3 Parasagittal Craniotomy

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3.1 Background

- This chapter will explore the techniques used for parasagittal craniotomies for lesions in the parafalcine, interhemispheric, and intra- or paraventricular regions. We will also discuss the preoperative, intraoperative, and postoperative considerations.

3.2 Indications and Contraindications

3.2.1 Indications

- Parafalcine tumors (▶ Fig. 3.1)—most typically meningioma but also including lesions such as dural-based lesions arising from the linings of the superior sagittal sinus (SSS).
- Access to the interhemispheric space—most commonly for falcine meningiomas but also for medial hemispheric lesions—tumors, vascular lesions, abscesses, subdural hemorrhage, or placement of monitoring grids for epilepsy.
- Extracerebral approach to intra-/paraventricular tumors of the lateral and third ventricles (▶ Fig. 3.2).

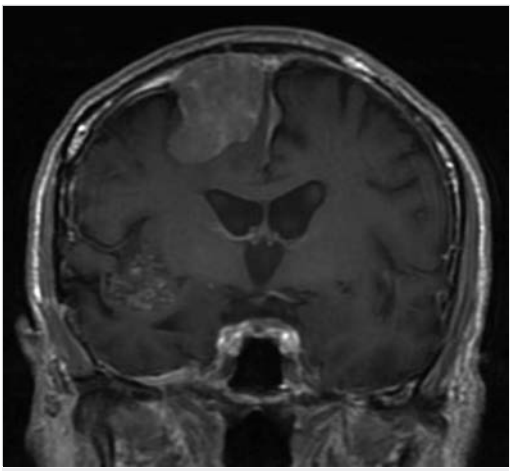

Fig. 3.1 Coronal postcontrast T1-weighted MRI depicting a medially located meningioma.

3.2.2 Contraindications

- Tumors with possible involvement or invasion of the SSS.
- The lesion demonstrates extensive invasion of the overlying bone.

3.3 Informed Consent: Expected Benefits and Potential Complications To Be Mentioned

- Risk of venous injuries or infarctions associated with the manipulation of the SSS and its associated venous structures.
- Risk of venous drainage removal leading to a venous infarction.
- Risk for serious complications that may permanently alter a patient's ability to perform everyday tasks (including disconnection syndrome from callosotomy, anterograde amnesia from forniceal injury, or akinetic mutism from cingulate injury).

3.4 Instruments

- High-speed drill.
- Frameless stereotaxy.
- Mayfield head holder.
- Yasargil bar and Greenberg retractor.
- Headlight.
- Loupes.
- Bipolar cautery and Bovie cautery.
- Microscope.
- Precordial Doppler—if opening is across the SSS.
- Neuromonitoring if the lesion is along the middle third of the anterolateral plane.

3.5 Patient Preparation

- Computed tomography (CT) of the head without contrast for overlying bony involvement to determine the necessity of the craniotomy.
- Magnetic resonance imaging (MRI) with and without contrast should be obtained to define

the tumor and visualize relevant anatomy (▶ Fig. 3.3 and ▶ Fig. 3.4).
- MR venography (MRV) or CT venography (CTV) to look at SSS occlusion/involvement, cortical and venous displacement, or cortical or scalp venous collateral drainage.
- A surgeon may also consider CT angiography (CTA) or digital subtraction angiography (DSA) for this as well as evaluating the feeding arterial supply and venous drainage profile, especially for surgical targets of vascular pathologies (▶ Fig. 3.5).
- Anesthesia should have the following prepared: standard antibiotics, dexamethasone, mannitol, furosemide, levetiracetam, and hydration.

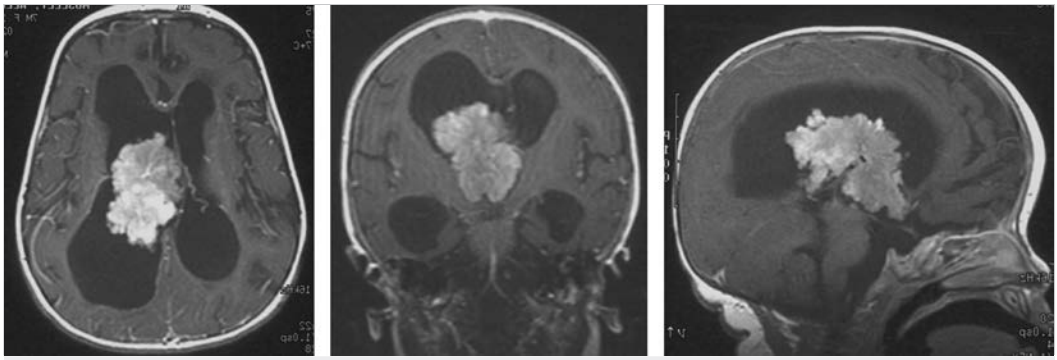

Fig. 3.2 Postcontrast T1-weighted MR images depicting large intraventricular mass with associated ventriculomegaly.

