Middle Cranial Fossa approach to Petrous Apex

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Introduction:

This surgical approach provides access to the lateral skull base which includes the cranial side of petrous bone, internal auditory canal, geniculate ganglion of facial nerve and the petrous apex. This classic neurosurgical approach was described way back in 1891 by Frank Hartley. He used the intracranial, extradural approach to access trigeminal ganglion to block it as a treatment of trigeminal neuralgia. The overall morality in his hands was around 10%. Cushing modified this approach slightly by minimizing traction on the brain and also reduced hemorrhage from middle meningeal artery by providing less traction. This effort lowered the mortality rate.   The first authentic description of this procedure as an approach to CP angle was from the work of RH Parry 1904. He used this approach to section the vestibular nerve as a treatment for intractable giddiness. William House popularized this approach by routinely performing it to decompress internal auditory canal for cochlear otosclerosis. It was House who first used this approach to perform removal of acoustic neuroma in 1961.

Indications:

This surgical approach can be used for a variety of indications which include:

1. Resurfacing technique for superior semicircular canal dehiscence syndrome. Middle cranial fossa approach for managing this condition was first described by Minor et al. A 4x4 cm craniotomy is drilled. The temporal lobe is retracted to enable the arcuate eminence to be identified. At this point the superior semicircular canal dehiscence may clearly be visualized. The canal is opened using diamond drill and then it is plugged. The canal may additionally be capped / resurfaced using bone pate, bone wax or hydroxyapatite cement. Some surgeons prefer to use soft tissue for the purpose of resurfacing the superior canal.

   This approach provides direct access to the arcuate eminence without the need for removing labyrinthine bone and exposure of the surrounding skull base area.

Resurfacing of the dehiscent canal also prevents chronic stimulation from the pulsating temporal lobe of brain.

2. Internal auditory canal decompression for:
Skull base dysplasias (hyperostosis cranialis interna with encroachment of the internal auditory canal due to hyperostosis causing function loss of facial or vestibulocochlear nerves.

Facial nerve schwannomas

3. Supralabyrinthine cholesteatomas
4. Meningoencephalocele
5. CSF leak repair either during primary surgery or in the case of failed Transmastoid surgery either intradural or extradural.
6. Cholesterol granulomas / congenital cholesteatoma of petrous apex
7. Removal of a wide number of neurosurgical lesions
8. Small tumors (>15mm) primarily located in the internal auditory canal with serviceable hearing (class a or b).

Preoperative evaluation:

1. Puretone audiogram and speech audiogram. This helps in ascertaining whether the patient has serviceable hearing or not.
2. HR CT scan. This is performed for diagnostic purposes as in the case of bone dysplasias and superior canal dehiscence syndrome.
3. MRI scan with gadolinium if neuronitis / edema which is specific for evaluation of facial nerve. When gadolinium contrast is used, then normal facial nerve enhances faintly in the geniculate ganglion area, tympanic and mastoid segments. The cisternal, intracanalicular, labyrinthine and parotid segments of the nerve do not normally enhance. Enhancement of the nerve in these regions should cause suspicion of inflammatory / neoplastic process involving the nerve. Asymmetric enhancement / thickening of the tympanic / mastoid segments relative to the contralateral side should be considered as abnormal. In Bell's palsy, MRI with gadolinium contrast demonstrates enhancement of the intracanalicular and labyrinthine segments of the facial nerve. There is also greater degree of enhancement of the geniculate ganglion, tympanic and mastoid segments.
4. Diffusion weighted MRI scan in patients with supralabyrinthal / congenital apex cholesteatomas.
5. Sequential brainstem-evoked auditory potentials can be used to detect subclinical auditory nerve damage
6. Vestibular function testing

Anesthetic considerations:

General anesthesia is preferred with orotracheal intubation. Short acting nondepolarizing muscle relaxant should be used to facilitate nerve monitoring equipment usage.

Arterial line should be started to monitor real time blood pressure.

Patient should be catheterized in order to accurately maintain fluid balance.

