

Skull Base Approaches to the Lesions of Sellar and Parasellar Regions: Anatomy, Techniques, and Insights

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■ Overview

Lesions of the sellar, parasellar, and suprasellar regions are common and account for up to 20% of all intracranial neoplasms. Of these, pituitary adenomas are the most common in adults, accounting for over 50% of all lesions in this region.¹ However, rare lesions involving vascular structures can arise in this region.² Magnetic resonance imaging has been a modality of choice to identify the type, location, and extension of the lesions, which determines the surgical planning and prognosis in sellar and parasellar pathologies.

With the use of endoscope as a routine surgical practice for sellar lesions, it is quite uncommon for sellar and suprasellar lesion to require complex intracranial approaches. However, the frontotemporal transcavernous approach can be used for tumors with extensive invasion. This approach defines the most intricate and advanced cranial base approach,³ requiring elite surgical skills, and providing a maximal surgical corridor to adequately access the lesions.

The anatomy of the sellar region and its contents is important to understand the concept of skull base approach in surgical management of the lesions in these areas.

■ Anatomy

Located in the sphenoid bone, the sella turcica lies behind the chiasmatic groove and the tuberculum sellae, forming a part of the middle cranial fossa. The sella turcica houses the pituitary gland that rests on the hypophyseal fossa (the seat of the sella). Posteriorly, the bony sella is continuous with the clivus, which terminates laterally to form the posterior clinoid process.

These bony structures are valuable anatomical landmarks for surgical approaches to the lesions arising in these regions and also direct the course of the internal carotid artery (ICA)

as it takes a torturous course during its extradural ascend from the parapharyngeal recess to the clinoid process.

Given the complex anatomy of the sellar region and the adjacent cavernous sinuses, bounded closely by the bony structures and the optic nerve pose a challenge in obtaining access while operating on lesions in the region. In this chapter, the approach to sellar lesions using a transcavernous frontotemporal modification of the conventional Dolenc's approach, for a bloodless, extradural surgical corridor has been discussed.

■ Surgical Techniques

■ Extended Skin Incision and Craniotomy

Lesions of the sellar and suprasellar regions are ideally approached using an extended skin incision to expose the frontotemporal, orbitobasal, and middle fossa. This skin excision is an extension of the routine pterional approach (**Fig. 11.1a**). A layer-by-layer dissection allows removal of subcutaneous tissue and the temporalis muscle is retracted to expose the bony structures underneath (**Fig. 11.1b, c**). The pterion and the keyhole serve as important landmarks for a craniotomy; the lateral margin of the sphenoid is drilled off as close to frontal bone as possible (**Fig 11.1d**) and craniotomy is performed to prevent any interference with the retracted temporalis muscle (**Fig. 11.2**).

■ Brain Unlocking in Axial and Sagittal Planes

Extradural maneuvers to “unlock” the frontotemporal folds of the brain allow for a wider surgical corridor to the sellar and suprasellar region. The frontal and temporal lobes are “unlocked” from each other in the **sagittal** and **axial** fashion, by drilling off the sphenoid and dissecting the

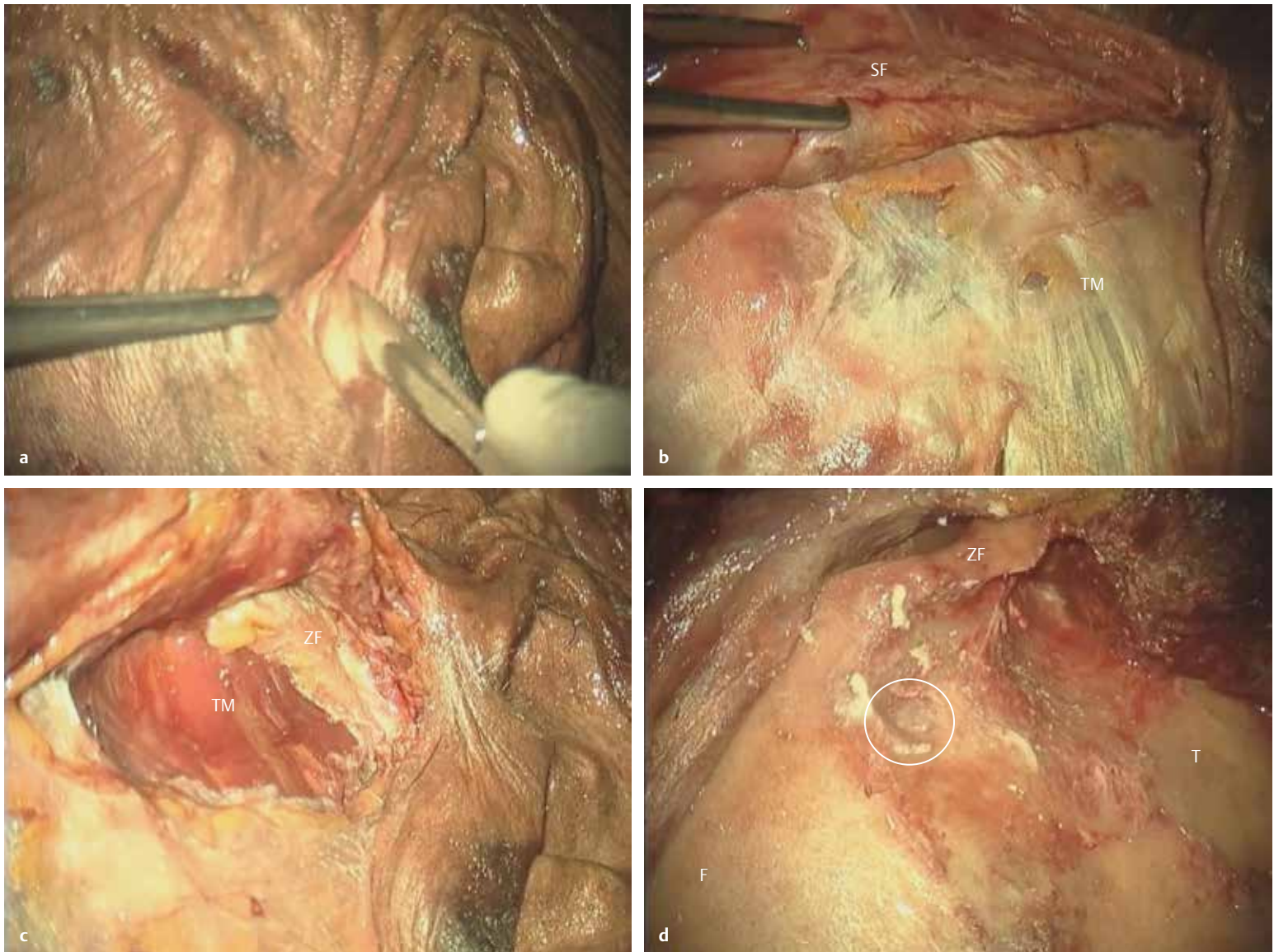


Fig. 11.1 Skin incision. **(a)** Extended incision for frontotemporal, orbitobasal, and middle fossa exposure; must be an extension of the incision in the routine pterional approach. Dissection is performed in layers. **(b)** Subcutaneous fat dissection of the tempoparietal muscle layer. **(c)** Separation of temporal muscle fascia from muscle fibers in the zygomatic arch before its exposure. **(d)** Exposure of the zygomatic arch (ZF), temporal bone (T), and frontal bone (F); the circle indicates the point where the keyhole for the craniotomy is made. Drilling should be done across the lateral surface of the greater wing of the sphenoid bone as close to the frontal process as possible.