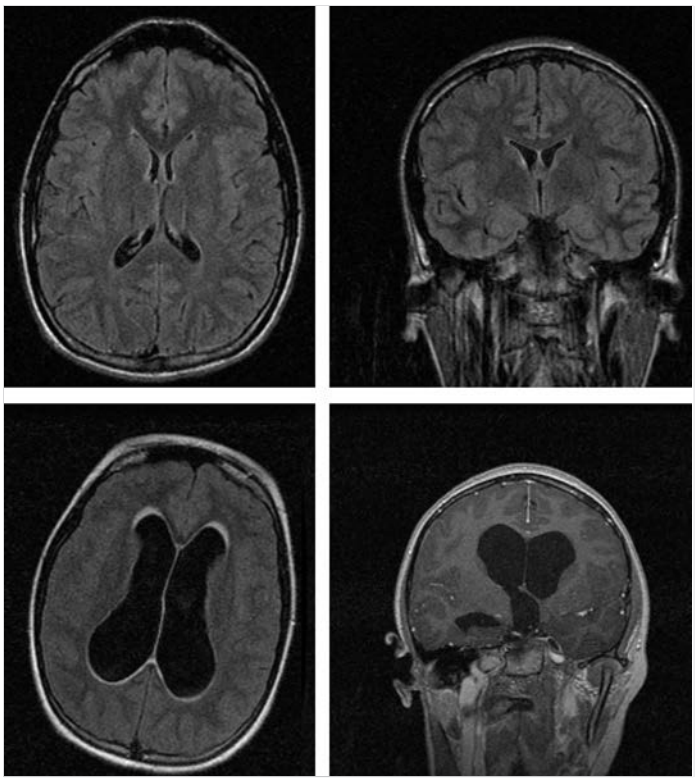

Fig. 3.3 Top panel: Axial and coronal views of T1-weighted MRI sequences demonstrating lateral and third ventricles of typical caliber for a healthy adult. The bottom panel images demonstrate significant ventriculomegaly of the lateral and third ventricles. The anterior and posterior interhemispheric approaches may be used to access the ventricular system in the absence of ventriculomegaly.

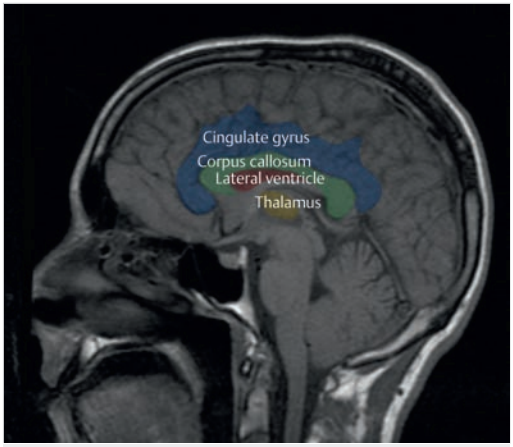

Fig. 3.4 Midline, sagittal T1-weighted MRI with highlighted cingulate gyrus, corpus callosum, lateral ventricle, and thalamus as relevant anatomy to the interhemispheric transcallosal approach to intraventricular lesions.

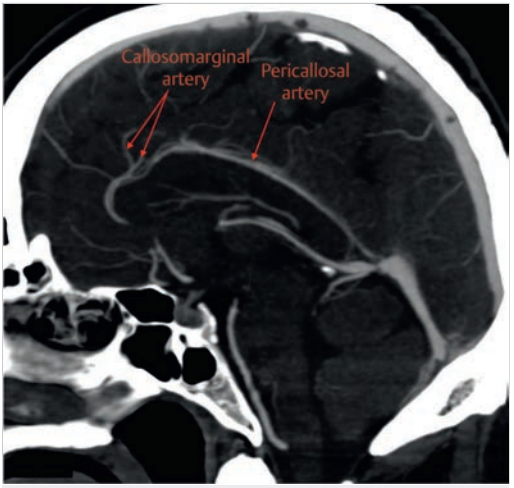

Fig. 3.5 Sagittal CT angiogram depicting midline vascular structures, including the pericallosal and callosomarginal arteries.