Perioperative antibiotics need to be administered (cefazoline / amoxycillin/clavulanic acid) and they should be continued for 1 week postoperatively.

Hydrocortisone administration intravenously is advisable in the event of intraoperative nerve manipulation.

Procedure:

The hair over the temporal region is shaven and the surgical field is sterilized.

The head is fixed in a skull clamp. Patient is positioned with 3-point body straps in order to allow easy rolling of the bed of the patient during surgery to improve exposure.

Electrodes are placed to monitor facial nerve and auditory brain stem response is also recorded by placement of electrodes in real time. To monitor facial nerve electrodes are placed over orbicularis oculi and orbicularis oris. The ground electrode is placed on the chest. ABR click generator is placed over the operative side ear canal. The ABR electrodes are placed one on each mastoid and one over the vertex.

Incision:

Two incisions can be used.

1. Anterior/inferiorly based skin flap. This incision starts anterior to tragus, extending posteriorly to about 3-4 cms posterior to pinna, superiorly 5-6 cm, and anteriorly again to the temporal hair line. This incision is good for extended middle cranial fossa approaches. The temporalis muscle is reflected inferiorly.
2. Posteriorly based skin flap. This incision starts just behind the temporal hair line and a rounded box shape approximately 6 cm wide is carried back to approximately 6-7

cms. The incision is begun as low onto the pinna as possible. Temporalis muscle flap is reflected anteriorly.

Illustration showing the incision commonly used

The temporoparietal facial layer is attached to the scalp during skin flap elevation. A large piece of temporalis fascia is harvested prior to elevation of the muscle flap, leaving behind a cuff of fascia on either side of the muscle flap. This tissue will be of immense help during wound closure.

Image showing flap being elevated exposing temporalis fascia

Elevation of muscle flap:

If the skin flap is posteriorly based then anteriorly based temporalis flap is elevated. If the skin flap is anterior based then temporalis flap should be inferior based. The surgeon should be able to see the root of zygoma easily after elevation of muscle flap.

Craniotomy:

Before proceeding on to craniotomy the anesthesiologist needs to administer 0.4 g /kg of mannitol. The patient is hyperventilated till the end tidal carbon dioxide of 30 is reached. The craniotomy is centered on the root of zygoma.
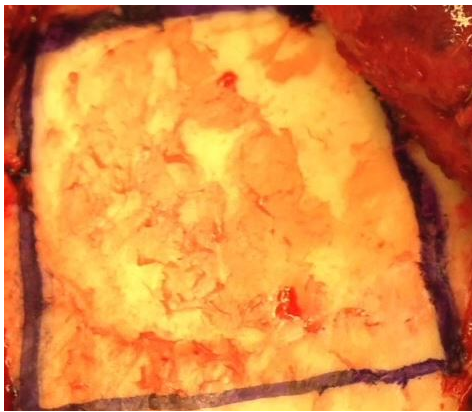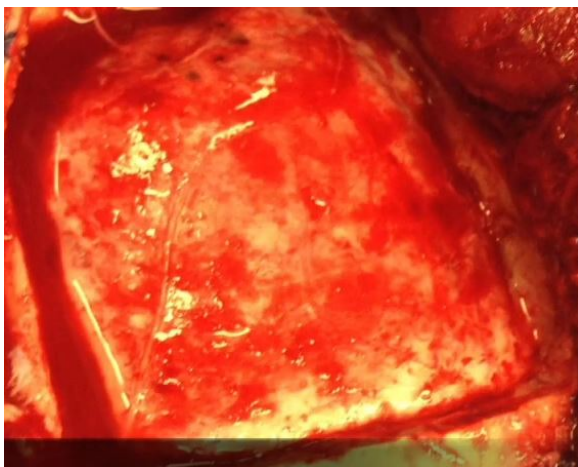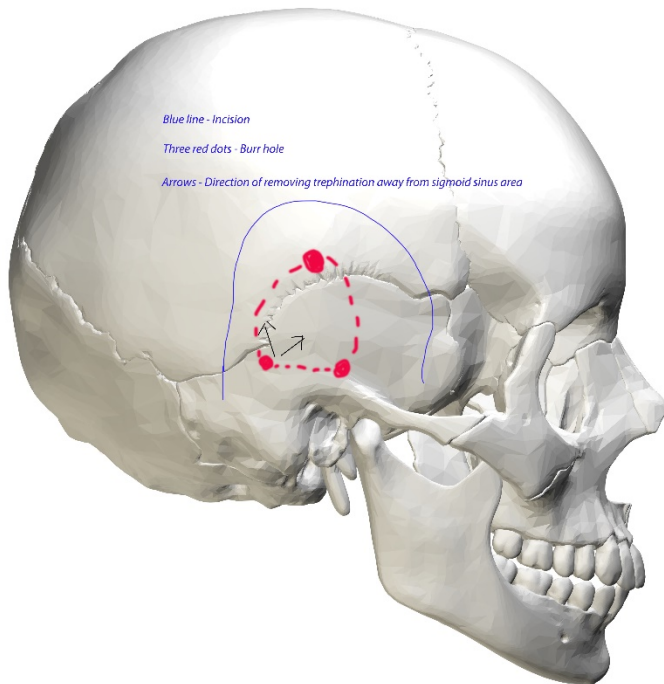