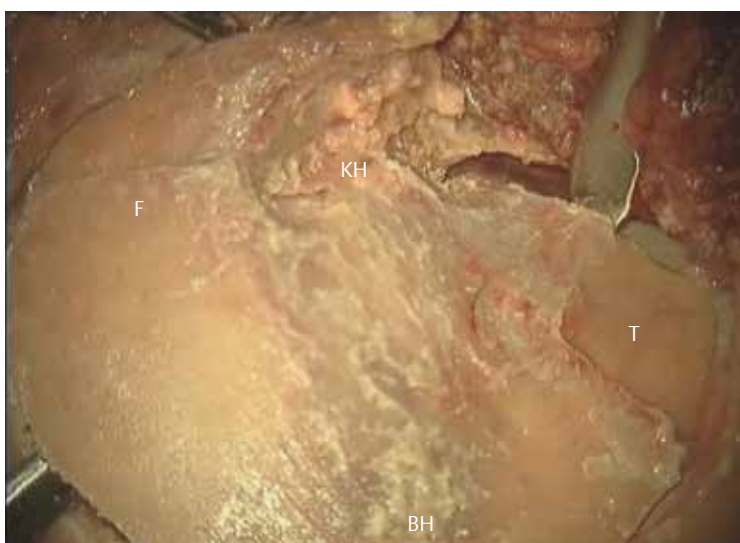


Fig. 11.2 Craniotomy. For exposure of the floor or the temporal base, groove is drilled to prevent interference with retracted temporal muscle. After drilling, a craniotomy is done.

orbitomeningeal band (OMB), respectively. Adding a sylvian dissection (**oblique intradural** unlocking) to the above-said maneuvers, greatly improves the basal exposure by opening up the brain in a lateral oblique fashion.⁴

■ Orbitomeningeal Band Dissection

Once the dura is exposed, the sphenoid ridge and the temporal bone are drilled to unfold the frontal lobe from the temporal lobe in a sagittal manner, providing a major view of skull base (**Fig. 11.3**). The OMB is located at the junction of basifrontal and temporal lobe and is the lateral aspect of superior orbital fissure (**Fig. 11.4**). Once the OMB is dissected under high magnification, the surgeon can clearly see a plane where the frontal lobe dura can be dissected off the

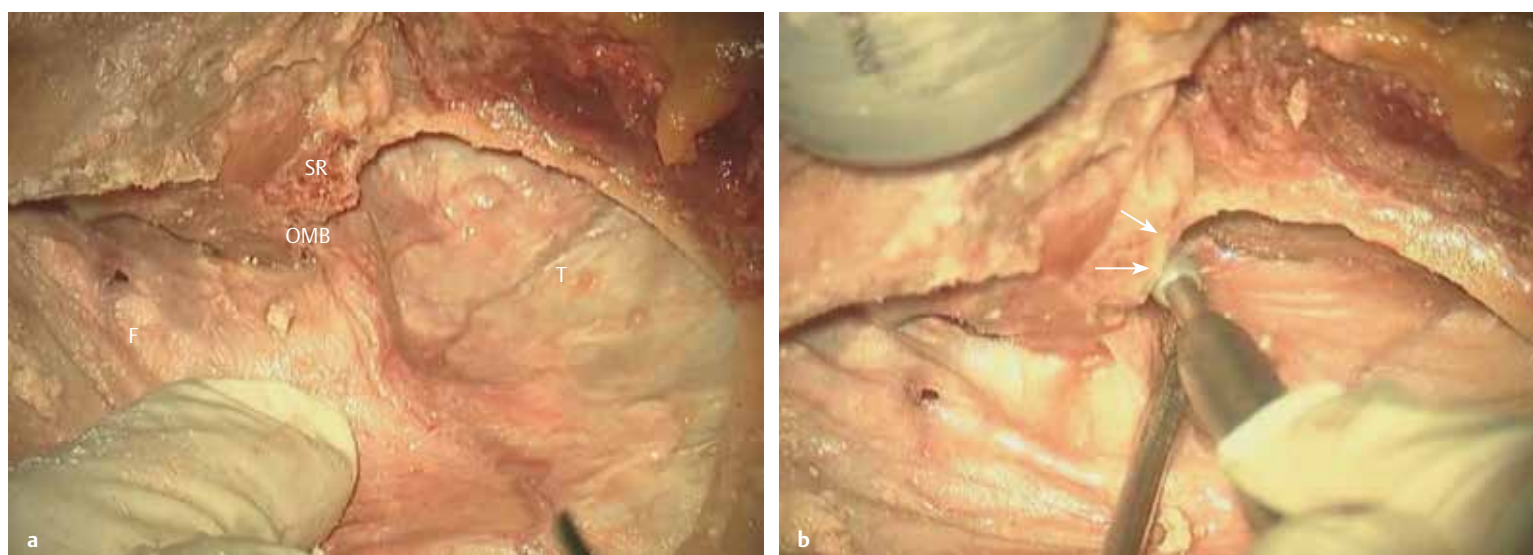


Fig 11.3 Sagittal unlocking. **(a)** Exposure of the dura. The temporal lobe (T), frontal lobe (F), orbitomeningeal band (OMB), and sphenoid ridge (SR) can be seen. **(b)** The sphenoid ridge and temporal bone are drilled for one major view of the skull base.

anterior clinoid and the temporal dura can be dissected off the true cavernous membrane of the cavernous sinus. This uncovers the clinoid for easier anterior clinoidectomy and displaces the temporal lobe laterally in an extradural fashion, thus enabling axial unlocking.⁵

■ Pericavernous Dissection Techniques

Once the true cavernous membrane plane is reached by accurate dissection of the OMB, the surgeon can follow sharp dissection to maintain a pericavernous plane. At the level of V2 and below, this plane is absent, but the interdural plane may be maintained, thereby decreasing the bleeding. In cases of bleeding, fibrin glue and Surgicel is useful. Using this technique, once the dissection is extended behind V3, and the middle meningeal artery is coagulated and divided, the GSPN^{A01} can be seen as a dural band rather than a nerve. To prevent bleeding that usually occurs as a result of transcavernous technique, a modification in the conventional Dolenc's approach can be used to preserve the TCM^{A02}. This modification is the sharp dissection in a pericavernous plane such that the nerves of the cavernous sinuses remain covered by the TCM.

