Original Article

# An Alternative Route for Petroclival Tumors: Without Mastoidectomy and Superior Petrosal Sinus Ligation: A Cadaveric Study

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## Abstract

**Objective:** Retrosigmoid approach and presigmoid approach and its derivatives including retrolabyrinthine, translabyrinthine, and transpetrosal approaches have long been used for reaching posterior and middle cranial fossa. In neurosurgery perspective, many types of tumors arise extradurally and surgical resection of these tumors is still challenging. We aimed to describe a modified way to approach posterior and middle fossa to contribute to the surgical management of petroclival tumors with posterior extension. **Methods:** Modified sigmoid approaches were performed bilaterally in 5 fresh adult cadaver heads. **Results:** In this approach, it was possible to reach the middle and posterior fossa with a single craniotomy. Temporal dura matter was dissected from the temporal bone with extradural gentle dissection. In addition, sigmoid sinus and superior petrosal sinus (SPS) were dissected off from the petrous bone meticulously. Subsequently, the posterolateral superior arcuate petrosectomy was performed with high-speed surgical drill extradurally by protecting the semicircular canal, labyrinthine channel, and cochlea. Dura matter was elevated for 1.5 cm with retractor above the mastoid bone. Dura was opened from an alternative area of Trautmann's triangle. After having exposed and opened the dura, posterior fossa was reached at the level of 7.−8. cranial nerves. **Conclusion:** We described an alternative route which seems to be a feasible way to reach posterior and middle fossa without mastoidectomy and SPS ligation. Notably, this technique can be applicable to petroclival tumor surgery after more anatomic studies with cadaveric specimens.

**Keywords:** *Extradural sigmoid approach, petroclival tumors, without mastoidectomy, without superior petrosal sinus ligation*

## Introduction

In neurosurgical practice, petroclival region is quite challenging in terms of microneurosurgical technique. Petroclival tumors usually extend into both the middle and posterior fossa and thereby they pose a significant challenge to the neurosurgeons.[1] Their large size at presentation and proximity to the critical neurovascular structures further complicate the surgical management. The surgical corridor in common use is very deep and narrow, thus rendering current approaches spatially being limited. There are variety of skull base approaches including middle fossa (Kawase and extended middle fossa), retrosigmoid, retrosigmoid intradural suprameatal approach, and combined subtemporal–presigmoid and transpetrosal approaches for the purpose of access to the petroclival region.[1,2]

In accordance with the requirements, classical skull base approaches could be modified or be used in combination. However, the surgeon needs to consider many factors to determine which of these approaches is appropriate for the patient. The general condition, age, current neurological deficits, normal vascular anatomy, planned treatment (palliative/radical), prediction and histopathology of lesion, compartment (s) (intradural/extradural/intra-extradural), extension (midline/lateral extension), tumor size, its relationship with neurovascular structures, experience and the preference of the surgeon are important. Although surgical approaches to this region have been applied for many years, mortality and morbidity rates were quite high. Microneurosurgical experience indicates that the most important reasons for high morbidity and mortality are the difficult and inadequate surgical access to the region, mostly because of giant size of the tumors at diagnosis and suboptimal radiologic evaluation of the relationship between tumor and neurovascular structures.[3-5]



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## Methods

In this study, 5 fresh cadaver heads were harvested. The heads were embalmed in 10% formaldehyde solution and dissected bilaterally so that a total of 10 sides were used. Vessels were not cannulated and not injected with colored latex solution.

Cadaveric heads were placed first in right then left lateral position. Heads were fixed in a headholder (Doro, QR3, USA) and entrenched in lateral decubitus position (the zygomatic arch parallel to the floor with the vertex facing the floor, and the mastoid as the highest point). Central temporo-occipital reversed U-shaped skin incision was fashioned around the ear to expose anatomical landmarks clearly. Skin incision was performed starting about 1 cm anterior to the tragus on the root of zygoma and extending posterior to expose the posterior fossa. The superficial and deep temporal fascia was opened and the temporal muscle was then dissected forward from the skull [Figure 1]. A previously described modified temporo-occipital craniotomy was performed.[6,7] For preparation of the temporo-occipital bone flap, burr holes were marked and drilled with Midas Rex Legend high-speed drill (Medtronic, USA). The first burr hole was positioned at the level of zygoma to flush with the floor of the middle fossa dura. The second burr hole was placed 3 cm above the first burr hole. The third burr hole was placed at the occipitomastoid suture 1.5 cm below the asterion, and the fourth burr hole was positioned 2 cm above asterion and above the squamous portion of the occipital bone [Figure 1]. The burr holes were connected with the high-speed drill. A sizeable (4 cm × 8 cm) temporo-occipital craniotomy flap was elevated to expose both the middle and the posterior fossa.

