Microsurgical and Endoscopic Anatomy of the Retrosigmoid Intradural Suprameatal Approach to Lesions Extending from the Posterior Fossa to the Central Skull Base

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ABSTRACT

This article evaluates the accessibility of the posterior part of the central skull base via the extended retrosigmoid intradural suprameatal approach. In formaldehyde-fixed specimens, the retrosigmoid intradural suprameatal approach was performed, and the feasibility of reaching central skull base structures was analyzed. Microscopic and endoscopic techniques were used. The main outcome measures were digital films and screenshots, which were analyzed regarding quantitative and qualitative aspects of visual structures. By drilling off the suprameatal tubercle and part of the petrous apex, Meckel's cave may be opened, the trigeminal nerve mobilized, and the tentorium divided. Thus the parasellar area may be exposed and the posterosuperior space of the cavernous sinus approached. Using an endoscope-assisted technique and following cisternal anatomy, the sellar and parasellar region may be explored even if the working space is narrow. The retrosigmoid intradural suprameatal approach provides optimal accessibility to medially located central skull base structures, in particular to the posterior part of the cavernous sinus. Use of the endoscope may remarkably optimize the accessibility.

KEYWORDS: Central skull base, retrosigmoid suprameatal approach, cavernous sinus, endoscopy

Depending on their topographical location, tumors involving the central skull base may be approached with various strategies. Lesions that involve both posterior and middle fossae have

been treated by the retrosigmoid intradural suprameatal approach (RISA).^{1,2} After performing a standard retrosigmoid craniectomy, the suprameatal tubercle is drilled away to gain access through

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Meckel's cave to the central skull base area. In this report, the main neuroanatomic landmarks and possible extensions of the RISA to middle fossa structures have been anatomically investigated.

MATERIAL AND METHODS

In 10 formaldehyde-fixed specimens (20 sides), a retrosigmoid intradural craniectomy was performed. The suprameatal tubercle was drilled off (high-speed drill, Zeppelin Medical Instruments, GmbH, A-6850 Dornbirn, Austria) using the microsurgical technique (Zeiss OPMI PRO Magis, Oberkochen, Germany). In addition, the approach was endoscopically extended (5 mm, 25 degrees, Richard Wolff GmbH, Knittlingen, Germany). The surgical procedures were video documented. The anatomical feasibility of reaching central skull base structures via the RISA was analyzed.

RESULTS

The suprameatal tubercle was developed in variable degree, but in all cases it impeded microscopic

visualization of Meckel's cave. Therefore, the suprameatal tubercle and part of the ventrally located petrous bone were drilled. The anatomical boundaries of the suprameatal tubercle were respected as follows: posteroinferiorly, the inner auditory canal with cranial nerves VII and VIII and the labyrinthine artery; superiorly, the superior petrosal sinus and superior cerebellar artery; and laterally, the common crus formed by superior and posterior semicircular canal (Fig. 1A and B).

Meckel's cave was then opened and the trigeminal nerve mobilized. Thus, it was possible to access the middle cranial fossa medially as well as laterally to the nerve. To gain a better microscopical view toward the central skull base, the tentorium cerebelli was dissected and divided cranially to Meckel's cave. Attention was paid to preserve the trochlear nerve during this maneuver. For detailed inspection of the central skull base, the petrosal vein was sacrificed in all cases.

The cavernous sinus (CS) was then approached posteriorly. Its posterior border extended from the posterior clinoid process to the medial border of Meckel's cave. At the oculomotor triangle, the oculomotor nerve and, posterolaterally to it, the trochlear nerve pierces the roof of the CS—the trochlear nerve represents the landmark for the CS opening. The CS was incised medially

Figure 1 (A) Intraoperative microscopic view of the left cerebellopontine angle (CPA) and the suprameatal tubercle after a retrosigmoid approach (arrows). (B) Endoscopic view of segments I and II of the CPA after a retrosigmoid approach. AICA, anterior inferior cerebellar artery; SM, suprameatal tubercle; Tent., tentorium; v. Petr., vena petrosa; Sub. a, subarcuate artery; CN VII-VIII, cranial nerves VII and VIII.

to its entrance. Thus, the posterosuperior venous space was penetrated, and the posterior bend of the internal carotid artery with the meningohypophyseal trunk was exposed. Dissection could be carried on to the C4 segment without any vascular or nerve damage.