■ Anterior Clinoidectomy

The dissection of the OMB exposes the anterior clinoid process (ACP) that is covered laterally by the frontal and temporal dural folds. The basifrontal dura can be sharply dissected off the anterior clinoid to completely uncover it (**Fig. 11.5**, **Fig. 11.6**). This makes anterior clinoidectomy easier and safe.

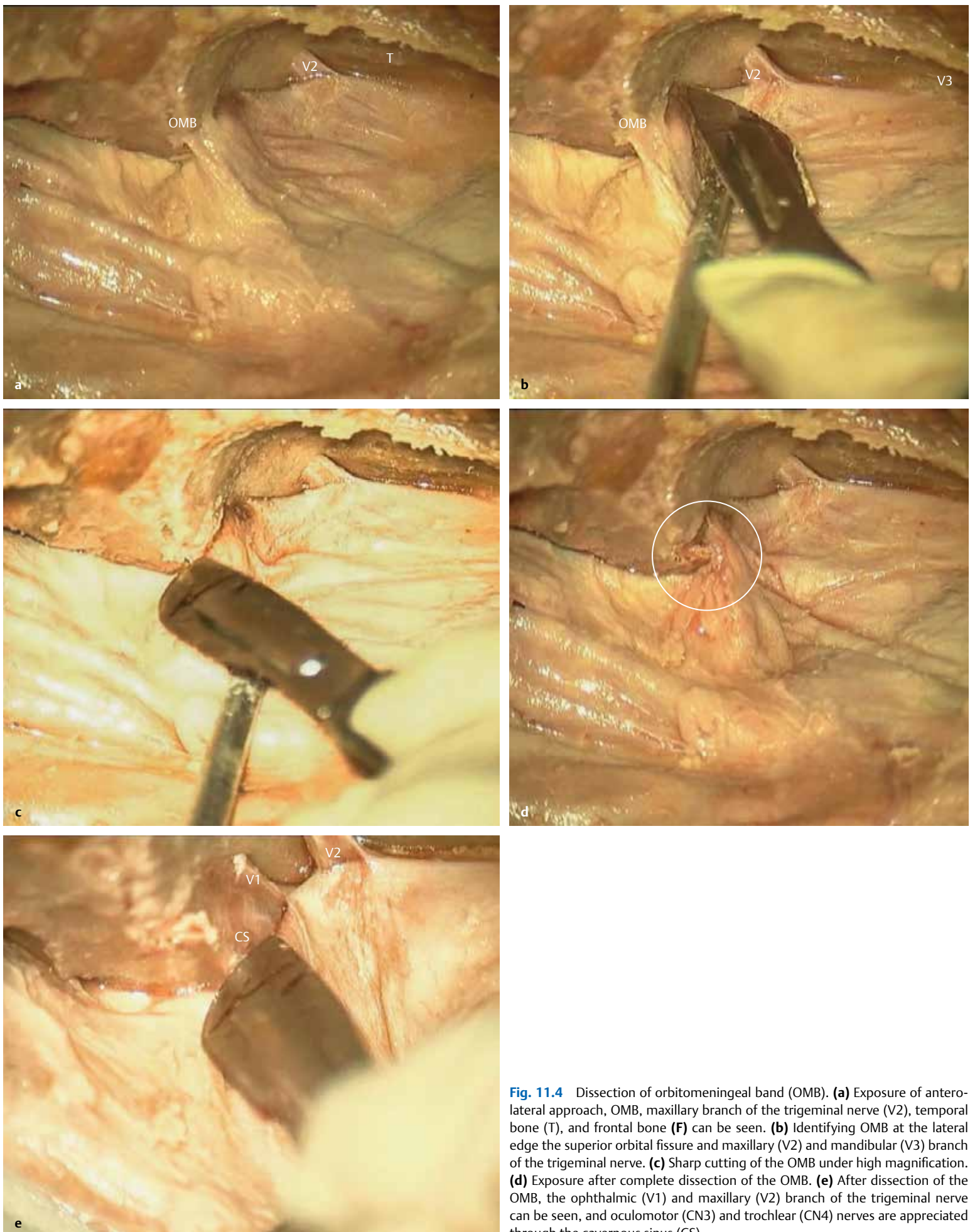
Orbital roof removal to uncover the extradural optic nerve can also be combined along with the dural cutting and sectioning the distal dural band. This allows the mobilization of the carotid muscle and increase space while dealing with aneurysms of this region.⁶ By complete removal of the ACP followed by careful extraction of the optic strut, one can visualize both, the extra and intra dural boundaries of the opticocarotid window and reach the interoptic or the suprasellar cisterns. This is the place where the entire skull base is centered, and this approach can allow for access to all sellar and suprasellar lesions.

■ Posterior Clinoidectomy

This maneuver is best done intradurally and requires understanding of microsurgical anatomy of the posterior clinoid process. The posterior clinoid may be drilled or removed using a Bone CUSA between the optic nerve, anterior cerebral artery, and carotid window or the window between the carotid and the oculomotor nerve (whichever is larger) (**Fig. 11.7**). This provides ample space to the posterior fossa and can be valuable in posterior circulation aneurysms as well as petroclival meningiomas. The key to safe drilling is that the drilling of the posterior clinoid needs to be performed in a "touch and back" manner (rather than clockwise or counterclockwise motion) to break the cortex.⁷

■ Petrous Anatomy and Anterior Petrosectomy

Once the dissection behind V3 is carried out, the surgeon must identify GSPN as a dural band thus protecting the