3.6 Patient Positioning

- Stereotactic navigation can be used to assist with positioning and planning of the incision by defining the margin of the lesion, as well as the SSS (**Video 3.1**).
- Lesions within the anterior third of the anteroposterior plane:
  - Incision should be in front of the coronal suture.
  - The patient should be positioned supine with the head neutral, or with slight flexion for a bicoronal incision.
- Lesions in the middle third:
  - A **U**-shaped skin incision is made with the base ipsilateral to tumor, with incision extending at least 2 cm across the midline while centered on the tumor over a region between displaced draining veins.
  - The patient should be positioned in the semi-sitting position or the lateral position with the vertex raised and the tumor side down to allow the brain to fall away from the tumor to decrease necessary brain retraction.
- Lesions in the posterior third:
  - A **U**-shaped incision is made suboccipitally, with a flap that has a width exceeding 1.5 times the height. A vascularized pedicle should always be maintained.
  - The patient can be positioned prone with head neutral or three-fourths prone with the head lateral.
- The head should be secured with a fixed head frame with at least three points of fixation to the skull. One point of fixation should be on the ipsilateral temple to minimize interference of the frame while also ensuring the side holding more weight of the head has a higher number of points of fixation.

3.7 Technique

- Bone flap (**Video 3.1**):
  - For complete resection, the bone will need to be removed as anywhere that bone bleeds excessively is likely to be fed by the tumor.
  - If there is no excessive bleeding, but there is hyperostosis, plan a flap based on the surgical approach only and drill off the inner table prior to replacement of the bone flap.
  - Use of neuronavigation should ensure the bone flap extends at least 2 cm beyond dural tails.
  - If the frontal sinus will likely be opened, a pericranial flap will be needed for closure.

- Tumors that do not invade the sinus:
  - Two or three burr holes can be made directly over the sinus, with one to two burr holes placed on the lateral side of the bone flap.
  - The dura or tumor can then be sharply dissected from the bone to ensure that the tumor is not torn from its underlying vascularity.
- Tumors that invade the sinus:
  - Two to three burr holes should be placed on either side of the SSS and one to two burr holes lateral to the tumor plus one to two burr holes on the contralateral side to expose the contralateral side of the sinus.
  - The craniotomy should be removed in two or three pieces, with the lateral portions removed first, followed by the portion over the sinus.
  - The last bony cuts of the craniotomy should be those directly over the sinus to allow for quick elevation of the bone flap in the event of bleeding.
  - Copious irrigation and Gelfoam should be ready to place over the sinus to control hemorrhage and avoid potential air emboli.
- Dural opening:
  - It should be **C**-shaped, starting furthest away from the SSS.
  - The dura should be opened 1 cm beyond the outer edge of the tumor. The dural resection medially occurs at the edge of the SSS, if the SSS is not to be resected.
  - The edge of the sinus can be sutured closed using running 4–0 Nurolon.
- Surgical resection:
  - Internal debulking of the tumor initially with concomitant use of bipolar electrocautery and suction, or with the Cavitron Ultrasonic Surgical Aspirator (CUSA), followed then by separation of the tumor from the surrounding brain.
  - If only the portion of tumor outside the SSS is being removed, then neuronavigation should be used to ensure that the dural plane is not crossed.
  - If the planning is to sacrifice the SSS, then the dura will also need to be opened on the contralateral side in a small **C**-shaped fashion and dissection down the contralateral falx is needed to expose the region of the SSS to be removed.
  - Upon completion, the dural opening can be closed with a dural patch, followed by possible mesh cranioplasty or replacement of the original bone flap with the inner table shaved down.

3.8 Postoperative Care

- The patient should be monitored postoperatively in the neurointensive care unit for observation particularly for venous injury.
- Postoperative imaging with a head CT should be obtained and venous injury should be suspected if CT shows progressively worsening edema or hemorrhage into adjacent brain.
- If venous injury is suspected, MRV or CTV is utilized for diagnosis. The patient should be kept hydrated with a hematocrit goal above 30 and low-dose mannitol at 30 mL/h.
- The patient should be monitored for 2 to 4 days during the window of risk of venous injury or infarct.
- Steroids may be administered for managing vasogenic edema.
- Antiseizure medications are often used depending on the location and pathology of the lesion.
- Hypertension or hypotension should be avoided, as well as overmedication with sedatives such as narcotics that would affect the ability to follow a patient's neurological examination.

