Preservation of the superior petrosal sinus during the petrosal approach

Technical note

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Object. The petrosal approach is based on sectioning the superior petrosal sinus (SPS) and the tentorium. However, the venous anatomy in certain situations forbids this maneuver. The authors have derived a technique that enables the SPS to be spared during the performance of the petrosal approach. They describe the anatomical basis of this technique and report on 2 cases in which the technique was applied.

Methods. Five alcohol-preserved cadaveric heads injected with colored silicone were used for bilateral dissection and demonstration of the technique. The described method was thoroughly investigated in these cadavers to assess its advantages, variabilities, and limitations. Subsequently, the technique was applied during the resection of petroclival tumors in 2 patients.

Results. The authors were able to demonstrate that the approach provides good access to the petroclival area through both the middle and posterior fossa in cadavers. By deriving a new technique of applying the combined petrosal approach without cutting the SPS, the senior author (O.A.M.) managed to achieve total resection of a dumbbell-shaped trigeminal schwannoma in a 19-year-old woman and of a petroclival meningioma in a 49-year-old man.

Conclusions. This modification of the petrosal approach involving sparing of the SPS or cutting of the tentorium is an effective means for cases in which the venous anatomy mandates preservation of these structures.

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KEY WORDS • petrosal approach • superior petrosal sinus • adjusted approach • infratentorial approach

The petrosal approach has been developed for access to the petroclival area. The venous anatomy and its variations remain some of the most crucial factors in the safe application of this approach. In certain situations, the anatomy of the venous system may not permit safe ligation of the SPS or sectioning of the tentorium. We have derived a method in which the aim is to preserve the SPS while maintaining adequate exposure of important structures in the middle and posterior fossa.

Methods

Anatomical Study

Five alcohol-preserved cadaveric heads injected with colored silicone were prepared for bilateral dissection. The specimens were fixed in alcohol, cranial arteries were injected with red latex rubber, and veins were injected with blue latex rubber. Each head was placed in a 3-point fixation device during the dissection. The head was turned to the opposite side, with the mastoid as the highest point. The initial portion of a combined petrosal approach, as described by Cho and Al-Mefty, was then performed. After raising the bone flap, a total mastoidectomy and the skeletonization of the sigmoid sinus to the jugular bulb were performed with the aid of the operating microscope to expose the sinodural angle and the presigmoid dura mater. Subsequently, the dura mater of the middle fossa was dissected from the temporal base. The middle meningeal artery was identified and transected at the foramen spinosum. The greater superficial petrosal nerve was dissected sharply. The carotid artery canal was then visualized and secured. An extradural dissection of the outer layer of the lateral wall of the cavernous sinus over the third division of the trigeminal nerve was then performed. Drilling of the lateral and anterior edges of the foramen ovale aided in providing more working space underneath the trigeminal ganglion.
Superior petrosal sinus preservation

The petrous apex, bounded by the trigeminal impression anteriorly, the arcuate eminence posteriorly, the greater petrosal groove laterally, and the carotid artery canal inferiorly, was then drilled as described in the anterior petrosal approach by Kawase et al.10 We then directed our attention to the presigmoid area, where the dura mater was dissected up to the petrous ridge. We proceeded to dissect the dural lamina from the SPS from the medial wall of the petrous bone. The SPS was then freed from its groove at the petrous ridge, and was skeletonized by fine drilling of the petrous ridge. This drilling maneuver could be continued along the medial wall of the petrous bone, enabling us to reach anteriorly up to the suprameatal area (the area located above and anterior to the internal auditory meatus). Posteriorly in the presigmoid area, the endolymphatic sac was exposed and secured after dural dissection was completed. Anteriorly, the dura overlying the Meckel cave had a thickened appearance due to the presence of the tentorial edge, which contains the SPS (see Fig. 1).

The dura mater was then opened in the presigmoid area and extended under the SPS, all the way to the Meckel cave. Then, the tentorium under the SPS was separated from the Meckel cave and lifted upward. This maneuver enables the surgeon to connect the middle fossa to the posterior fossa, under the tentorium, while partially transecting the tentorium and preserving the SPS (see Fig. 2).