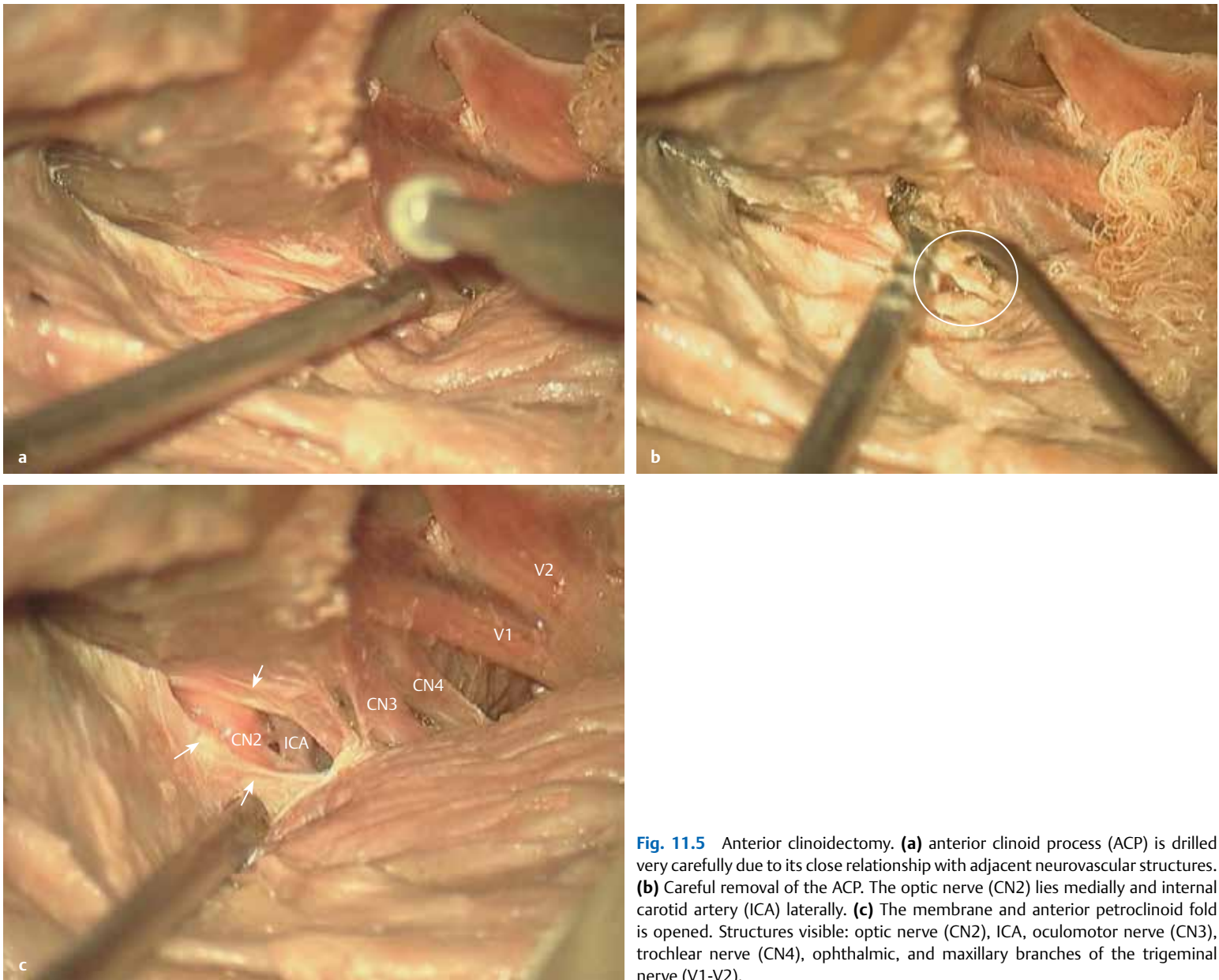


Fig. 11.5 Anterior clinoidectomy. **(a)** anterior clinoid process (ACP) is drilled very carefully due to its close relationship with adjacent neurovascular structures. **(b)** Careful removal of the ACP. The optic nerve (CN2) lies medially and internal carotid artery (ICA) laterally. **(c)** The membrane and anterior petroclinoid fold is opened. Structures visible: optic nerve (CN2), ICA, oculomotor nerve (CN3), trochlear nerve (CN4), ophthalmic, and maxillary branches of the trigeminal nerve (V1-V2).

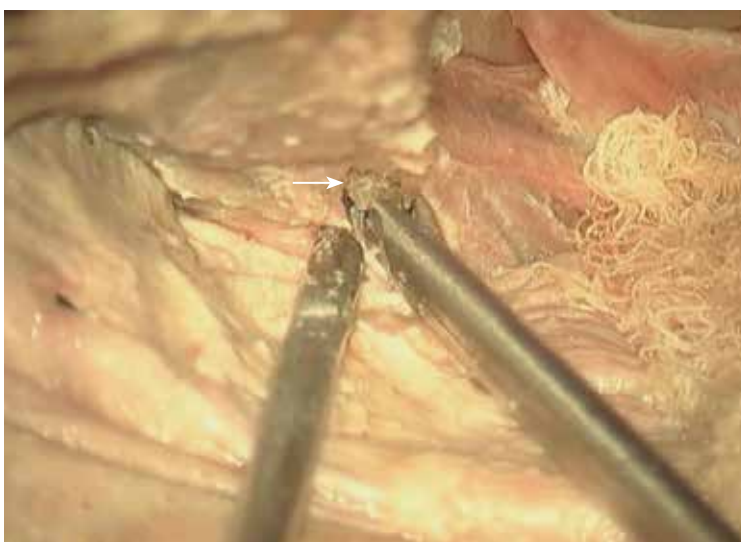


Fig. 11.6 Removal of the optic strut. After anterior clinoid process is dissected, optic strut is removed.

nerve in the plane below. The middle meningeal artery is coagulated and cut to attain this plane.⁸ The petrous ridges can be reached with continuous dissection and the arcuate eminence may be identified. The V3 may be drilled into the infratemporal fossa and this will help in mobilizing the Gasserian ganglion anteriorly so that petrous apex can be drilled more. Posteriorly, the surgeon can unroof the internal auditory meatus (IAM) and even do some drilling posterior to IAM. As the petrous bone is removed, the petrous carotid can be found in the lateral boundary and the cochlea that is anterolateral to IAM is avoided. The posterior fossa dura is exposed till the surgeon reaches the inferior petrosal sinus and the jugular tubercle is visualized (**Fig. 11.8**). Dural opening is a combination of temporal and posterior fossa

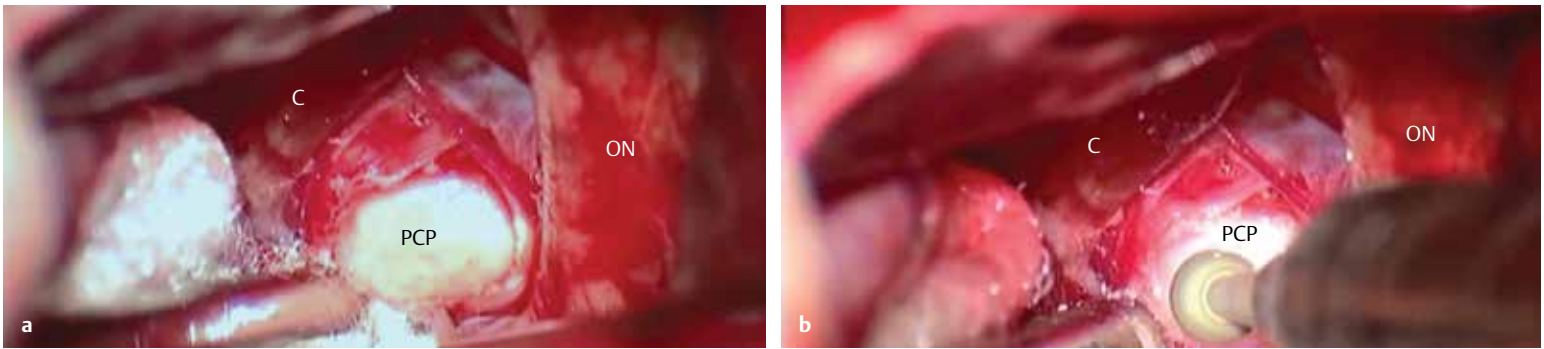


Fig. 11.7 Posterior clinoid process (PCP) drilling. **(a)** The dura covering the PCP is excised carefully between the optic nerve (ON) and the internal carotid artery (C). **(b)** The PCP is drilled using a bone CUSA between the opticocarotid window.