3.9 Complications

- Venous injuries or infarctions associated with the manipulation of the SSS and its associated venous structures.
- Injury to the SSS.
- Venous drainage removal leading to a venous infarction.
- Arterial injury.
- Subdural or epidural hematoma.
- Bone flap infection.
- Seizures—depending on the location and pathology of the lesion.

3.10 Management Pearls

- It is imperative to notify anesthesia prior to removal of the bone so that they may lower the head if needed and monitor for cardiovascular instability.
- In the event of injury to the sinus, avoid the use of bipolar electrocautery as it will cause dural edges to shrink and expand the tear.

4 Temporal Craniotomy

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4.1 Background

- Temporal craniotomy is a workhorse neurosurgical approach through the temporal bone of the skull that provides access to the temporal lobe, mesial temporal structures, lateral aspect of the thalamus, and basal cisterns.[1,2,3,4] Its counterpart, the subtemporal craniotomy, provides additional access to the middle fossa floor, upper clivus, and basal cisterns.

4.2 Indications and Contraindications

- Extra-axial tumors (e.g., meningiomas and schwannomas).
- Intra-axial tumors (e.g., gliomas; **Video 4.1**).
- Vascular lesions (e.g., cavernous malformations, arteriovenous malformations, aneurysms, and intraparenchymal hemorrhages; **Video 4.2**).
- Epilepsy (with multiple possible approaches, such as temporal lobectomy or selective amygdalohippocampectomy).[4,5,6,7,8,9,10,11,12,13,14]
- Trauma.
- Extensions to the temporal approach may be utilized to gain access to additional areas:
  - Pterional craniotomy for lesions extending superior to the sylvian fissure.
  - Extended middle fossa approach for lesions that extend deep into the middle fossa, such as those in the internal auditory canal, and to access the prepontine clivus and superior cerebellopontine angle.
  - Lateral orbitotomy for lesions in the dorsal, anterior, lateral, or inferior aspects of the orbit.
- Consider patient functional status, medical comorbidities, radiological findings, anatomical variants, expectations, and anticipated outcomes; multidisciplinary discussion involving neuroradiology, radiation oncology, and neuro-oncology may be beneficial to determine the best treatment plan for a given patient.[7,13,15]

4.3 Instruments

- Mayfield clamp.
- Perforator or other drill.
- Kerrison punches or rongeurs.
- Penfield 3.
- Craniotome.
- No. 15 blade.
- Metzenbaum or tenotomy scissors.
- Bipolar cautery and hemostatic agents.
- Titanium plating systems.
- Depending on the indication for surgery, intraoperative adjuncts such as the microscope or exoscope, neuronavigation, neurophysiological monitoring including subcortical motor mapping, ultrasound, and fluorescence guidance are used.

4.4 Patient Preparation

- Functional magnetic resonance imaging (MRI) scan or a magnetoencephalogram (MEG) can help determine language dominance and localization of Wernicke's area involving the superior temporal gyrus. For lesions in close proximity to the eloquent cortex, preoperative resting-state or task-based functional MRI can be used for functional mapping, the latter of which can help in understanding language dominance.
- Diffusion tensor imaging (DTI) and tractography can help localize adjacent medial corticospinal motor tracts traveling through the posterior limb of the internal capsule and optic radiations involving the posterior temporal lobe.
- Comprehensive assessment of all arterial and venous structures along the surgical trajectory should be performed to avoid vascular injury.
- In select instances, cerebrospinal fluid (CSF) diversion can be considered to promote brain relaxation, minimize need for brain retraction, and facilitate intra- and extradural dissection; this is typically accomplished through lumbar drain placement and external ventricular drainage.[13,14,15,16]

- Perioperative medications include the following:
  - Dexamethasone for neuroprotection and to minimize postoperative edema.
  - Mannitol for osmotic diuresis to achieve temporal lobe relaxation.
  - Seizure prophylaxis (most commonly with levetiracetam).
  - Antibiotic prophylaxis (most commonly with cefazolin).