Image showing craniotomy site marked

Image showing bone flap being elevated

Bone flap of 4.5 X 4.5 cm is marked and 4 mm cutting burr is used to remove majority of the bone. A 4 mm diamond burr is used to remove the final layer of bone over the dura. Branches of middle meningeal artery will be encountered, and the same needs to be controlled using cautery or bone wax. The bone flap is elevated off the dura with the use of Joker elevator. The bone flap should be kept moist by placing a wet gauze over it. Now is the time to check the exposure. If the bone window is not flush with the tegmen, then the excess bone is removed using a drill.

Blue line - Incision

Three red dots - Burr hole

Arrows - Direction of removing trephination away from sigmoid sinus area

Elevation of Dura:

Dura is circumferentially elevated from the overlying cranium. Bipolar cautery is liberally used during this procedure to stop bleeding from the dura. Oxygel cigars are placed under the bone flap anteriorly, posteriorly and superiorly. Ideally dura is elevated along the floor of middle cranial fossa from posterior to anterior so that the greater superficial nerve is protected. During this stage the arcuate eminence, greater superficial petrosal nerve and petrous ridge are identified.

Cottonoids are placed anteriorly and posteriorly during dural elevation. Brisk bleeding from the middle meningeal artery at the level of foramen spinosum may be encountered. This can be controlled by the use of bone wax or oxycel packing.

House urban retractor is placed under the lip of petrous ridge at the anticipated location of the internal acoustic meatus.
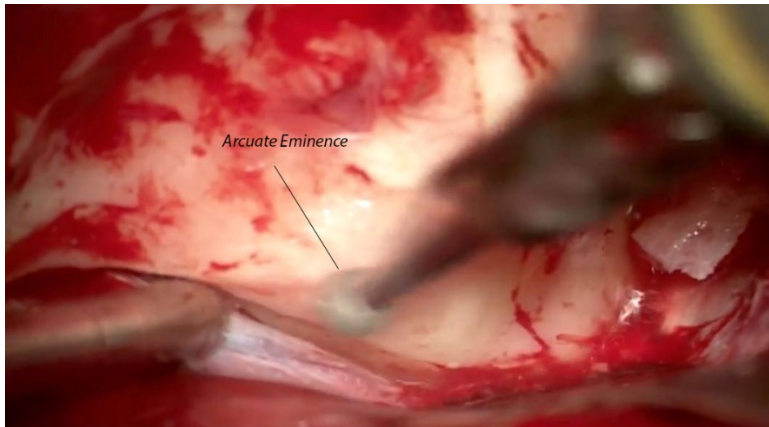
Image showing arcuate eminence

