Which Routes for Petroclival Tumors? A Comparison Between the Anterior Expanded Endoscopic Endonasal Approach and Lateral or Posterior Routes

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OBJECTIVE: **Petroclival tumors remain a surgical challenge. Classically, the retrosigmoid approach (RSA) has long been used to reach such tumors, whereas the anterior petrosectomy (AP) has been proposed to avoid crossing cranial nerves. More recently, the endoscopic endonasal approach has been "expanded" (i.e., EEEA) to the petroclival region. We aimed to compare these 3 approaches to help in the surgical management of petroclival tumors.**

METHODS: **Petroclival approaches were performed on 5 specimens after they were prepared with formaldehyde colored via latex injection.**

RESULTS: **The EEEA provides a simple straightforward route to the clivus, but reaching the petrous apex requires the surgeon to circumvent the internal carotid artery either via a medial transclival, an inferior transpterygoid, or a lateral variant through the Meckel's cave. In contrast, the AP offers a narrow direct superolateral access to the petroclival region crossed by the trigeminal nerve. Finally, the RSA provides a wide simple and quick exposure of the cerebellopontine angle, but access to the petroclival region needs the surgeon to deal with the Vth to XIth cranial nerves.**

DISCUSSION/CONCLUSION: **The EEEA should be preferred for extradural midline tumors (chordomas, chondrosarcomas) or for cystic lesions when drainage is essential. The AP could be optimal for the radical removal of intradural vascularized tumors (meningiomas) with intrapetrous or supratentorial extensions. The RSA retains an advantage for small or cystic tumors near the internal acoustic meatus. The skull base surgeon has to master all of these routes to choose the more appropriate one according to the surgical objective, the tumor characteristics, and the patient's medical status.**

INTRODUCTION

The petroclival region is a "surgical" space limited anteriorly by the clivus, laterally by the petrous apex, medially by the brainstem, and posteriorly by the *internal acoustic meatus* (IAM). It extends from the dorsum sellae to the foramen jugularis. It's crossed by cranial nerves IVth to VIIIth and by the basilar artery with its branches (15). Because of their critical neurovascular relationships and their deep-seated location, the surgical removal of petroclival tumors remains a fascinating challenge. These tumors have long been considered as inoperable because the resection often was incomplete, with a high morbidity (48).

Advances in microsurgical techniques, operative microscopes, anesthesia, and neuroradiology have allowed the field of surgery to move forward with strategy for petroclival tumors. Through a few series from leading neurosurgeons, some surgical approaches turning around the petrous bone to the petroclival region have been reported with hopeful results but still frequent cranial nerves deficits (2, 6, 12, 25, 35, 42).

A century ago, the posterior retrosigmoid approach (RSA) was described to reach the petroclival region with the main disadvantage of working through the cranial nerves (11). Then, lateral approaches such as the anterior petrosectomy (AP) were proposed despite a "tricky" drilling around the intrapetrous otologic

Key words
- Endonasal
- Endoscopy
- Skull base
- Petroclival
- Petrosectomy
- Petrous apex

Abbreviations and Acronyms
AP: Anterior petrosectomy
EEEA: Expanded endoscopic endonasal approach
IAM: Internal acoustic meatus
ICA: Internal carotid artery
RSA: Retrosigmoid approach

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structures (23, 47). More recently, an anterior corridor has been developed with the expanded endoscopic endonasal approach (EEEA), which provides a broad exposure vertically from the cribriform plate to the craniovertebral junction and laterally toward the middle cranial or infratemporal fossas (4, 19, 21). From the literature (8, 9, 18, 41), the experience of our surgical team and anatomic dissections, we compared the anterior endoscopic endonasal approach with the classical posterior and lateral ones and propose decisional criteria for the management of petroclival tumors.

METHODS

Anatomical Study

Five fresh cadaver's heads were harvested at the Anatomy laboratory of University Lyon 1 (Lyon, France), prepared with 10% formaldehyde, and then injected with colored latex (Phocéenne de chimie, Marseille/France; Aérographe Colorex Technics, Magenta et Cyan).

Five EEEAs were performed according to the technique described by Kassam et al. (21). A 180-mm long, 4-mm diameter endoscope was used with a 0 or 30° lense (Karl STORZ Endoskope GmbH, Tuttlingen, Germany). A bi-nostril path was necessary, and the use of a self-retaining endoscope holder allowed a 2-hands technique by a single operator. After an anterior classic transphenoidal approach (5) was underaken with the cadaver's head positioned as for pituitary surgery, the intrasphenoidal landmarks were identified: the paracavernous and paraclival segments of the internal carotid artery (ICA), the optic canals, the lateral and medial optic-carotid recesses, the *sella turcica*, the paraclival recess, and the *planum sphenoidale*. Access to the clivus was straightforward, but access to the petrous apex was required to circumvent the ICA. Three variants were described: medial, lateral, and below the ICA (**Figure 1**).