4.5 Patient Positioning

- The patient is placed supine with a bump under the ipsilateral shoulder and hip to minimize neck strain (▶ Fig. 4.1a, b).
- The head is turned away from the surgical site and positioned in three-point fixation with the Mayfield clamp with a slight downward tilt to facilitate gravity retraction and venous drainage.
- Avoid nonphysiologic neck rotation, as this may compromise venous return and increase postoperative pain.
- Upper extremities should be padded to minimize pressure injuries and draped over the torso or by the patient's ipsilateral side.
- Lateral rather than supine positioning should be considered for older patients, patients with a large body habitus, and patients with cervical spondylosis.

4.6 Technique

- Skin incision is planned based on the required surgical access to the temporal lobe (anterior, middle, or posterior temporal lobe lesions) and middle fossa (▶ Fig. 4.1c, d):
  - Access to the superior or middle temporal gyri necessitates a small curvilinear incision; in these cases, the lower limb starts anterior to the tragus and the curve starts directly above the pinna, the superior end of the curve reaches the superior temporal line, and the anterior end reaches the hairline (▶ Fig. 4.1c).

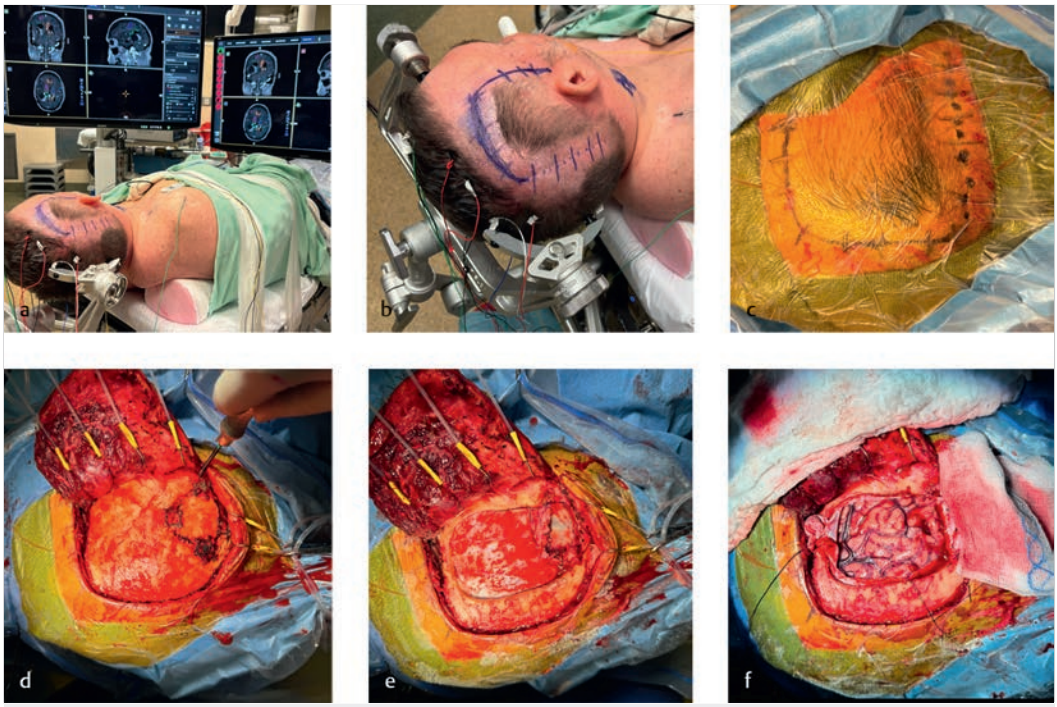

Fig. 4.1 **(a, b)** Patient positioning for redo temporal craniotomy. Exoscope monitors are placed in ergonomically favorable positions for the surgeon. **(c)** Horseshoe-shaped skin incision. **(d)** Elevation of myocutaneous flap. **(e)** Completion of craniotomy. **(f)** Dural opening and tack-up to facilitate temporal lobe visualization.

