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Combined Exoscopic- and Endoscopic-Assisted Resection of an Interpeduncular and Middle Fossa Epidermoid Cyst via a Transcavernous Approach: Technical Note

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■ OBJECTIVE: **The endoscope and exoscope are gaining momentum as alternative visualization tools in the neurosurgical field, trying to overcome the limitations of an operative microscope and support minimally invasive approaches. However, few case series are available in the literature regarding their use in skull base surgery, especially in combined assisted resection, and their usefulness still needs to be proved.**

■ METHODS: **An illustrative case to present the feasibility and minimally invasive advantages of a combined exoscopic- and endoscopic-assisted resection is reported.**

■ RESULTS: **A 22-year-old man presented with a history of seizures and dizziness. Brain imaging showed a lesion involving the anteromedial middle fossa invading the interpeduncular cistern and impinging the brainstem, suggestive of an epidermoid cyst. A combined exoscopic- and endoscopic-assisted resection through a pterional transcavernous approach was planned and performed. No neurologic deficit occurred after the surgery, providing further evidence about the usefulness and safety of this hybrid technique.**

■ CONCLUSIONS: **Combined exoscopic and endoscopic resection is also feasible and safe in complex skull base surgery. Moreover, this technique seems to be effective for minimizing the surgical invasiveness in skull base lesions.**

INTRODUCTION

The operative microscope (OM) has been considered one of the major technical revolutions in the neurosurgical field, paving the way for the microneurosurgical era due to the high magnification, illumination, and stereoscopic vision granted by this tool.[1] However, the presence of blind spots, frequent need for repositioning, and limited ergonomics represent some shortcomings related to OM. The endoscope (EN) and exoscope (EX) represent 2 other visualization instruments that were developed attempting to overcome those limitations.[2] Nevertheless, in common clinical practice, the diffusion of EX is limited to a few highly specialized centers and its real potential has not been explored in full, especially in skull base surgery.[3] Moreover, the standard skull base approaches for the resection of lesions extending from the middle fossa to the interpeduncular and sellar region often require an orbitozygomatic osteotomy.[4,5] However, this approach is burdened by high complication rates,[6] and minimally invasive strategies should be pursued to limit surgery-related morbidity.

Herein, we present a technical note describing the nuances of a combined EX-EN resection of an interpeduncular and middle fossa epidermoid cyst through a transcavernous approach.

METHODS AND MATERIALS

An illustrative case of a patient harboring a middle and interpeduncular extraaxial lesion is presented. The surgical procedure was performed under general anesthesia through a right pterional transcavernous approach. The Aesculap AEOS 3-dimensional robotic digital system (Aesculap, Tüttlingen, Germany) integrated with a full high-definition intracranial EN

Key words
- Endoscope
- Epidermoid cyst
- Exoscope
- Skull base
- Transcavernous approach

Abbreviations and Acronyms
EN: Endoscope
EX: Exoscope
ICA: Internal carotid artery
MCA: Middle carotid artery
OM: Operative microscope

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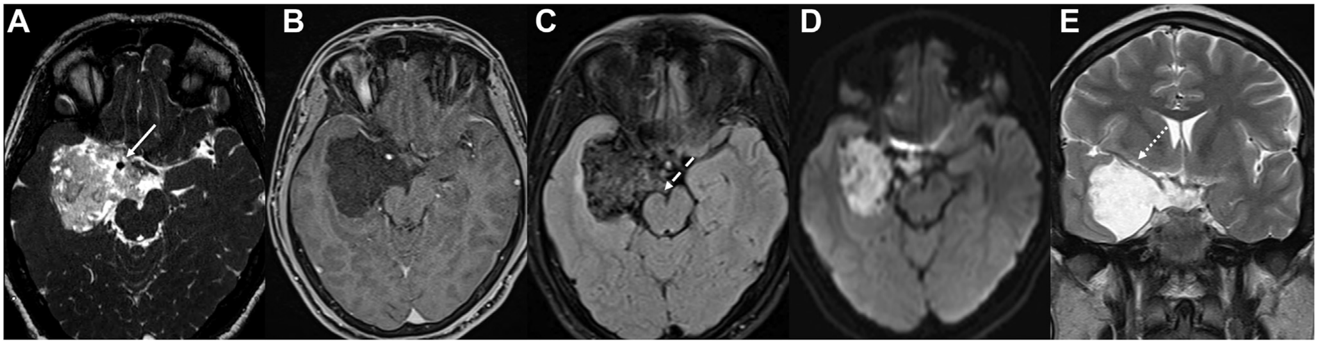

Figure 1. (**A**—**E**) Preoperative magnetic resonance imaging images demonstrating an extraaxial, inhomogeneous, and nonenhancing lesion involving the medial posterior fossa and the interpeduncular cistern encasing the internal carotid artery (**A**, *arrow*), compressing the ipsilateral cerebral peduncle (**C**, *dashed arrow*) and the right mesial temporal lobe, and displacing upward the middle cerebral artery (**E**, *dotted arrow*).

