Dural Opening/Removal for Combined Petrosal Approach: Technical Note

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ABSTRACT

Detailed descriptions of stepwise dural opening/removal for combined petrosal approach are presented. Following maximum bone work, the first dural incision was made along the undersurface of the temporal lobe parallel to the superior petrosal sinus. Posterior extension of the dural incision was made in a curved fashion, keeping away from the transverse-sigmoid junction and taking care to preserve the vein of Labbé. A second incision was made perpendicular to the first incision. After sectioning the superior petrosal sinus around the porus trigeminus, the incision was extended toward the posterior fossa dura in the middle fossa region. The tentorium was incised toward the incisura at a point just posterior to the entrance of the trochlear nerve. A third incision was made longitudinally between the superior petrosal sinus and the jugular bulb. A final incision was initiated perpendicular to the third incision in the presigmoid region and extended parallel to the superior petrosal sinus connecting the second incision. The dural complex consisting of the temporal lobe dura, the posterior fossa dura, and the freed tentorium could then be removed. In addition to extensive bone resection, our strategic cranial base dural opening/removal can yield true advantages for the combined petrosal approach.

KEYWORDS: Combined petrosal approach, dural opening, petroclival lesion, skull base surgery

The basic concept of the combined petrosal approach was first introduced by Hakuba et al, who combined the preauricular and postauricular transpetrous routes in 1988.¹ The combined petrosal approach provides better access to the petroclival region with distinct advantages over the conventional approach. Several expert skull base surgeons have employed this approach for petroclival meningiomas and have significantly improved the surgical results of resection of this formidable lesion.^{2–8} Even if the surgical strategy for petroclival meningiomas is controversial, it is essential to visualize the petroclival lesion and the important neural

and vascular structures during the combined petrosal approach. The petrous temporal bone is an obstacle on the approach to the petroclival region. Therefore, several modifications regarding resection of the petrous bone were developed, each with its own advantages and disadvantages.^{9–13} In contrast, little attention has been paid to surgical techniques for opening the cranial base dura and tentorium for this approach.⁸ In this article, we present detail descriptions of stepwise dural opening/removal for the combined petrosal approach. The combined petrosal approach was defined as a combination of the anterior petrosal approach (extended middle fossa

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approach) and the posterior petrosal approach (retrolabyrinthine presigmoidal transtentorial approach).¹⁴

STEPWISE DURAL OPENING/REMOVAL

Before opening/removal of the cranial base dura and tentorium, the following procedures needed to be accomplished. The outer layer of the lateral wall of the cavernous sinus was peeled off, and the third branch of the trigeminal nerve and the porus trigeminus were exposed. The posterior fossa dura was exposed down to the level of the inferior petrosal sinus by removal of the bone of Kawase's triangle.¹⁵ Maximum drilling of the cortical bone of the cochlea was performed while preserving hearing. The internal auditory canal was partially opened. A mastoidectomy was performed, exposing the presigmoid dura and keeping the bone labyrinth and the fallopian canal intact. The sigmoid sinus was skeletonized down to the level of the jugular bulb. Temporo-occipital craniotomy was performed to expose the temporal lobe dura and the transverse-sigmoid sinus junction (Fig. 1).

Step 1: Dural Opening in the Middle Fossa Region

The first dural incision was made along the undersurface of the temporal lobe parallel to the superior petrosal sinus

Figure 1 Diagram of complete bone work for combined petrosal approach. Exposure of the following anatomic landmarks is desired: (1) the third branch of the trigeminal nerve and the porus trigeminus; (2) the superior and inferior petrosal sinuses and the posterior fossa dura; (3) the cochlea, the internal auditory canal, and the bone labyrinth; and (4) the presigmoid dura and skeletonized sigmoid sinus and the jugular bulb. Co, cochlea; IC, internal carotid artery; IPS, inferior petrosal sinus; JB, jugular bulb; LSC, lateral semicircular canal; PSC, posterior semicircular canal; SPS, superior petrosal sinus; SS, sigmoid sinus; SSC, superior semicircular canal; V2, second branch of the trigeminal nerve; V3, third branch of the trigeminal nerve.

