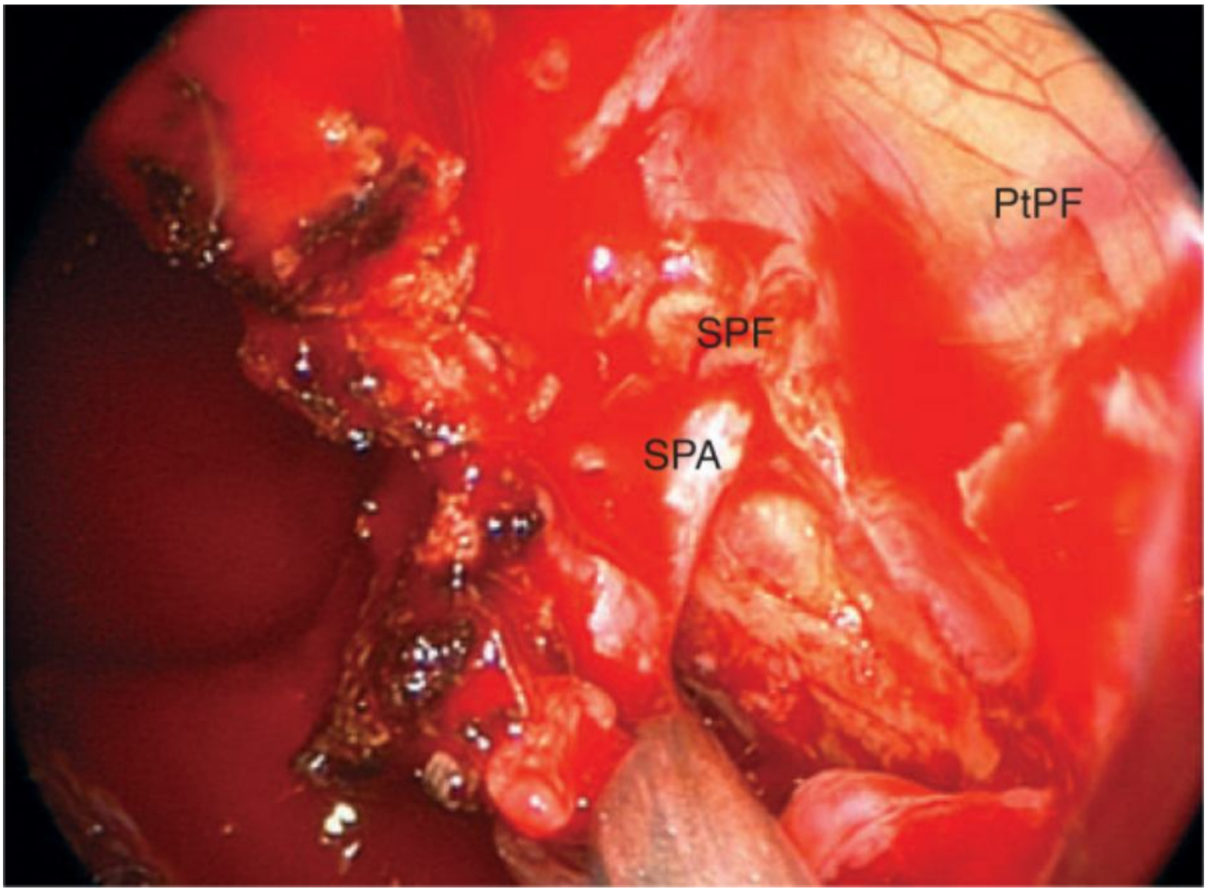

Figure 103-9 A left antrostomy has been performed and the sphenopalatine artery (SPA) exposed at the sphenopalatine foramen (SPF). Overlying bone is removed to expose the pterygopalatine space (PtPF).