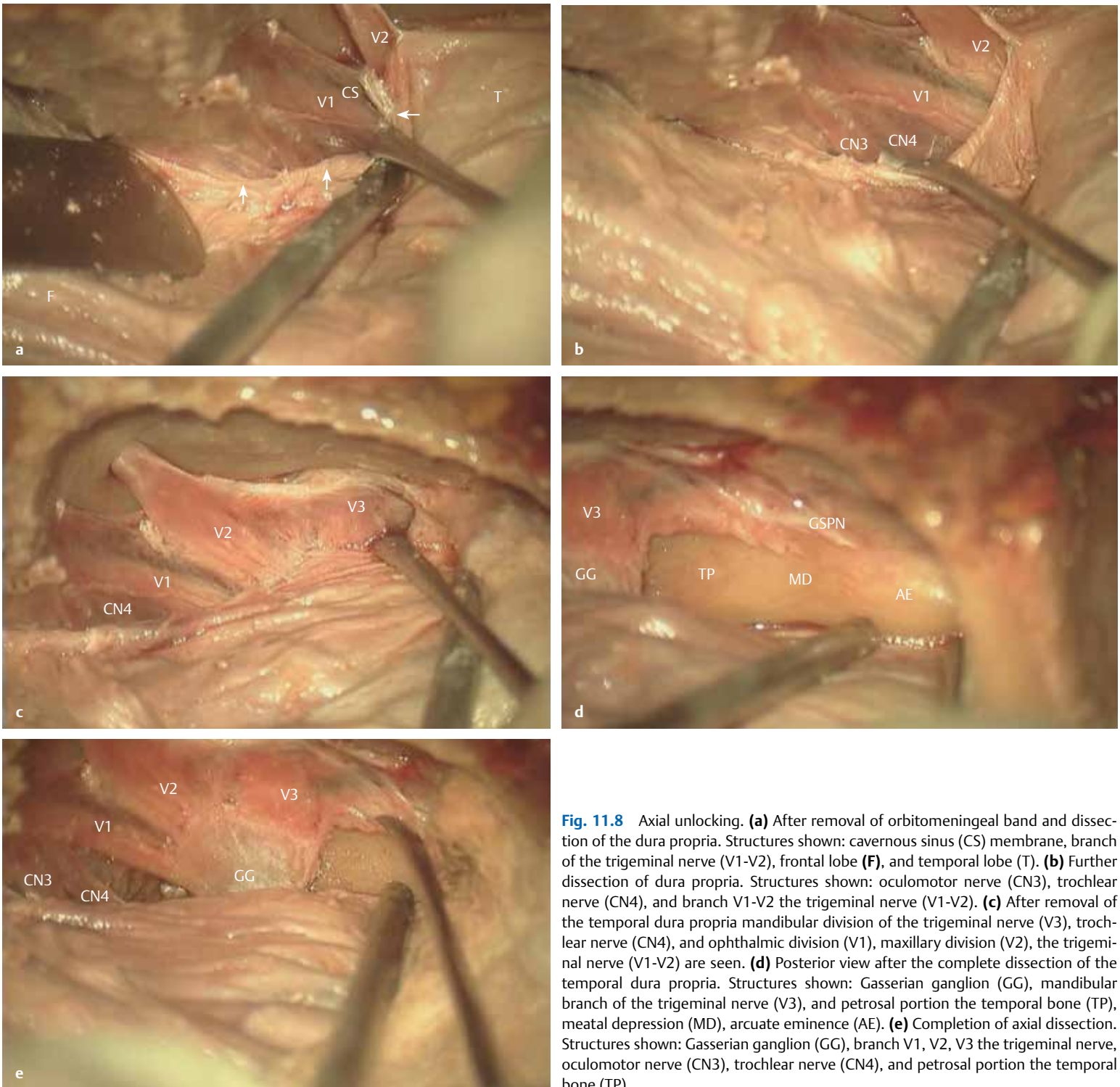


Fig. 11.8 Axial unlocking. **(a)** After removal of orbitomenigeal band and dissection of the dura propria. Structures shown: cavernous sinus (CS) membrane, branch of the trigeminal nerve (V1-V2), frontal lobe (F), and temporal lobe (T). **(b)** Further dissection of dura propria. Structures shown: oculomotor nerve (CN3), trochlear nerve (CN4), and branch V1-V2 the trigeminal nerve (V1-V2). **(c)** After removal of the temporal dura propria mandibular division of the trigeminal nerve (V3), trochlear nerve (CN4), and ophthalmic division (V1), maxillary division (V2), the trigeminal nerve (V1-V2) are seen. **(d)** Posterior view after the complete dissection of the temporal dura propria. Structures shown: Gasserian ganglion (GG), mandibular branch of the trigeminal nerve (V3), and petrosal portion the temporal bone (TP), meatal depression (MD), arcuate eminence (AE). **(e)** Completion of axial dissection. Structures shown: Gasserian ganglion (GG), branch V1, V2, V3 the trigeminal nerve, oculomotor nerve (CN3), trochlear nerve (CN4), and petrosal portion the temporal bone (TP).

durotomies after which the superior petrosal sinus is bipolarized off and the tent is cut to the incisura posterior to the entrance of the fourth nerve.

■ Opening the Membrane of Liliequist

The membrane of Liliequist can be cut using the window that can be seen between the optic nerve and the carotid artery. A sharp dissection is made using bayoneted side curve microscissors (working length 90 mm). The basilar quad comprising the superior cerebellar artery, the P1 segment, and the basilar artery is exposed. Tumors of the sellar and suprasellar lesions can be surgically removed using this surgical field.

■ Internal Carotid Artery in Relation to the Skull Base

The ICA is the most important vascular structure of the central nervous system providing two-thirds of the cerebral irrigation. It is important to understand the course of the ICA in the cranial base. The carotid artery follows a torturous course with sharp turns and relations to the adjacent bony structures. Knowing the anatomy of the carotid is crucial to all skull base surgeries involving the sellar region, and care needs to be taken to prevent any damage to the vessel.

An easier classification of the carotid artery can be used to understand the skull base anatomy. In a coronal plane, the carotid segments can be divided into horizontal and vertical, each responding to even and odd segments, respectively, in accordance to their adjacent bony, ligamentary, vascular, and nerve relationships. These anatomical landmarks help

identify each segment, as well as its spatial position in the skull base. Over the years, many classifications have been proposed by dividing the carotid in segments, some simpler than others depending on the utility they pursue.⁹⁻¹¹ In this chapter, authors have decided to use a classification similar to the one proposed by Professor Fukushima,¹² yet much more simplified model based on the spatial guidance of each segment (**Fig. 11.9**).