The first medial and easier technique, the transsphenoidal transclival, required a continuously irrigated, high-speed drilling (Integrated Power Console and Handpieces, Medtronic, Louisville, Kentucky, USA) of the clivus and reached the tip of the petrous pyramid medially to the ICA. The second lateral variant was transsphenoidal trans-Meckel's cave which. It involved a skeletonization of the vertical paraclival ICA segment and extended laterally to expose the orbital apex, the cavernous sinus, and the Meckel's cave. In addition to the sphenoidotomy, a middle turbinectomy and a posterior ethmoidectomy were mandatory to enlarge enough the corridor laterally. The inferior third variant was transphenoidal transpterygoid. It required a maxillary sinus as well as a pterygopalatine fossa aperture and a section of the sphenopalatine artery. Having lateralized the pterygopalatine fossa content, the medial pterygoid plate was long drilled. Thus, the vidian canal led to the *foramen lacerum* (20) and inferiorly to the inferior petrous apex (46).

Five controlateral microsurgical AP were performed according to the technique described by Kawase et al. (23). After the cadaver's head was fixed at 45° to the floor, a curvilinear incision was made anterior to the tragus extending from the zygomatic arch to the temporal line and behind the *external acoustic meatus*. The temporalis muscle was cut vertically and retracted anteriorly. Then, a classical temporal craniotomy was performed as low as possible, one third posterior and two thirds anterior to the external acoustic meatus. The dura mater was elevated at the superior part of the petrous bone in a posterior-to-anterior direction. The rhomboid construct (13) was gradualy discovered: the IAM located at the bissectrix of the superficial petrosal nerves and the eminentia arcuata (37), the geniculate ganglion, the *cochlea*, the *foramen rotondum*, the *foramen ovale*, and the horizontal petrous ICA segment. The Kawase's triangle extending before the IAM up to the trigeminal print and from the upper petrous ridge to the petroclival fissure was drilled gently. Care was taken to not damage the ICA or superficial petrosal nerves laterally and cochlea or the acoustic facial bundle posteriorly (16, 23, 29, 47). Finally, the posterior cranial and midle fossa dura mater was opened cautiously and the tentorium split after having checked the IVth nerve course. Thus, it offered a broad supra/infratentorial exposure of the petroclival area through the drilled petrous apex (**Figure 2**). RSA and posterior transpetrosal approches were already well described by previous anatomical or surgical studies (28, 30, 38, 43, 45).

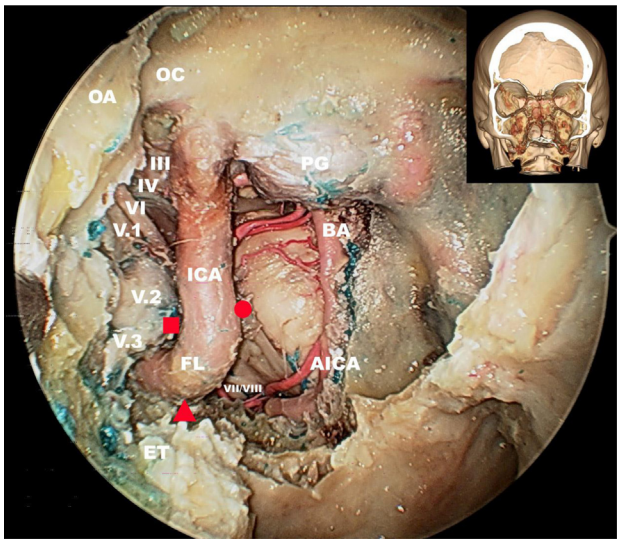

Figure 1. Endoscopic view of the final exposure after an expanded endoscopic endonasal approach. Despite the clivus being straightforward, to reach the petrous apex needs to circumvent the internal carotid artery (ICA). Three variants are described: a medial transsphenoidal transclival route (●) toward the pit of the petrous pyramid, a lateral transsphenoidal trans-Meckel's cave route (■) including a ICA skeletonization then a cavernous sinus and Meckel's cave opening and an inferior transpterygoid route (▲), which passes below the ICA to the low petrous apex after a time-consuming drilling of the sphenopterygoid complex along the vidian nerve. The cavernous sinus is recognized as a dural bag lateral to the paraclival-paracavernous ICA junction containing the cranial nerves IIIth, IVth V.1, and VIth. Meckel's cave is inferior anterior the cavernous sinus containing the cranial nerve V.1 and V.2 and fat tissue. III to VIII, cranial nerves IIIrd to VIIIth; AICA, anterior inferior cerebellar artery; BA, basilar artery; ET, Eustachian tube; FL, foramen lacerum; OA, orbital apex; OC, optic canal; PG, pituitary gland.

Clinical Data

In addition, we used data and experience obtained in our recent petroclival tumors cases, who underwent various surgical