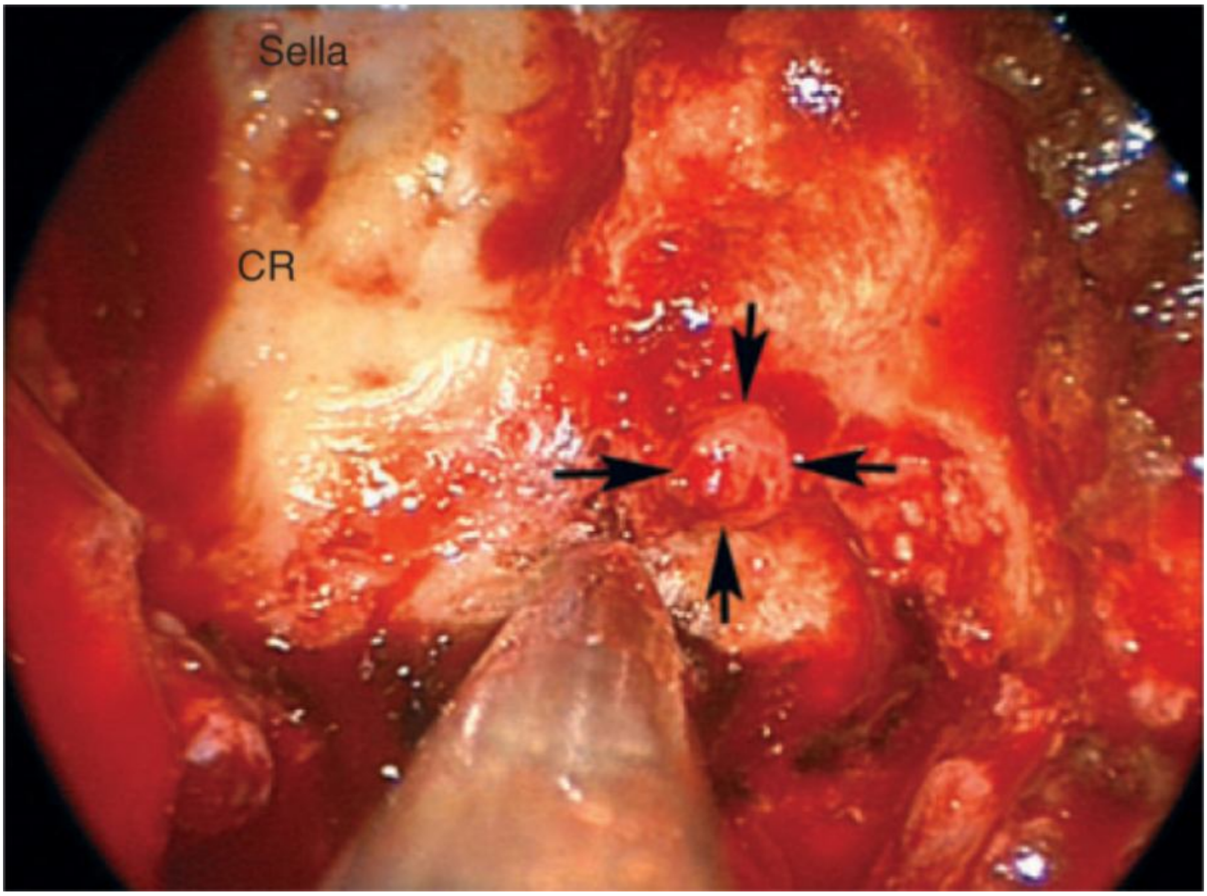

Figure 103-10 The contents of the left pterygoid canal *(arrows)* have been exposed and the surrounding bone has been drilled. CR, clival recess.