Each segment is named in accordance to its relationship with an adjacent structure. Therefore, the C7 segment is “cervical,” C6 “petrosal” segment, C5 “paraclival” segment, C4 “cavernous” segment, C3 “paraclinoid or parasellar” segment, and C2 “ophthalmic” segment. Throughout its course, the carotid is in close relationship with the following bony structures: the petrosal bone, clivus, and posterior and anterior clinoid process, as shown in **Fig. 11.10**.

The majority of C7 is extracranial and only the distal part is in the petrosal bone. The entire C6 segment is intraosseous, within the petrosal bone. The small proximal part of C5 segment is within the petrosal bone (more specifically in the foramen lacerum); however, it lies in a close relationship with the clivus and the dorsum sellae. The proximal part of C4 is related to the posterior clinoid process, and parts of C3 and C2 are in relation to the anterior clinoid process.

Starting from the inferior, the parapharyngeal (C7 segment) enters the cranium most posterior-laterally. This segment is the first vertical segment, hence corresponding to the C7 (odd) part or the ICA. The distal end of the C7 reaches the petrosal bone, where it sharply takes a medial turn to follow the course of the petrosal bone horizontally. This segment is the petrosal part of the carotid, and is the first horizontal segment, C6 (even). The greater superior petrosal nerve lies

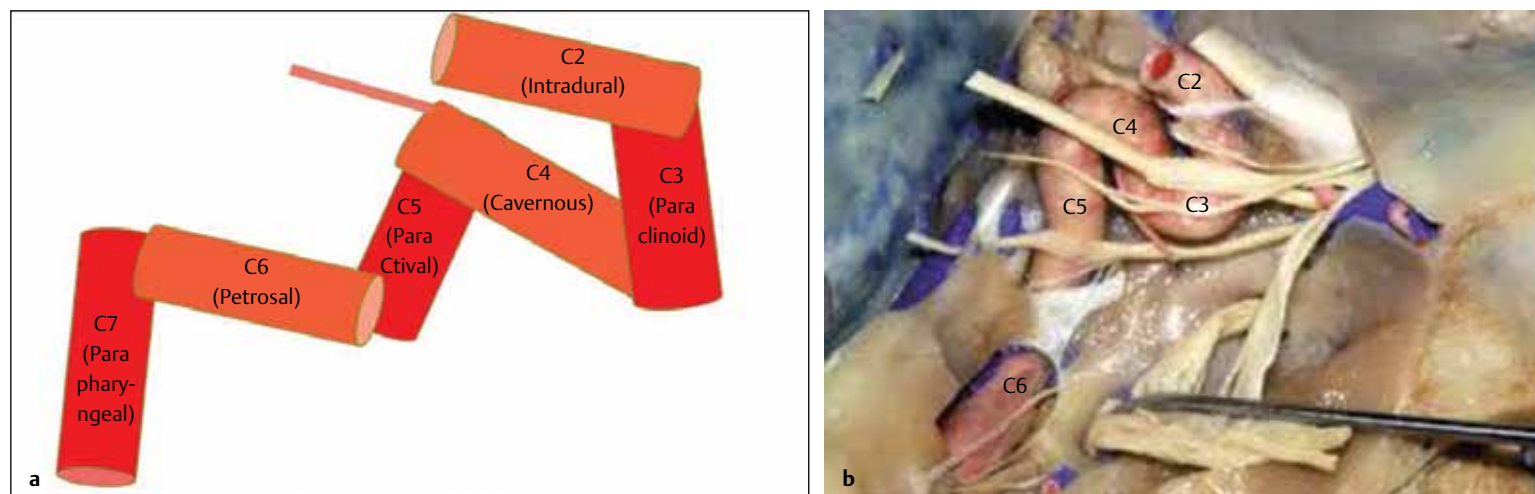


Fig. 11.9 (a) Schematic; (b) Cadaver: The carotid segments: two-dimensional orientation of horizontal and vertical segments. Note the sequence of odd and even numbers. (Dissection Image Courtesy: Rhoton Collection).

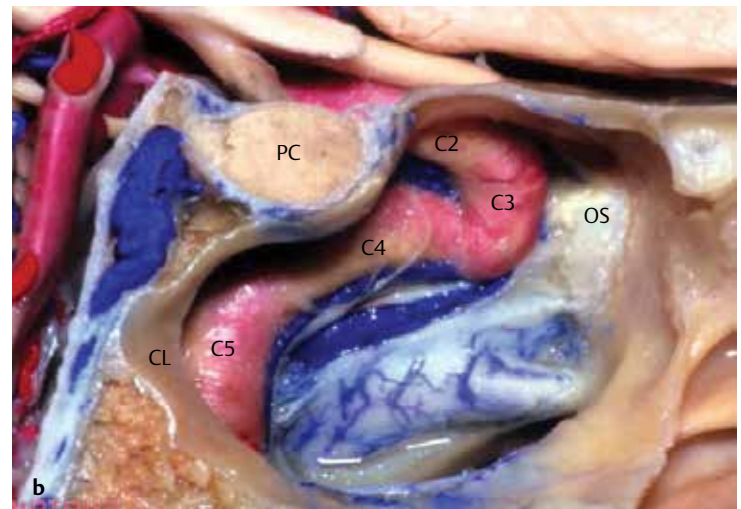
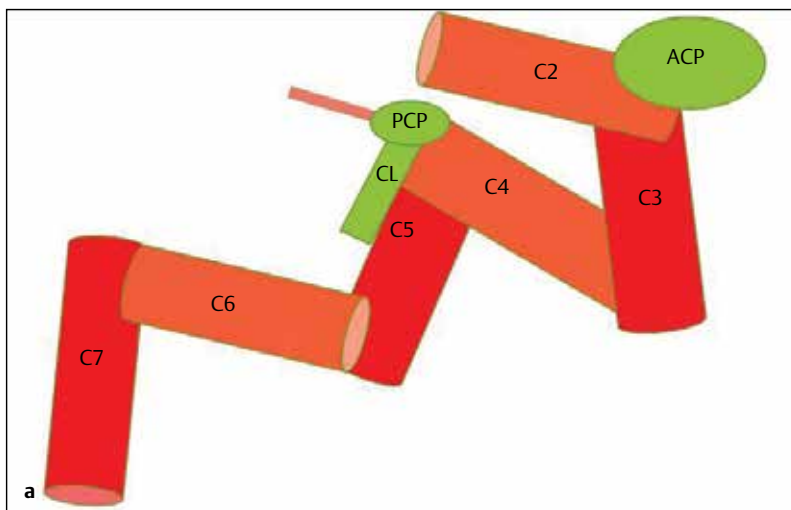


Fig. 11.10 The carotid segments (a) and bone relations (b). (C2) Ophthalmic segment, (C3) paraclinoid or parasellar segment, (C4) cavernous segment, (C5) paraclival segment, (C6) petrosal segment, and (C7) cervical segment. ACP, anterior clinoid process; CL, clivus; OS, optic strut; PCP, posterior clinoid process.