Identification of arcuate eminence is vital as it indicates the approximate level of the superior semicircular canal which invariably lies underneath. Greater superficial petrosal nerve should also be identified before proceeding any further. The internal acoustic meatus is known to bisect the angle formed by these two landmarks.
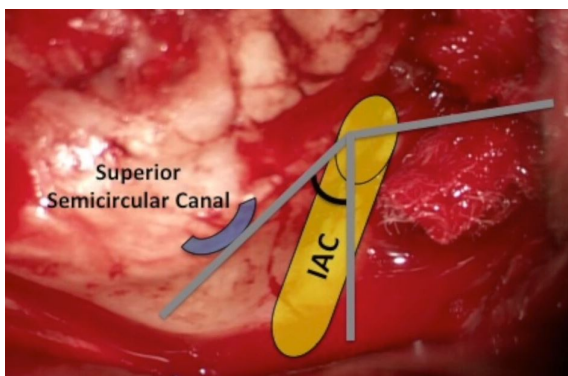

Figure showing the approximate position of internal acoustic meatus

Drilling is begun using a 4-0 diamond burr over the arcuate eminence. The superior semicircular canal will lie perpendicular to the petrous ridge. The superior canal is blue lined. The internal auditory canal would be located at 60° anterior to the blue lined superior semicircular canal. The meatal plane over the internal auditory canal is lowered down to the level of posterior fossa dura. The superior semicircular canal forms the posterior limit of dissection.

The bone over the internal acoustic meatus is drilled till it becomes paper thin. The thinned-out bone can be removed using a 90° pick. The skeletonization of internal auditory canal should be continued up to the level of Bill's bar. The labyrinthine segment of the facial nerve is identified at the transverse crest. The cochlea lies deeper than the plane of the labyrinthine segment of the facial nerve. If the surgeon does not drill deep to the facial nerve anteriorly then cochlea will not be violated. Auditory brain stem potentials should be continuously monitored by an audiologist at this stage.
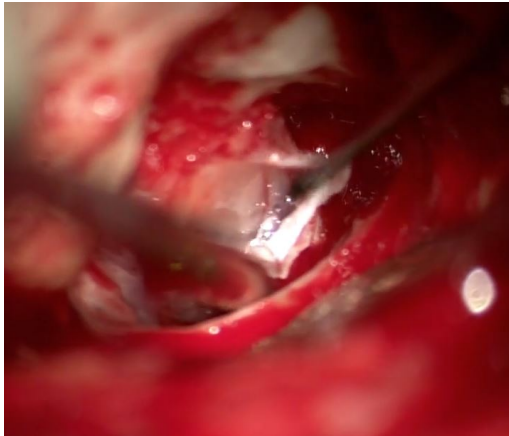
Image showing dura over the internal auditory canal excised

Dura over the internal auditory canal over the superior vestibular nerve is excised exposing the contents. A direct auditory nerve electrode is placed between the dura of the internal acoustic meatus and the cochlear nerve for monitoring the cochlear action potential in real time.

The separation between the facial nerve and superior vestibular nerve is identified at the level of transverse crest. The facial nerve is separated from the superior and inferior vestibular nerves at this location.

Tumor occupying the internal acoustic meatus can be addressed. In case of larger tumors then it is necessary to debulk the tumor before establishing a plane between the facial nerve and the tumor. If real time monitoring of ABR reveals increased latency or reduction in the amplitude of the recorded waves, the act of tumor dissection is paused for several minutes.