### Middle fossa

Middle cranial fossa dura was dissected off from the temporal base from posterior to anterior and elevated gently from middle cranial fossa. The middle meningeal artery was identified at the foramen spinosum. Mandibular nerve (V3) and maxillary nerve (V2) on the floor of middle cranial fossa were identified near the ventrolateral wall of the Meckel's cave. Dorsolateral wall of the Meckel's cave was occupied by superior petrosal sinus (SPS). From this step on, the greater superficial petrosal nerve was dissected and Kawase triangle was exposed. The drilling was limited to this triangle to expose the supratentorial ventral brain stem area.

### Posterior fossa

*Extradural dissection of sigmoid sinus, superior petrosal sinus, and posterolateral superior arcuate petrosectomy and dural opening*

Following the elevation of the craniotomy flap, the transverse sinus, sigmoid sinus (SS) junction was identified. SS was dissected gently from the groove in the mastoid bone with blunt dural dissection. SS dissection was proceeded up to its anatomical limits. After dissection of SS, squamous part of occipital bone was drilled up to the superior border of the mastoid bone. The appearance of mastoid air cells was considered as an anatomical limit. Then, SPS was dissected from SPS groove of petrous bone from lateral to medial. SPS dissection limit was the subarcuate fossa level in the groove of the petrous bone [Figure 2]. The integrity of both sinuses was preserved. The posterior fossa dura was elevated up to 1.5 cm. The posterior wall of the petrous bone was drilled extradurally with high-speed diamond drill. Drilling area; Its inferior border is the subarquat fossa, and its medial border is deep part of posterior semicircular canal. Drilling was started from the groove of SPS from superiorly and continued inferiorly (posterolateral subarcuate petrosectomy) [Figure 3]. Hence, we obtained a rhomboid shaped area. This rhomboid bone cavity was bounded by the dissected part of the SS posteriorly, the subarcuate

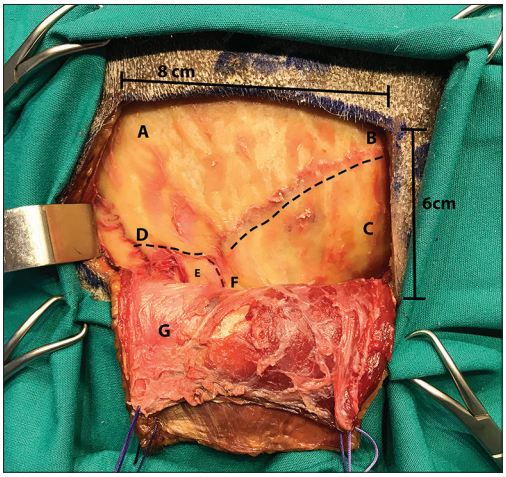


**Figure 1: Skin incision. (A) Parietal bone. (B) Squamous suture. (C) Temporal bone. (D) Parietomastoid suture. (E) Mastoid bone. (F) Mastoid part of temporal bone. (G) Temporal muscle**

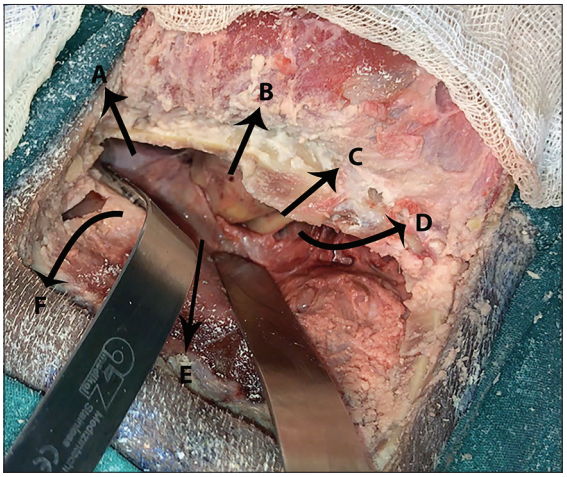


**Figure 2: Extradural approach. (A) Middle fossa. (B) Petrous bone. (C) Groove of superior petrosal sinus. (D) Posterior cranial fossa after extradural dissection. (E) Superior petrosal sinus. (F) Dura mater**

fossa inferomedially, posterior semicircular canal in petrous bone medially, and the posterior petrosectomy area superolaterally [Figures 4 and 5]. This area was greater than that obtained with the posterior intradural petrous apicectomy. Another novel modification was dural opening which was placed at the level of subarcuate fossa with a linear incision. This is an alternative dural opening to the opening in Trautmann's triangle. After dural opening, facial nerve (CN. VII) and vestibulocochlear nerve (CN. VIII) were exposed at the level of the internal acoustic canal. In addition, infratentorial brain stem and tentorium were visualized medially and superiorly, respectively.