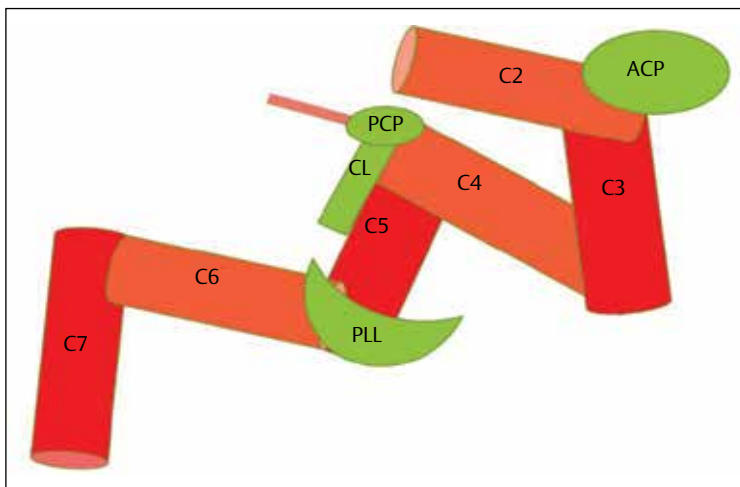


Fig. 11.11 The C5 segment crossing the petroclival ligament (PLL) at the foramen lacerum.

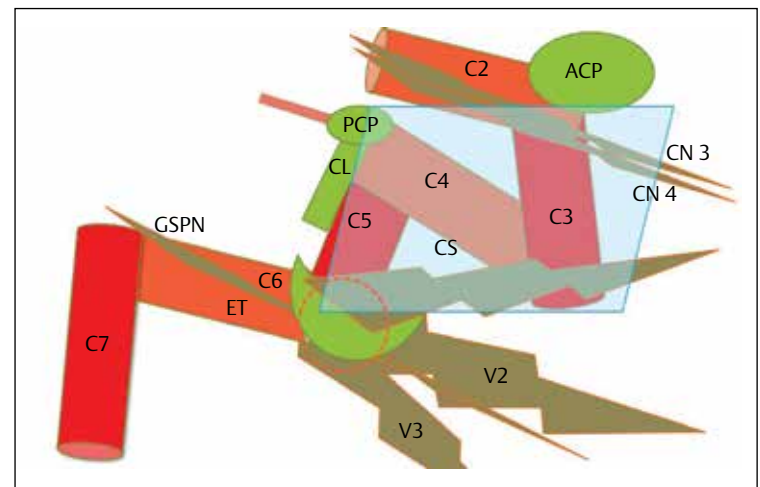


Fig. 11.12 Cavernous sinus (CS) in relation to carotid segments. The CS is covering a segment completely and part of two segments, as shown.

lateral to the C6 carotid segment and can predict the course of the ICA at this level.

The petro-lingual ligament lies anteromedial to petrous bone and is an important landmark where the carotid again takes a sharp ascend vertically, and through the foramen lacerum, ascends along the clivus to form the second vertical segment, the paraclival or the C5 (odd) part of the carotid (**Fig. 11.11**). This segment is in close relationship to the trigeminal ganglion laterally and is an important structure in clival lesions.

The clivus ends at the posterior clinoid process where the C5 carotid continues horizontally to form the cavernous or the C4 (even) segment of the carotid. This segment spans the cavernous sinus and supplies the pituitary gland and the chiasma through the hypophyseal branches. The cavernous sinus completely covers the C4 segment, the distal part of C5 segment, and the proximal part of C3 segment (**Fig. 11.12**).

Likewise, the cavernous sinus covers part of the cranial nerves III, IV, V1, V2, and part of the Gasserian ganglion.¹³

Some other important relationships of the carotid artery that the authors have identified are seen in **Fig. 11.13**. The proximal and distal dural rings practically delimit the C3 segment. The cochlea serves as an important structure to predict the location of the carotid curve from C7 to C6 (it is posterior and lateral to this curve). However, care must be taken while exposing the cochlea during petrosectomy to avoid hearing loss.¹⁴

While removing lesions of the pituitary gland, one needs to preserve the superior hypophyseal branches to prevent infarction of the optic chiasma. The C4 carotid runs inferomedially and then forms the clinoid segment or the C3 (odd), which ascends vertically in a close relationship with the optic nerve. This segment is the last extradural part of the ICA, which, on reaching the ACP anteriorly, can be exposed after

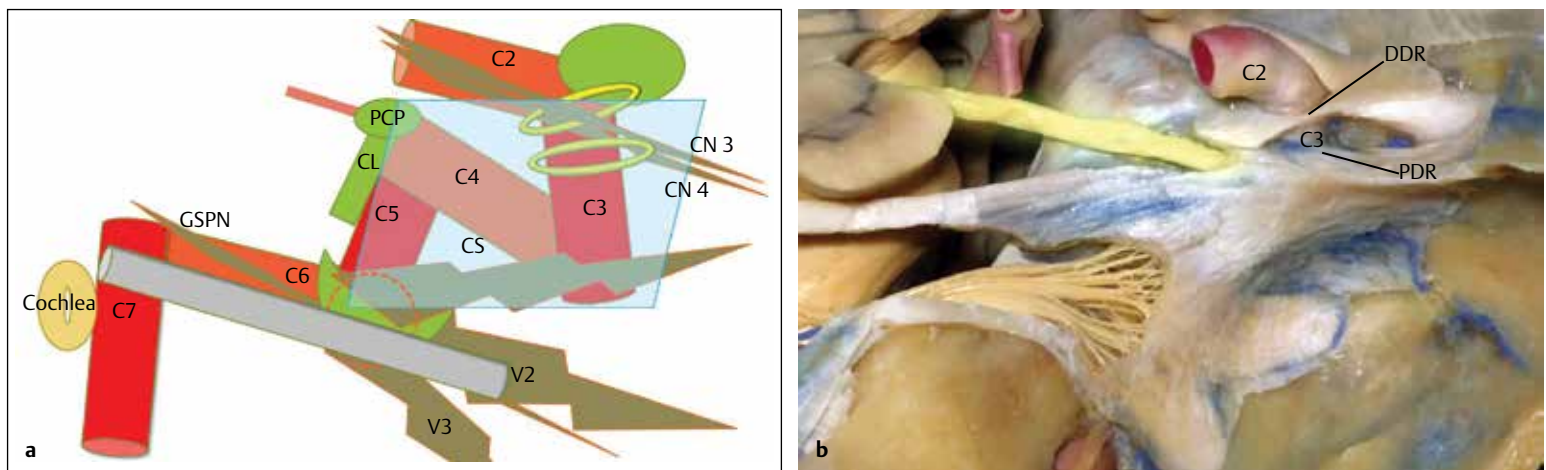


Fig. 11.13 (a) Schematic and (b) cadaver: Carotid segments, dural rings, and the cochlea. C2 (intradural segment); C3, clinoid; DDR, distal dural ring; PDR, proximal dural ring.