(Fig. 2). The veins of Labbé usually terminate in the transverse sinus area more than 1 cm posterior to the sinodural point, at which the superior petrosal sinus drains into the transverse sinus.¹⁶ Sometimes it courses onto the temporal lobe dura like a dural sinus. Therefore, posterior extension of the dural incision was made in a curved fashion, keeping away from the transverse-sigmoid junction and taking care not to injure the vein of Labbé. The dural incision was extended anteriorly beyond the level of the foramen ovale. A sufficiently long dural incision in the temporal base results in favorable retraction of the temporal lobe. A second incision was made perpendicular to the first incision. The superior petrosal sinus was clipped with titanium clips or ligated with stitches and sectioned around the porus trigeminus. In cases other than the petroclival meningioma, incision of the posterior fossa dura and aspiration of the cerebrospinal fluid prior to sinus sectioning are recommended procedures. The trigeminal root lies just under the superior petrosal sinus, and it can be injured if one is not aware of its anatomic proximity. The dural incision of the posterior fossa dura was extended down to the level of the inferior petrosal sinus. Attention was paid to preserve the sixth cranial nerve. The cisternal portion of the sixth cranial nerve adjacent to the Dorello's canal was located just beneath the incision line of the posterior fossa dura. In cases of petroclival meningiomas, vast bleeding may be encountered while cutting the posterior fossa dura because the lesion usually emanates at or medial to the Meckel's cave. Meticulous hemostasis at this region results in early devascularization of the tumor. After getting brain slack with lumbar drainage of cerebrospinal fluid, the head position was moved slightly downward. The temporal lobe was gently retracted and the tentorium

Figure 2 The first and second dural incisions in the middle fossa region are demonstrated. Attention should be paid to preserve the sixth cranial nerve located just beneath the incision line of the posterior fossa dura. The tentorium was incised toward the incisura at a point just posterior to the entrance of the trochlear nerve. IV, trochlear nerve; VI, abducens nerve; T, tentorium; TL, temporal lobe; VL, vein of Labbé.

was incised toward the incisura at a point just posterior to the entrance of the trochlear nerve. Large petroclival meningiomas frequently encase the trochlear nerve and conceal its location. Tracing the tentorial incisura in the anterior-to-posterior direction followed by identification of the oculomotor nerve, which is rarely involved by the tumor, is a practical method for location of the exact entrance point of the trochlear nerve to the tentorium. The dura over the gasserian ganglion was also incised to open the Meckel's cave, which is often invaded by the tumor.

Step 2: Dural Opening in the Presigmoid Region

The posterior fossa dura in the presigmoid region was incised longitudinally between the superior petrosal sinus and the jugular bulb as a third incision (Fig. 3). The dural incision was extended inferiorly toward the sigmoid-jugular bulb junction. The temporal lobe was gently retracted, and the superior petrosal sinus was clipped or ligated and transected, with careful inspection of the venous drainage pattern of the temporal lobe. The temporal bridging veins other than the vein of Labbé may also play an important role in venous drainage from the temporal lobe in some cases.¹⁶ Extensive drilling of the petrous bone may create a working space for tentorium section in front of the tentorial bridging vein. The incision was continued on the tentorium, parallel to the pyramid, and extended through the incisura at a point 1 cm posterior to its junction with the trochlear nerve. The surgeon must make every effort to preserve the trochlear nerve during this procedure.

Step 3: Removal of the Dural Complex

The fourth dural incision was initiated perpendicular to the third incision in the presigmoid region and extended

Figure 3 The third dural incision was made in the presigmoid region. Prior to the superior petrosal sinus and the tentorium sectioning, the venous drainage pattern of the temporal lobe was carefully inspected. BV, temporal bridging vein; SPS, superior petrosal sinus; V, trigeminal nerve.