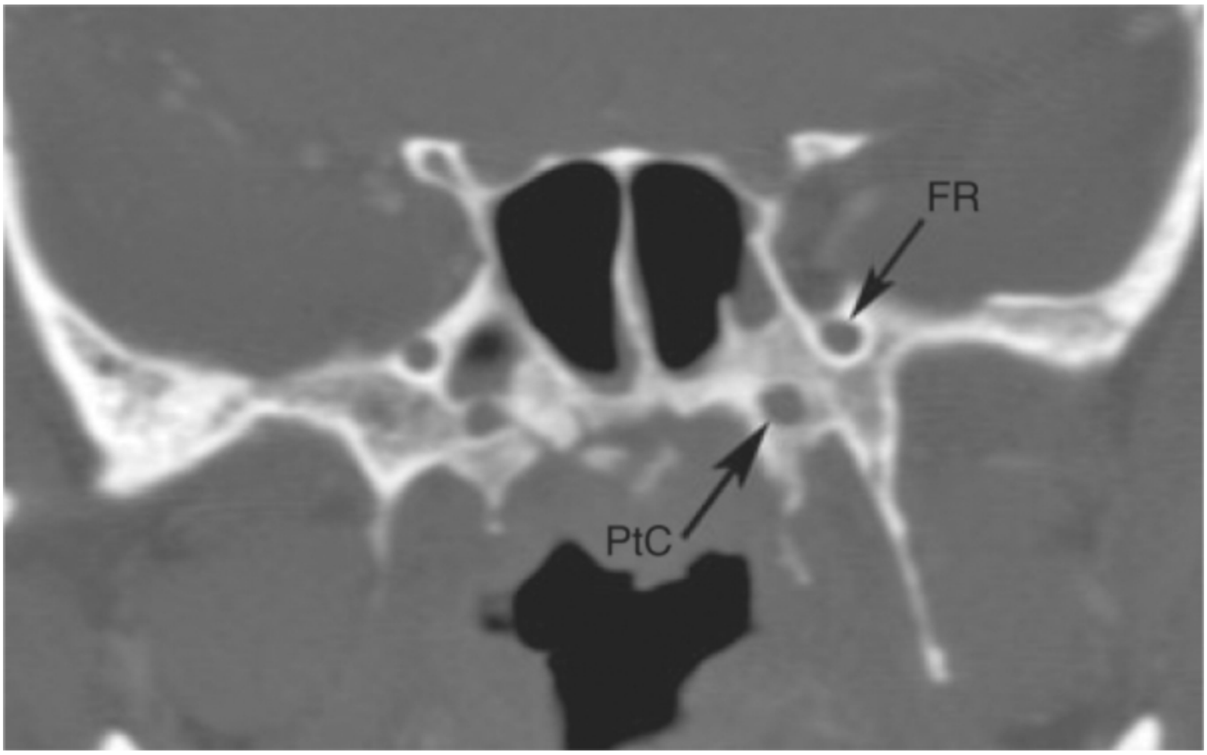

Figure 103-11 The lateral recess of the sphenoid sinus is bounded laterally by the pterygoid canal (PtC) inferiorly and the foramen rotundum (FR) superiorly.