(Aesculap) was used for the procedure. The patient gave his consent for the publication and use of his protected health information, including his image. The institutional review board approval was waived given the nature of the study.

RESULTS

A 22-year-old man presented with a 1-year history of epilepsy, dizziness, and headache. Magnetic resonance imaging examination revealed an extraaxial nonenhancing lesion extending from the right medial portion of the middle cranial fossa into the interpeduncular cistern (50 × 47 × 40 mm), compressing the ipsilateral cerebral peduncle, encasing the internal carotid artery (ICA) bifurcation, and displacing superiorly the middle cerebral artery (MCA). The radiologic findings were suggestive of an epidermoid cyst (**Figure 1**). In light of the neurologic symptoms and compression of the cerebral peduncle, a surgical option was offered to the patient. The transcavernous approach was selected as the best option to provide wider exposure to the middle fossa and interpeduncular cistern. To minimize the surgical footprint of a 3-step surgery, using the combination of EX and EN was performed.

Surgical Procedure

The patient was placed supine with the head fixed on a Sugita clamp and a 30-degree rotation to the left side. The 3 steps of the surgery were performed as follows:

1. Under exoscopic vision, a right pterional craniotomy was performed in a standard fashion; after the bone removal, the frontal and temporal dura were gently dethatched, exposing the sphenoid ridge. Subsequently, the meningoorbital band was progressively dethatched from the lesser sphenoid wing; the cutting of the meningoorbital band allowed the peeling of the dura propria from the lateral wall of the cavernous sinus, and, after a sharp incision of this loose connective tissue, the exposure of the anterior clinoid process and the anteromedial floor of the middle cranial fossa with the first and second branches of the trigeminal nerve. After the extradural anterior clinoidectomy was performed, the sphenoid ridge and orbital roof were flattened to gain a wider surgical corridor to the cranial base cisterns. Afterward, the dura was opened and the superficial part of the tumor was appreciable into the Sylvian cistern.

Finally, the ending part of the first step was focused on the removal of the lesion from the carotid and interpeduncular cistern, progressively identifying the ICA and its bifurcation in the anterior cerebral artery and MCA, the posterior cerebral artery, the posterior communicating artery, the basilar perforators, and the first, second, third, and fourth cranial nerves (**Figure 2A** and **B**).

2. We switched from the exoscopic to endoscopic vision to check the removal of the tumor in the upper portion of the carotid cistern, interpeduncular cistern, and frontobasal region (see **Figure 2C**). To complete this step, the use of an EN was paramount, permitting the preservation of the zygomatic arch and orbital rim that otherwise should have been removed to gain a wider working angle to reach and get control of the frontobasal and interpeduncular regions, including the ICA bifurcation, first segment of the MCA (M1 segment and its perforators), first segment of the anterior cerebral artery (A1 segment), frontobasal gyri, and mesial temporal lobe, especially the uncal region. In fact, the field of view granted by the endoscopic vision allows completing the tumor removal in this region, maximizing the exposure and minimizing the craniotomy size and brain retraction.
3. We performed this step under exoscopic vision with the excision of the middle fossa component of the tumor along the brainstem, the ambient cistern, and the tentorial notch; a segment of the right basal vein of Rosenthal was also appreciated during the procedure (see **Figure 2D**). The highlights of the procedure can be seen in the 3-dimensional **Video 1**.

Video

Video available at www.sciencedirect.com

After surgery, no new neurologic deficits occurred, with a progressive resolution of the dizziness. The histopathologic examination was consistent with an epidermoid cyst. Postoperative magnetic resonance imaing showed a gross total removal of the lesion (**Figure 3**).