Results

Illustrative Cases

Case 1. This 19-year-old woman presented with headache and a right-sided cranial nerve V deficit. An MR imaging study of her brain showed a heterogeneously enhancing mass in the right cerebellopontine angle extending to both the middle and posterior cranial fossa and into the Meckel cave region (Fig. 3A). An MR venogram revealed a hypoplastic right transverse sinus with a prominent SPS on the right side (Fig. 3B). It also revealed a prominent vein of Labbé that emptied at the distal tip of the SPS. Two months after diagnosis, a combined petrosal approach was planned, but with an important modification, which included preserving the SPS and the tentorium. Initially, an anterior petrosal approach was performed, followed by a presigmoid approach (retrolabyrinthine). The dura mater was carefully dissected from the petrosal bone, up to the petrous apex. After fine drilling of the bone underneath it, the SPS was then released from the petrous ridge. At this point, dissection could proceed underneath the sinus and therefore under the tentorium. Subsequently, the dura of the posterior fossa (presigmoid) was opened. This opening was carried along the SPS laterally, heading toward the Meckel cave. This enabled us to connect the openings between the posterior and middle fossa, while staying under the tentorium. Drilling of the suprameatal petrous bone provided good access to the Meckel cave and the middle fossa. We were able to achieve a total resection of the tumor while remaining under the tentorium. The patient had an uneventful postoperative course, with full recovery. A postoperative MR imaging study demonstrated total resection of the lesion (Fig. 3C; see Fig. 4 for intraoperative detail).
**Case 2.** This 49-year-old man presented with headaches, balance problems, and a left-sided trigeminal nerve deficit. An MR imaging study was obtained and revealed an extraaxial tumor in the petroclival area, with some compression of the brainstem on the right side (Fig. 5A). On an MR venography study, codominant transverse sinuses, with the vein of Labbé identified bilaterally entering the distal transverse sinuses, were seen (Fig. 5B). Four months after diagnosis, a combined petrosal approach was planned in this case as well, with the goal of achieving total resection. After initial exposure was completed, we skeletonized the sigmoid sinus down to the jugular bulb, and then proceeded to dissect the SPS off of the underlying petrous ridge, while preserving the sinus intact as well as all surrounding venous structures. The dura mater was opened in the presigmoid area up to the level of the tentorium. The dura was also opened along the middle fossa, again up to the tentorial insertion. These 2 openings were not completely connected, to preserve the continuity of the SPS. The tumor was then resected using standard microsurgical techniques. A total resection of the tumor was achieved (Fig. 5C). The patient had an uneventful postoperative course, with full recovery.

**Discussion**

**Venous Anatomical Challenges**

Familiarity with the anatomy of the bridging veins can minimize their intraoperative sacrifice and avoid subsequent postoperative complications.4,14,15 The technical difficulty in handling the tentorium and the temporal lobe depends on the venous drainage pattern of the temporal lobe.14 In rare cases the vein of Labbé drains directly into the SPS. In addition, in nearly one-third of cases there are bridging veins emptying directly into the SPS. This group of veins is referred to as the petrosal group of temporal bridging veins.7,14 On the other hand, there are many bridging veins on the basal surface of the temporal lobe that adhere to the dura mater covering the middle fossa or the tentorial surface before joining the venous sinuses.14 In such situations it is wise to preserve the SPS, to keep the tento-
Another important anatomical variant in this area is the so-called sphenopetrosal sinus. In this variation, the superficial sylvian vein merges into the middle fossa dura, forming a dural sinus along the middle fossa floor. This sphenopetrosal sinus drains into the SPS or the lateral sinus. Sectioning of the tentorium in a patient with a dominant sphenopetrosal sinus may disturb the venous drainage in the region of the sylvian fissure. In such cases the surgeon may be forced to abandon the petrosal approach or to find an alternative way to circumvent this structure.

In a variety of petrosal approaches (anterior, posterior, combined), to mobilize the sigmoid sinus the tentorium and the SPS must be cut. There are several techniques available to maneuver around the venous structures to preserve them. However, when the venous anatomy is totally forbidding, then the approach described here applies. An alternative is to perform the operation in 2 stages, using (at different settings) a supratentorial and an infratentorial approach. When the petrosal approach is applied and in cases in which the SPS cannot be safely sacrificed (as in the cases described above), a modification of the petrosal approach is possible in which this sinus is preserved. In this modified approach, the tentorium is kept intact and dissection is performed underneath it (Fig. 1). In some cases, the tentorium can be divided at a more anterior point, sparing the drainage of the vein of Labbé. This vein may be seen to drain into the SPS, and runs along the tentorium before emptying into the sigmoid sinus.

**Advantages and Limitations of This Approach**

This technique does not add any significant extra difficulty for the neurosurgeon when compared with standard petrosal approaches. One advantage of this technique is the potential decrease in the risk of postoperative venous complication. Postoperative complications such as rupturing of the bridging veins, which may result in a venous infarction or hemorrhage, may then potentially be circumvented. Finally, avoiding a cut at the medial edge of the tentorium while mobilizing it has a greater likelihood of preserving the trochlear nerve secured.

Limitations of this approach include the narrow working space under the tentorium along the posterior trajectory. As in the traditional petrosal approach, a high position for the jugular bulb can narrow the posterior working space. Manipulation of the sinus can cause more venous complications such as laceration, both intra- and postoperatively.

Further working space can be achieved in the lateral window, especially if the tentorium is tacked up under the SPS medially, outside the dura mater (see Fig. 2). The petrosal (Dandy) vein can be mobilized up with the SPS, and can be safely preserved and secured.

**Conclusions**

By combining the anterior petrosal and the presigmoid approaches while “sneaking” under the SPS, the senior author managed to obtain adequate access to the petroclival area without cutting this sinus. We believe that this modification of the petrosal approach can be safely applied by the experienced neurosurgeon, especially when facing a situation where the traditional petrosal approach cannot be used due to the venous anatomical diversion.
Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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