## Discussion

The petroclival region is a critical area that harbors vital neurovascular structures and it has anatomical limitations to access. Therefore, the microsurgical resection of the lesions in this area always posed great problems until today. Fortunately, advances in neuroimaging provided better preoperative identification of these lesions and improvements in microsurgical techniques and skull base approaches resulted in more acceptable mortality and morbidity rates. However, the narrow surgical corridors to the petroclival region still stand as a challenging factor.

The suboccipital retrosigmoid approach (RS) approach was first described by Dandy in 1925 and is now widely used in neurosurgery practice. With this approach, it is possible to reach centrolateral tumors, lesions of the mid-clivus and petrous apex, and the tentorium region from the petrosal line to the adhesion angle. The advantages of this approach are it provides a physiological pathway to reach large petroclival masses infiltrating the internal acoustic meatus (IAM) and with a minimal neural tissue injury due to retraction. Minimal cerebellar retraction and a wide surgical opening could be achieved with gentle subarachnoid dissection and maximum cerebrospinal fluid (CSF) drainage. In this approach, mild–to-moderate cerebellar retraction is well tolerated. This becomes important especially in cases of severe brain stem compression due to tumoral mass. However, the main disadvantage of this route is the difficulty to remove the tumor through a narrow corridor bounded by the cranial nerves and vascular structures as well as inadequate exposure of the brain stem. The RS approach can be extended to the petrosal approach for large lesions, and the subtemporal approach can be combined with the transcochlear–translabyrinthine approach.[1,8] The advantage of these combined approaches is that they provide better visualization of the brain stem and facial nerve with minimal brain retraction in large tumors.[9]

Anterior subtemporal approach provides access to the upper and middle clivus and cavernous sinus without excessive temporal lobe retraction.[10,11] The posterior subtemporal approach may be associated with a high morbidity because of potential injury to vein of Labbé and cerebral edema because of temporal lobe retraction. However, the anterior temporal approach is particularly advantageous when combined with the transsylvian approach, and when an extensive sylvian dissection is performed, the temporal lobe retraction is

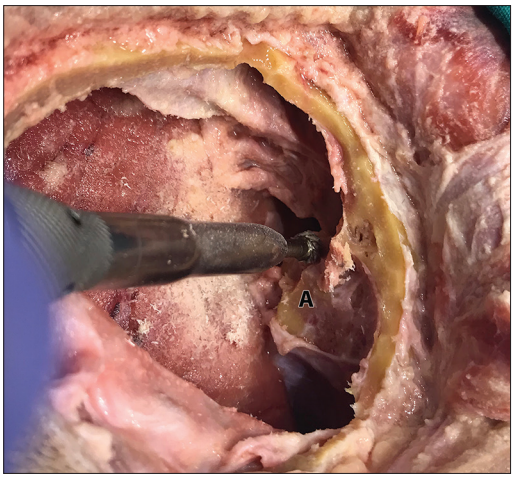


**Figure 3: (A) Posterolateral subarcuate petrosectomy (drilling process)**

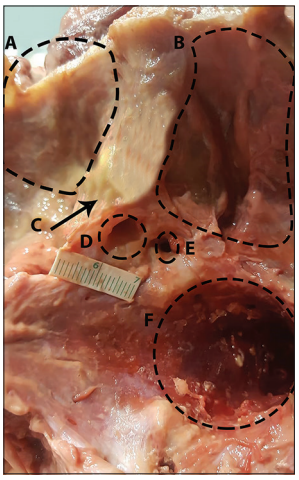


**Figure 4: After posterolateral subarcuate petrosectomy. (A) Middle fossa. (B) Posterior fossa. (C) Posterolateral subarcuate petrosectomy area. (D) Internal acoustic canal. (E) Jugular foramen. (F) Foramen magnum**

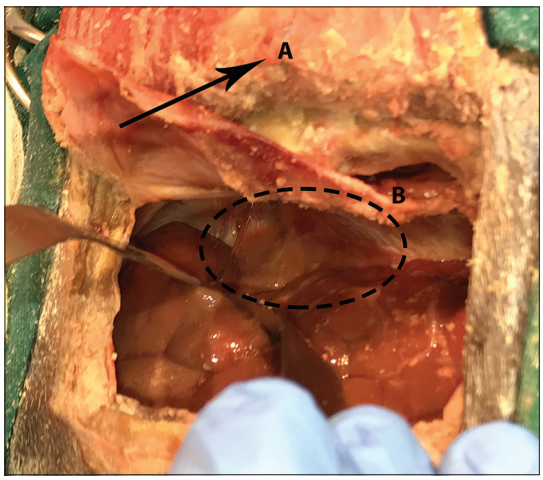


**Figure 5: Intradural view after posterolateral subarcuate petrosectomy (A) Dura mater (B) Posterolateral subarcuate petrosectomy area**

minimized compared to the subtemporal approach. With this combination, an excellent opening is provided for resection of the upper clivus and tentorial notch tumors. In selected cases, zygomatic osteotomy or orbitozygomatic ostetomy may be added to the cavernous sinus approach to provide a clival angle of view extending from the parasellar area to the basion. This approach is also suitable for opening the ipsilateral side of the upper clivus and the anterior temporal notch. Mid-clivus tentorium can be seen easily by cutting or suturing the tentorial edge toward the lateral side.[12,13]