ACP removal. Exiting from the distal dural ring, the C3 carotid enters the dura to form the horizontal C2 (even) segment, terminating the extradural course of the ICA.

From view of endoscope, the vertical segments can be seen as shown in **Fig. 11.14**.

It must be noted, however, that the ICA has three planes and each segment has an orientation in each of these three planes. Moreover, there are anatomical variants between one patient and another. Step-by-step transcavernous frontotemporal approach in craniopharyngioma is shown in **Fig. 11.15**.

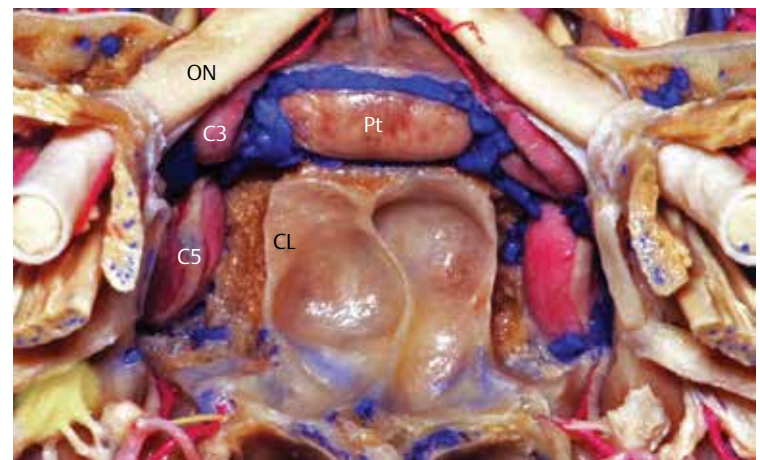


Fig. 11.14 Endoscopic view of carotid in relation to the clivus and cavernous sinus. C3, paraclinoid or parasellar segment; C5, paraclival segment; CL, clivus; ON, optic nerve; Pt: pituitary gland. (Image Courtesy: Rhoton Collection).



Fig. 11.15 Surgical Steps in a Craniopharyngioma using transcavernous frontotemporal approach. (a) Sagittal unlocking to expose the opticocarotid and the lateral carotid window. (b) Axial unlocking with sharp dissection of the orbitomeatal band (OMB), followed by the dissection of the temporal dura from the true cavernous membrane. (c) Basal cisternal opening.

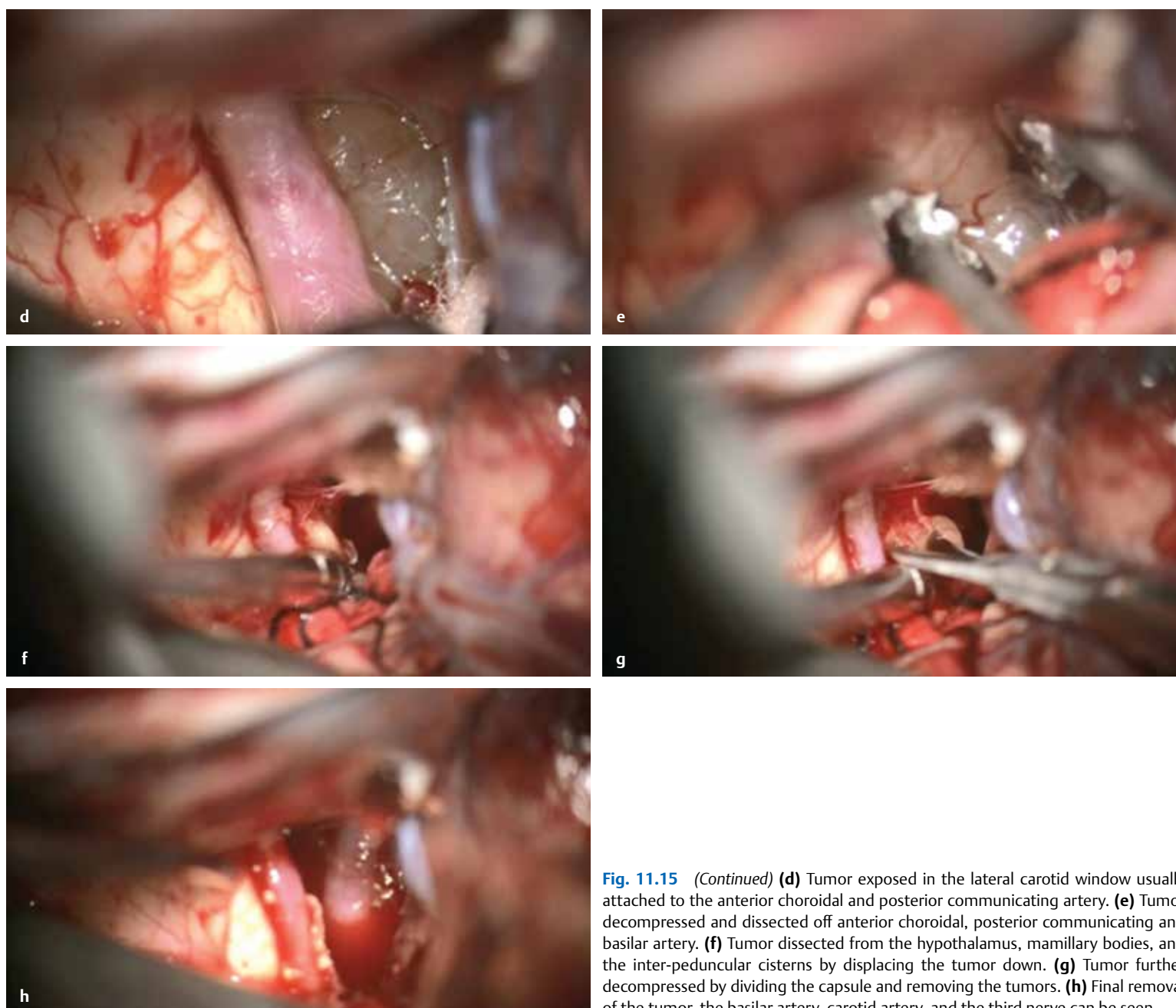


Fig. 11.15 (Continued) **(d)** Tumor exposed in the lateral carotid window usually attached to the anterior choroidal and posterior communicating artery. **(e)** Tumor decompressed and dissected off anterior choroidal, posterior communicating and basilar artery. **(f)** Tumor dissected from the hypothalamus, mamillary bodies, and the inter-peduncular cisterns by displacing the tumor down. **(g)** Tumor further decompressed by dividing the capsule and removing the tumors. **(h)** Final removal of the tumor, the basilar artery, carotid artery, and the third nerve can be seen.

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Author queries

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AQ2. Please provide expansion of TCM