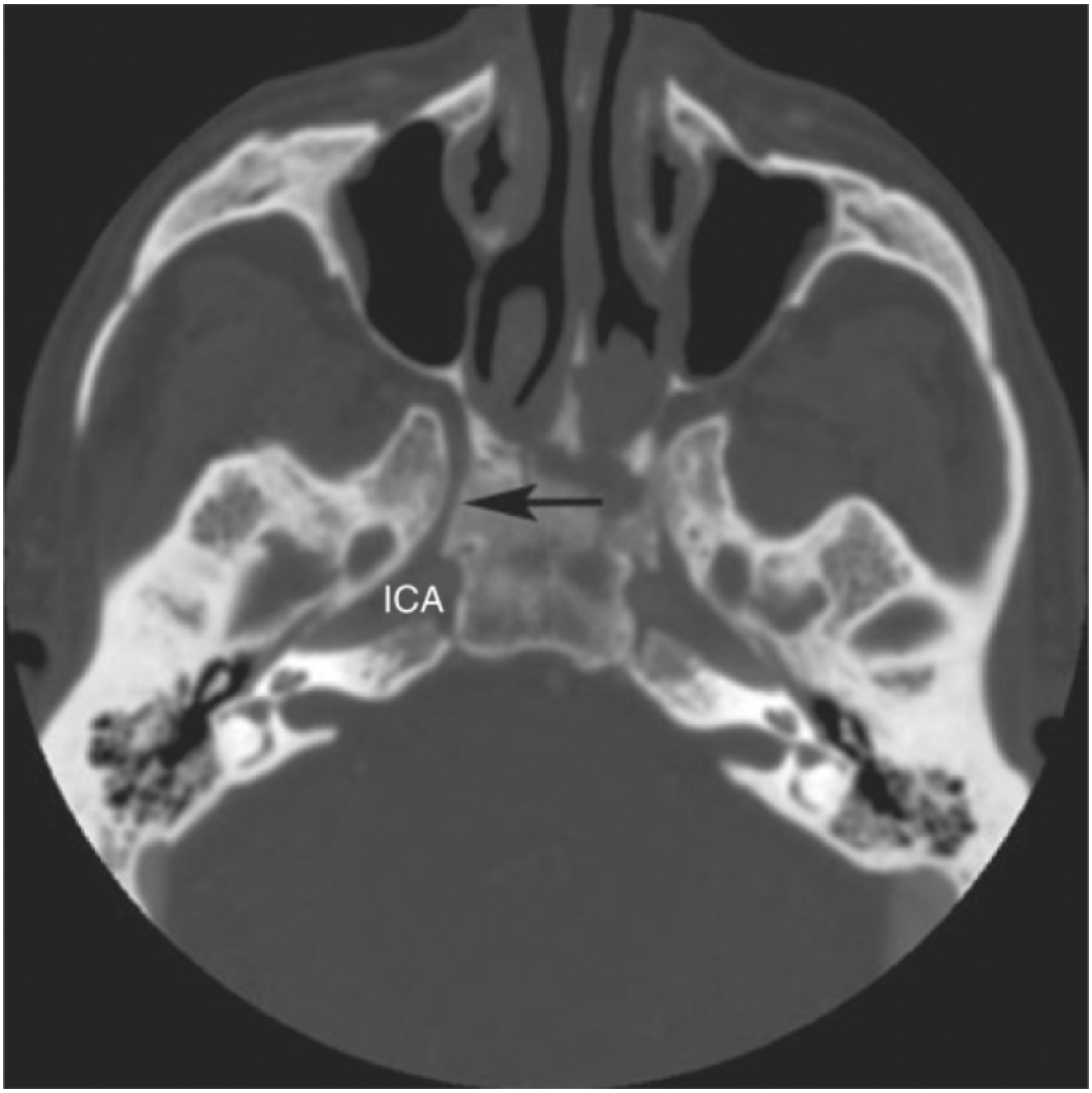

Figure 103-12 The pterygoid canal *(arrow)* is a reliable landmark for locating the petrous internal carotid artery (ICA) at the second genu.

Any dural defects are repaired with inlay and onlay fascial grafts; a synthetic dural substitute may be used. The septal mucosal flap is then retrieved from the oropharynx and rotated to cover the grafts and exposedbone (Fig. 103-13). If there is a deep space that is not suitable for contouring of the flap, the space is first obliterated with an abdominal fat graft to create a planar surface for the flap. The flap is covered with a layer of oxycellulose (Surgicel) followed by a synthetic glue (DuraSeal). This is supported by nasal tampons or a Foley urinary catheter inflated with saline to counteract intracranial CSF pressure. The nasal septum is protected with Silastic splints.