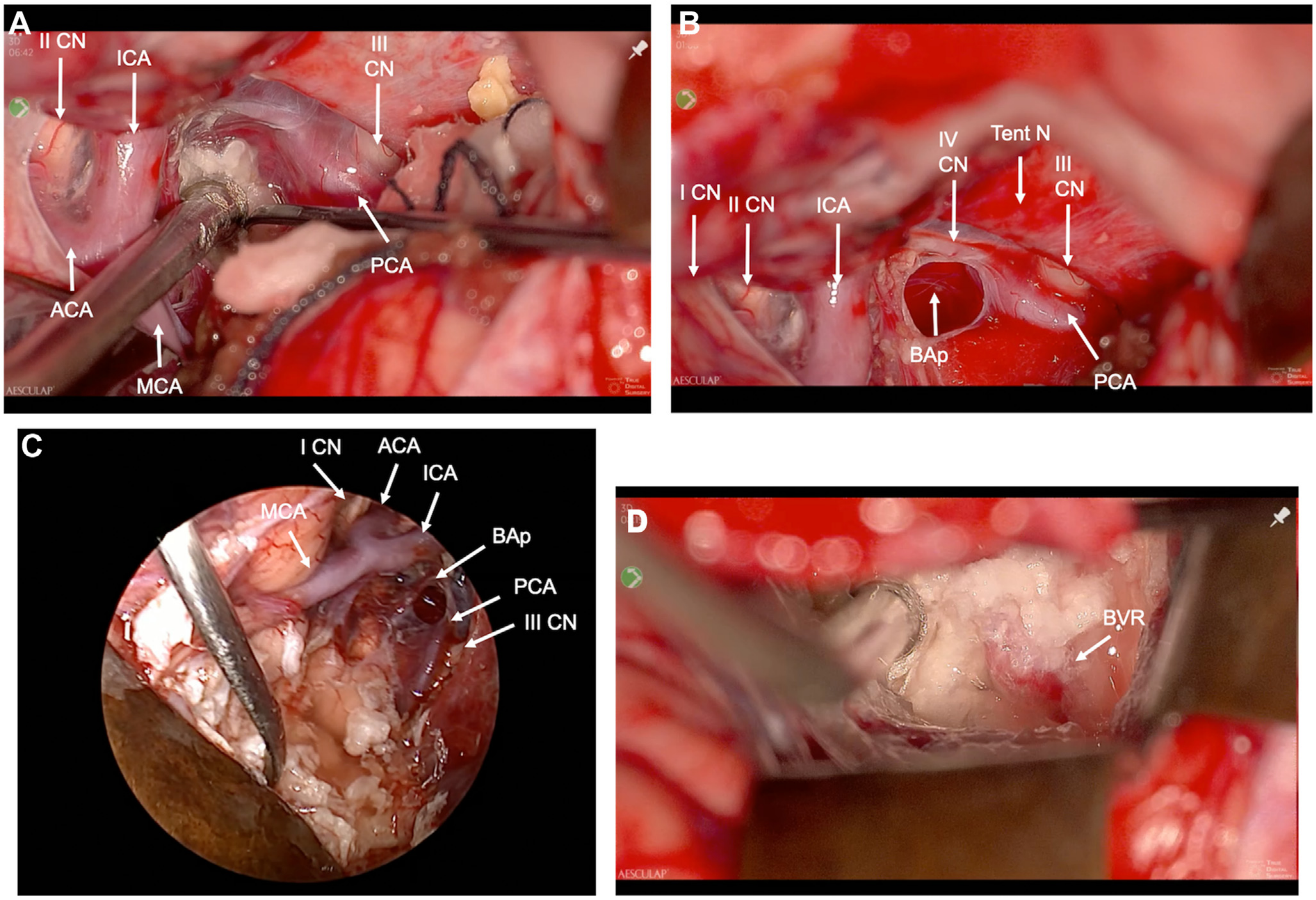

Figure 2. (**A**) Intraoperative exoscopic image showing the removal of the lesion from the interpeduncular cistern and the surrounding anatomy. (**B**) Intraoperative exoscopic anatomic overview after the removal of the interpeduncular component of the lesion. (**C**) Intraoperative image showing the endoscopic view of the basal cistern during the endoscopic stage of the tumor resection. (**D**) Intraoperative exoscopic image of the removal of the tumor in the ambient cistern. I CN, ophthalmic nerve; II CN, optic nerve; III CN, oculomotor nerve; IV CN, trochlear nerve; ACA, anterior cerebral artery; BAp, basilar artery perforators; BVR, basal vein of Rosenthal; ICA, internal carotid artery; MCA, middle carotid artery; PCA, posterior cerebral artery; Tent N, tentorial notch.