Transpetrosal approaches offer direct access to the upper and middle clivus when combined with the other approaches as suggested by many authors. One major drawback of transpetrosal approaches is even if they provide direct access to the supratentorial and infratentorial compartment, they have a high morbidity rate. Anterior transpetrosal approach was first used by Kawase in the sphenopetroclival meningiomas adjacent to the CNVII and provided access to the middle clivus and cavernous sinus.[14] The resection of the petrosal bone in this approach increases the surgical exposure of the petroclival area by allowing the brain stem and the petroclival groove to be exposed laterally.[15] Anterior, posterior, or combined petrosal approaches can be used depending on the extension pattern of the involved tumor. While posterior petrosal approach seems more appropriate for tumors extending to the lateral side of the posterior fossa and to the posterior cavernous sinus in the Meckel's cave, the anterior petrosal approach is more suitable for the exposure of the area adjacent to the anterior cavernous sinus, and for the lesions located on the midline and contralateral area or for those localized in IAM.[16] Anterior extradural petrosal approach for Meckel cave, petroclival region, and brain stem lesions intended to be an excellent surgical way by some authors.[17,18] In patients with large tumors and hearing loss, complete petrosectomy provides the most extensive surgical exposure and it allows anterior, posterior, and lateral exposures in the petroclival area. The disadvantage of this approach is prolonged surgical time during drilling the petrous bone. Postoperative hearing loss is unavoidable in patients who undergo complete petrosectomy and this technique is only preferred in patients with complete hearing loss. There is also a risk of facial nerve injury. Petrosal approach is the most preferred approach for total mass resection, especially in large meningiomas with middle fossa and posterior fossa extension. Large petroclival meningiomas cannot be totally removed even after total petrosectomy and reoperations may be required for residual or recurrent lesions.

The most important common features of these two petrosal approaches are both are using a physiological pathway to access to the lesions, obtaining a wide surgical opening with minimal neurovascular injury, protecting the pertinent arterial and venous anatomy, and to combining with other approaches easily.

In this study, we tried to describe an alternative anatomical route to reach lesions of this region and posterior fossa. As a novel contribution, we tried an alternative route to reach to the intradural space with microdisection of the SS and the SPS extradurally. Mastoidectomy was not required in this approach. So, we could reduce the risk of CSF fistula (otorrhea) which may develop postoperatively. Also in this approach just petrous apicectomy is enough. In addition to these, hearing can be preserved. Obviously, the microdissection of the SPS and the SS from the skull base are difficult tasks and potentially fatal. However, we noticed that the dural thickness of the sinuses fixed to the skull base was thicker than those of the free dural faces. As a result, we offered a new alternative route to the Trautmann's triangle in this cadaveric study.

Advantages of this route are as follows:
1. Direct access to the CN. 7–8 complex
2. Short working distance
3. No need for mastoidectomy
4. No need for petrosal sinus ligation
5. Easy visualization of tumor portions extending to the brain stem
6. Larger surgical area
7. No hearing loss (no need for total petrosectomy) and
8. No potential risk of facial nerve injury (no need for extreme cerebellar retraction).

Disadvantage of this route are as follows:
1. Risk of damage to the sigmoid and SPS during extradural dissection
2. Risk of damage to the superior and posterior semicircular canals during drilling procedure
3. Duration of surgery may be longer (extradural dissection and drilling process may be more time consuming).

## Conclusion

Petroclival region tumors are rare in neurosurgical practice and the surgical access to the petroclival area is quite challenging in terms of microneurosurgical technique. Because of the relationship between tumor spread and skull base structures, one or more of the existing skull base approaches may be required. Petroclival region tumor surgery is still a pathology with high morbidity and mortality.

In this cadaveric study, we tried to describe a new and an alternative route for petroclival tumors with posterior fossa portion without mastoidectomy and SPS ligation. Of course, this approach has some advantages and disadvantages. We ponder to find an ideal approach for this region tumors and the main aim is to preserve more vascular and neural structure. For this new idea to become the ideal procedure, much more cadaver work is required and the advantages and disadvantages of its suitability for clinical use need to be determined. We hope this study can be a spark for a brain storming.

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Nil.

## Conflicts of interest

There are no conflicts of interest.

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