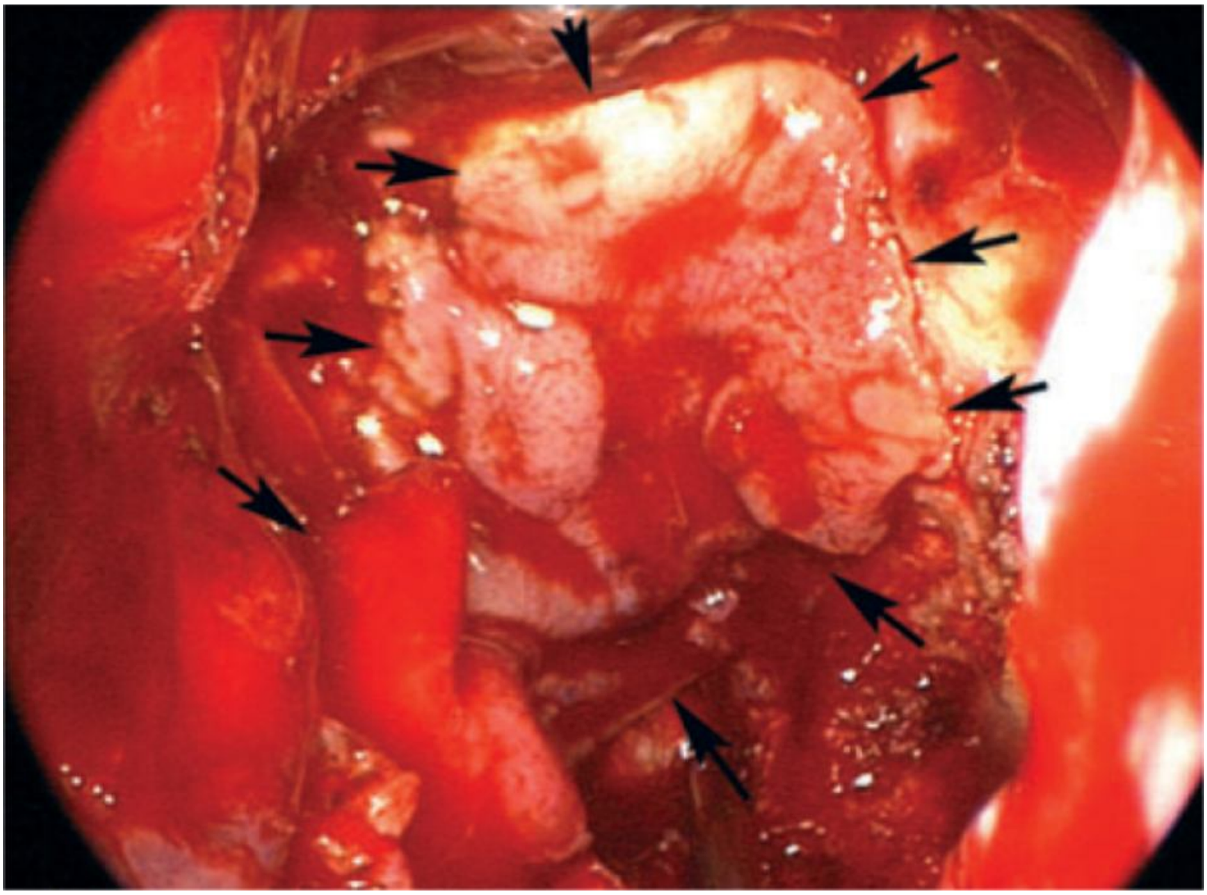

Figure 103-13 A right septal mucosal flap (*arrows* denote margins) has been transposed to cover the defect in the skull base.

POSTOPERATIVE CARE

In the absence of a CSF leak, any nasal packing is removed in 1 to 2 days. If dural repair has been performed, packing is maintained for 5 to 7 days. Prophylaxis with oral antibiotics is maintained as long as the nasal packing is in place. Patients are instructed to use a saline nasal spray after the packing is removed and to avoid strenuous activities that may increase intracranial pressure, such as nose blowing, bending, and lifting. Silastic nasal splints are maintained for 1 week if a septal mucosal flap is not harvested and for 3 weeks if it has. Protection of the exposed cartilage with Silastic splints prevents desiccation and promotes mucosalization. After the splints are removed, saline irrigation is instituted to prevent the accumulation of crust. Gentle endoscopic débridement of crust is performed periodically during the first month while taking care to not disrupt the dural repair. Healing is usually complete within 3 months, and the nasal crusting diminishes.