Closure:

Before closure hemostasis should be ensured at the internal auditory canal and cerebello pontine angle. Facial nerve should be documented by stimulation. ABR should reveal that hearing is intact after the surgery.
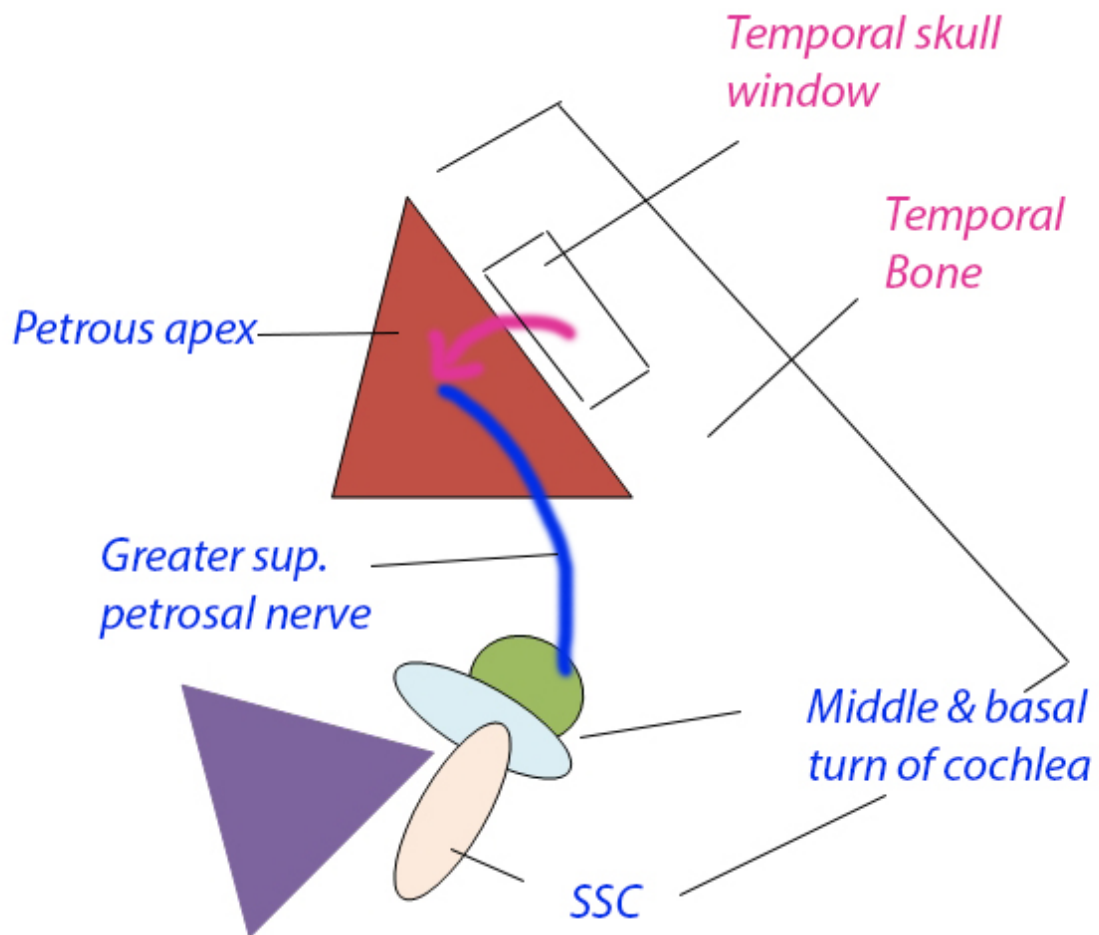
Now is the time to repair temporal bone defect. Bone wax is applied to all open air cells. A large temporalis muscle plug or abdominal fat is used to close the temporal bone defect. The inner table of the bone flap is placed over the defect to prevent temporal lobe herniation into the middle ear cavity. Tissue glue is used to further strengthen the seal.

Closure of craniotomy:

The House urban retractor is removed to allow the temporal lobe to re expand. Bone flap is replaced and secured. Wound is closed in layers.

Middle cranial fossa view

Temporal skull window

Temporal Bone

Petrous apex

Greater sup. petrosal nerve

Middle & basal turn of cochlea

SSC

Diagrammatic representation of structures visualized during middle crania fossa approach

Complications:

General:

1. Facial nerve palsy
2. Vestibulocochlear nerve damage
3. CSF leak

4. Intracranial extradural / intradural bleeding
5. Meningitis