Figure 4 After removing the dural complex, the entire length of the trigeminal nerve was located in the center of the surgical field. The lateral surface of the pons can be easily accessed within a short distance and the basilar trunk and its branches were clearly visualized. AICA, anterior inferior cerebellar artery; BT, basilar trunk; SCA, superior cerebellar artery; V, trigeminal nerve.

parallel to the superior petrosal sinus connecting the second incision (Fig. 4). Complete skeletonization of the cochlear, the internal auditory meatus, and the superior semicircular canal was required to make this incision. The incision should be made close to the superior petrosal sinus especially around the porus acusticus to avoid injury of the VIIth and VIIIth cranial nerve complex. Removal of the dural complex consisting of the temporal lobe dura, posterior fossa dura, and the freed tentorium can now be accomplished. Previous articles and books have never mentioned this concept of en bloc removal of the dural complex including the supra and infratentorial dura. After completion of this procedure, the third through eighth cranial nerves were clearly visualized, and the lateral surface of the pons was easily accessible.

Step 4: Dural Closure

The fascia lata and the remnant of the dura mater were approximated together and held in everted position (Figs. 5A, B). The AnastoClip Vessel Closure System (VCS; LeMaitre Vascular, Boston, MA) was then applied over the everted tissues, which was followed by application of polyglycolic acid nonwoven fabric (Neoveil, Gunze, Kyoto, Japan) or absorbable gelatin sponges (Gelfoam, Pharmacia and Upjohn, Kalamazoo, MI) with fibrin glue to reinforce the sealing effect. The VCS is an automatic suture device originally developed for microsurgical vascular anastomosis.^{17,18} The disposable clip applicator contains 25 to 40 (varied with clip size) preloaded nonpenetrating titanium clips. By squeezing the grip together, preloaded arcuated-legged titanium clips are closed and delivered one after another during repetitive firing. The Neoveil is an absorbable and

Figure 5 (A) The AnastoClip Vessel Closure System (VCS) was approved for dural reconstruction by the Food and Drug Administration. There are four sizes available (small, medium, large, extra-large) and large or extra-large clips are permitted for dural closure. (B) The dural defect was repaired by VCS clips and the fascia lata. Clips, VCS clips; FL, fascia lata; SS, sigmoid sinus; SSC, superior semicircular canal; TD, temporal dura.

biocompatible material, which is converted into recipients' own connective tissue in approximately 2 months.¹⁹ The dead space of the mastoid was packed with free abdominal fat graft, and cerebrospinal fluid drainage was placed for 48 to 72 hours postoperatively.

DISCUSSION

Despite a better understanding of the microsurgical anatomy and great advances in operative technique, the combined petrosal approach takes a long time.⁶ Despite increasing the duration of the surgery, this approach

provides the following advantages: (1) the cerebellum and temporal lobes are minimally retracted; (2) the surgeon has a direct line of sight to the petroclival region and lateral aspect of the brain stem; and (3) multiple axes for dissection are provided. In cases with petroclival meningiomas, devascularization of the tumor can be achieved before opening the dura.²⁰ Although many articles and books by expert cranial base surgeons emphasize that extensive bone removal mainly contributes these advantages mentioned above, we know dural opening/removal commensurate with extensive bone removal is a crucial procedure to bring a wide surgical corridor.

The fundamental concept of the combined petrosal approach is to unite the supra- and infratentorial surgical field. To actualize this concept, the tentorium always becomes an obstacle. We describe a detailed surgical technique of dural opening/removal for this approach, and the most important procedure is removal of the tentorium. The fourth dural incision connecting the third and the second incisions is critical for tentorial removal. Without maximum removal of the petrous bone, this dural incision cannot be achieved. The freed dural complex including the tentorium can be mobilized in the anterior-to-posterior direction and removed while avoiding injury of the fourth cranial nerve. During this procedure, the surgeon must keep in mind that the arachnoid membrane and the trochlear nerve in the ambient cistern are sometimes adherent the tentorial incisura.

After removal of the dural complex, the entire trigeminal nerve and lateral surface of the pons can be observed in the center of the surgical field. Our strategic cranial base dural opening/removal can yield "true" advantages of the combined petrosal approach.

CONCLUSION

Following maximum bone resection of the petrous bone, en bloc removal of the dural complex consisting of the temporal lobe dura, the posterior fossa dura, and the freed tentorium was performed. This procedure can yield true advantages, a short and wide surgical avenue to the petroclival lesion with minimal brain retraction, of the combined petrosal approach.

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