Patients are monitored for evidence of a CSF leak in the first few weeks postoperatively. Most CSF leaks are apparent once the nasal packing is removed and are characterized by clear rhinorrhea that is often unilateral, a reservoir sign, and occasionally, low-pressure headaches. When the diagnosis is questionable, the leak is confirmed by testing of a rhinorrhea sample for β_2-transferrin. Most leaks are managed by early surgical intervention consisting of endoscopic repair and placement of a lumbar spinal drain for 3 to 5 days.

COMPLICATIONS

Complications associated with the endonasal approach to the sella and parasellar areas can be categorized as nasal, vascular, and neural. Most otolaryngologic complications are minor but have a significant impact on quality of life: sinusitis, chronic rhinitis with nasal crusting, loss of olfactory function, nasal synechiae and obstruction, septal perforation, minor epistaxis, decreased tearing, and palatal or facial hypoesthesia. Patients require significant postoperative care with endoscopic removal of nasal crusts for approximately 3 months after surgery. A subset of patients will continue to have problems, however, especially after radiation therapy. Although a binarial approach increases the potential for nasal crusting, it appears that use of a septal flap greatly decreases the amount of crusting in the sphenoid region. Loss of olfactory function (and decreased taste) is observed for several months after surgery and probably reflects a combination of factors: mucosal edema, nasal obstruction from crusting, and some loss of olfactory mucosa. A transpterygoid ap-proach often results in loss of vidian nerve function. Most patients will not notice an appreciable change in tearing except in situations in which tearing is normally increased: emotional tearing, windy conditions, and cold weather. Dissection posterior to the sphenopalatine artery can injure the descending palatine nerve and result in palatal hypoesthesia. The infraorbital nerve may be injured along the roof of the maxillary sinus or at the foramen rotundum and result in numbness of the cheek.

Dreaded complications of endonasal surgery include injury to the ICA and optic nerves. These injuries can be avoided with a good understanding of endoscopic anatomy and its variations and by careful surgical technique. Most injuries to the ICA occur at the medial optic-carotid recess, where the ICA deviates medially. The vidian artery is a reliable landmark for locating the petrous ICA at the second genu (see Fig. 103-8). Injury to the optic nerve may occur as a result of direct trauma or thermal injury from electrocautery or drilling. The presence of an Onodi cell should be determined preoperatively to avoid injury during opening of air cells.

CSF leaks are a common sequela of endonasal skull base surgery and should be anticipated. A trajectory to the sphenoid sinus that is too high risks violation of the skull base through the posterior ethmoid air cells or planum sphenoidale and can be avoided by visualizing the inferior attachment of the nasal septum to the rostrum and using image guidance intraoperatively.

SUMMARY

The sphenoid sinus is the starting point for endonasal approaches to the sella and ventral skull base. A binarial approach maximizes visualization and allows bimanual dissection. The parasellar areas can be visualized by extending the sphenoidotomy superiorly or laterally. Reliable anatomic landmarks within the sphenoid sinus are used to avoid injury to the ICA and optic nerves.

PEARLS

- The need for a septal mucosal flap for reconstruction should be considered before performing a sphenoidotomy.
- The safest area to open the sphenoid sinus is in the midline at the sphenoid rostrum.
- The lateral recess of the sphenoid sinus extends between the pterygoid canal and the foramen rotundum.
- Lateral septations of the sphenoid sinus attach to the carotid canal.
- The lateral optic-carotid recess is a useful landmark for visualizing the course of the optic nerve and the ICA; it is formed by pneumatization of the anterior clinoid.

PITFALLS

- A high trajectory to the sphenoid sinus may result in violation of the planum sphenoidale and a CSF leak.
- Monopolar electrocautery should not be used within the sphenoid sinus because of the risk of injury to the ICA or optic nerve.
- The ICA deviates medially at the medial optic-carotid recess and may be injured when opening the sella.
- An unrecognized Onodi cell can result in injury to the optic nerve.
- The increased tortuosity of the carotid arteries in acromegalic individuals results in a narrowed surgical field.