Under microscopic control, an endoscope was inserted parallel to the posterior surface of the petrous bone toward Meckel's cave. The tip was introduced to the middle fossa through the gap between the posterior cerebral artery and the superior cerebellar artery, and medially to the oculomotor nerve. Then cisternal anatomy was used to explore the middle fossa content: The interpeduncular cistern is situated between the mesencephalic interpeduncular fossa and the dorsum sellae, which borders posteriorly to the prepontine cistern (mesencephalic fold of Liliequist's membrane); anteriorly to the chiasmatic cistern (diencephalic fold of Liliequist's membrane); and laterally to ambient, crural, and carotid cisterns. The P1 segment, branches of the posterior cerebral artery, and the basal vein of Rosenthal cross the ambient cistern. The oculomotor nerve may be followed in its course anterolaterally along the lateral border of the interpeduncular cistern to reach its entry point to the cavernous sinus. More medially, the basilar artery enters this cistern perforating the mesencephalic membrane from below, feeds the superior cerebellar artery (SCA), and divides into the posterior cerebral arteries with its branches (Fig. 2). Further, the veins crossing the interpeduncular cistern (median anterior pontomesencephalic veins) may be appreciated in the endoscopic view running parallel to the oculomotor nerve; the posterior communicating vein, which connects the first with the peduncular veins; and the vein of the pontomesencephalic sulcus.

By entering the chiasmatic cistern through the diencephalic fold—in the dorsoventral direction—the mammillary bodies, tuber cinereum, infundibulum, and pituitary stalk were explored; and below these features, the optic nerves, optic chiasm, and diaphragma sellae were explored.

Figure 2 Endoscopic view from the posterior into the middle fossa on the internal carotid artery and its branches. SCA, superior cerebellar artery; Thal. Per., thalamoperforating arteries; CN III, cranial nerve III; PcoA, posterior communicating artery; ICA, internal carotid artery.

The crural cistern is located laterally to the interpeduncular cistern and anterolaterally to the cerebral peduncles. It is bounded laterally by the uncus, medially by cerebral peduncle and crural membrane, and above by the optic tract. After opening the membrane using the endoscopic technique, the anterior choroidal arteries, the medial posterior choroidal arteries, as well as the posterior communicating artery were visualized (Fig. 2). Following these arteries ventrally in their course with the endoscope, the carotid cistern was entered. Here the internal carotid artery exits the CS inferomedially to the anterior clinoid process. The carotico-oculomotor membrane and fibrous ring, which delimit the C3, C2, and, cranially, the C1 segments, may be explored. The most ventrally located, well-visualized structure is the olfactory tract.

DISCUSSION

Lesions involving the central skull base may be operated on by various approaches according to their topographic location. The classic approaches (pterional, frontotemporal subdural and/or epidural, frontolateral, subfrontal, orbitofrontozygomatic,

temporal and subtemporal, and transpetrosal), as well as staged procedures are routinely used.^{3–10} More recently, transnasal, endoscopic techniques have been introduced for surgery of suprasellar lesions.¹¹ Petroclival meningiomas and trigeminal neurinomas may extend from the posterior into the middle fossa. These tumors have been commonly operated on via transpetrosal approaches.^{12,13} Samii introduced the RISA for microsurgery of tumors with this spatial extension.¹ Large infra- supratentorial tumors displace the neurovascular structures and hence allow an increased working space from posterior to middle fossa. Petroclival meningiomas, Meckel's cave meningiomas types III and IV, and trigeminal schwannomas types B and C (involving the posterior part of the central skull base) may be resected via the RISA. The central part of the middle fossa, the parasellar area, and the posterior part of the CS may be well reached with the presented extension. Hence, an intracavernous tumor portion limited to the posterosuperior venous space may be debulked and removed via the RISA.¹⁴ However, in small tumors, the working angle does not give satisfying insight to the middle fossa laterally to cranial nerve V2. If the tumor mass does not create an enhanced surgical corridor, tumors extending also to the lateral skull base may not be sufficiently exposed with this single approach. However, if the anatomy is not significantly distorted, an endoscope-assisted technique may be of aid.¹⁵

The RISA is less invasive than other skull base approaches, which are associated with higher incidence of morbidity.¹³ Particular attention should be paid, however, to preserve the petrosal vein whenever possible, to avoid venous complications.¹⁶

CONCLUSION

The retrosigmoid intradural suprameatal approach provides optimal accessibility to medially located central skull base structures, in particular to the posterior part of the CS. However, the working

space is narrow. Thus, in lack of significant displacement of the neurovascular structures, an endoscope-assisted technique may optimize the accessibility.

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