  - Cases requiring access to the temporal pole may benefit from a reverse question mark incision.[17,18,19,20]
  - For lesions involving the middle or posterior temporal lobe, a trapdoor incision is beneficial; it is centered over the external auditory canal.
- At least one burr hole is made with a perforator or other drill bit just above the root of the zygoma. Multiple other burr holes may be made as desired to facilitate careful dural dissection, especially with a trapdoor incision. Burr hole(s) can be extended with Kerrison punches or rongeurs (▶ Fig. 4.1e).
- The dura is dissected off the inner table of the calvarium using a Penfield 3 (▶ Fig. 4.1f).
- A craniotome is used to complete the craniotomy and subsequent bone flap elevation.
- The dura is carefully incised with a no. 15 blade and subsequently opened in the desired fashion using Metzenbaum or tenotomy scissors.
- Dural closure is ideally performed in a watertight fashion using a running suture when possible; for inadequate dural closure, use of dural substitutes for onlays or duraplasties may be considered.
- Bone flap is replaced and secured using titanium plating systems. Bone grafts or other sealant materials may be added if desired. If the mastoid air cells are exposed, they must be waxed to avoid a CSF leak.
- Incision is then reapproximated in layers, with careful approximation of the muscle, fascia, galea, and skin, to promote wound healing and satisfactory cosmetic outcome.[12,19,20,21,22,23,24,25,26,27]
- Use of a subgaleal drain or headwrap may be considered based on surgeon preference.

4.7 Postoperative Care

- Surgical site infection is avoided through strict aseptic and antiseptic technique, and prophylactic antibiotics (typically cefazolin or a similar agent with gram-positive coverage).[11,28,29,30,31,32]
- Patients may be initially monitored in the intensive care unit prior to transfer to the neurosurgical ward.
- Patients should be kept well hydrated to avoid venous infarction and vasospasm and placed on seizure prophylaxis with antiepileptic drugs for at least 1 week postoperatively.

4.8 Complications

- Injury may occur from damage to the superficial temporal artery (STA) or facial nerve during surgery. If the STA is affected, the risk of a wound-healing problem rises due to loss of the main blood supply of the myocutaneous flap.
- Sacrifice of veins should be avoided when possible to avoid venous infarcts.
- Care must be taken to avoid any injury to the vein of Labbe, which courses into the transverse sinus. Gelatin sponges or cottonoids can be placed on this vein in order to protect it.[3]
- If a dural sinus injury is encountered, it can be managed with packing, tamponade, and/or primary repair.
- Temporal lobe retraction should be minimized with a preference for gravity retraction. Fixed retraction should be avoided if possible.
- The temporal lobe contains the eloquent cortex involved with language in the perisylvian region and medially is adjacent to eloquent white matter tracts and hippocampal structures that should be carefully considered in approach planning to minimize postoperative neuropsychologic and visual deficits.
- Intraoperative neuromonitoring is critical for detecting and preventing inadvertent neural injuries; this may include some combination of somatosensory and motor evoked potentials, and in cases of awake craniotomy, language mapping.
- After execution of the procedure, there is potential for CSF leakage. Placing adipose tissue as a barrier during closure can prevent this complication.
- Thromboembolic complications are mitigated through early mobilization, sequential compression devices, and chemical prophylaxis.[33,34,35]
- Other general postsurgical complications include bone flap infection, soft tissue infections, empyema, extradural abscesses, cosmetic disfigurement, malocclusion, and trismus.[1]

4.9 Management Pearls

- The root of the zygoma is where the zygoma connects to the squamous part of the temporal bone; this key landmark is an external reference for the middle fossa floor.

- With each skin incision, the STA should be considered and preserved through careful dissection above the superficial temporal fascia. The STA typically lies one fingerbreadth anterior to the tragus, runs above the superficial temporal fascia, and bifurcates into its frontal and parietal branches approximately 5 cm above the zygoma.[1,11] The STA travels over the posterior zygomatic root before dividing into anterior and posterior branches, which run along the superficial temporal fascia with the corresponding vein and auriculotemporal nerve.
- The facial nerve is an important consideration during exposure; branches of the facial nerve course over the zygoma and under the superficial temporal fascia.[10,12]
- The vein of Labbe, also known as the inferior anastomotic vein, is the largest superficial vein on the lateral surface of the brain that connects the sylvian venous system to the transverse sinus. Its identification on preoperative imaging and intraoperative preservation are essential,[12,13,14] and special care should be taken to avoid it. It will usually be visualized at the posterior margin of the craniotomy.[1] This is particularly relevant in the cases requiring posterior subtemporal exposure.[16,17,18]
- In the cases where the dominant posterior superior temporal gyrus is involved, an awake craniotomy can be considered for language mapping with direct cortical stimulation.

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