DISCUSSION

The OM has represented in the past years the essential and irreplaceable visualization system in modern microneurosurgery, providing high-quality and magnified images, illumination of the surgical field, and stereopsis. Nevertheless, OM is burdened by some disadvantages including a limited working distance, blind spots, and demanding positions during surgery.[1,2] New technologies were developed to overcome those shortcomings, leading to the creation of alternative visualization tools such as the EN and, in recent years, the EX. Despite some limitations of the first-generation EX, including lack of stereopsis and suboptimal holders,[3,7] emerging evidence suggests the technical noninferiority of EX compared with OM, along with overcoming ergonomic problems and an increase of the field of vision.[2,8,9] Despite those improvements, systematic use of EX in clinical practice concerning skull base surgery is limited to a few case series.[3,10] A possible rationale can be sought in the extremely narrow and deep working space and loss of 3-dimensional depth perception[3,9]; however, the new-generation EXs are equipped with 3-dimensional cameras and footswitch pedals to exceed those drawbacks, reduce fatigue, and enhance the surgeon's ergonomics. Moreover, as shown in this case, the combined use of exoscopic and endoscopic vision allows for improved surgical procedure, reducing the surgery-related invasiveness that otherwise would have required a more invasive surgical approach. In fact, as shown by previous quantitative anatomic and clinical studies, the orbitozygomatic osteotomy was considered mandatory in case a wider exposure of the skull base was needed.[4,5,11,12] More in detail, Schwartz et al[12] showed that removal of the orbital rim and zygomatic arch are able to provide an increase in the operative exposure of the basilar tip and tentorial edge region up to 39% and 22%, respectively; analogously, Honeybul et al[11] reported an increase by up to 200% of the surgical window using the orbitozygomatic transsylvian approach. However, the utility frontoorbitotemporozygomatic approach is counterbalanced by nonrisible complication rates including a higher rate of cerebrospinal fluid leaks, cosmetic and functional issues (e.g.,

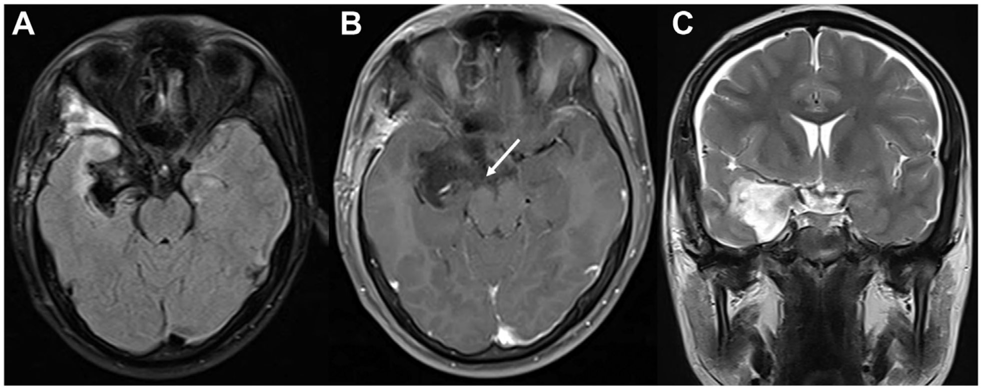

Figure 3. (**A—C**) Postoperative magnetic resonance imaging images showing the complete excision of the lesion and the initial re-expansion of the cerebral peduncle and mesial temporal lobe (*arrow*).

temporalis muscle atrophy), and new neurologic deficits.[6] In this respect, the combined use of exoscopic and endoscopic vision has been crucial for reducing the size of the craniotomy and preserving the orbital rim and zygomatic arch, otherwise not feasible through a pterional approach exclusively with EX or OM. Further studies to investigate the potential application in minimizing the surgical invasiveness of combined EX-EN skull base surgery are warranted to confirm our preliminary result.

CONCLUSION

Enhanced ergonomics, extremely high magnification, better field of vision, and improvement of the learning experience summarize the main advantages offered by the EX compared with traditional OM. Combined exoscopic and endoscopic resection is also feasible and safe for complex skull base lesions. Moreover, it seems to be a valuable technique to reduce the invasiveness of the surgical approaches that should be held in the neurosurgical armamentarium for selected cases.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Giacomo Bertolini: Conceptualization, Methodology, Writing — original draft, Investigation, Data curation, Visualization. **Harisinh Parmar:** Investigation, Data curation. **Sajeev Vadakkedam:** Investigation, Data curation. **Nargiza Saatova:** Investigation, Data curation. **Tamerlan Koniev:** Data curation. **Ranjeet Chaurasia:** Software. **Diego Mazzatenta:** Supervision, Writing — review & editing. **Iype Cherian:** Supervision, Writing — review & editing.

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