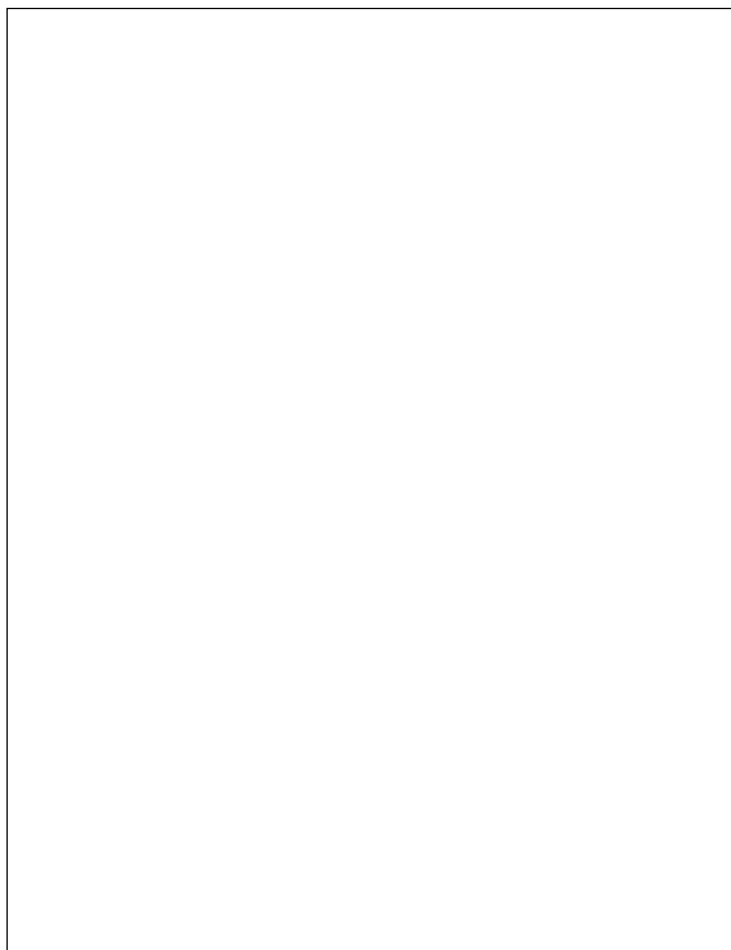


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Flexible Endoscopic-Assisted Microsurgical Radical Resection of Intracanalicular Vestibular Schwannomas by a Retrosigmoid Approach: Operative Technique

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Key words

- Endoscopic-assisted retrosigmoid approach
- Endoscopy
- Flexible endoscope
- Intracanalicular vestibular schwannoma
- Vestibular schwannoma

Abbreviations and Acronyms

- CPA:** Cerebellopontine angle
EARSA: Endoscopic-assisted retrosigmoid approach
IAC: Internal auditory canal
ICVS: Intracanalicular vestibular schwannoma
VS: Vestibular schwannoma

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INTRODUCTION

Intracanalicular vestibular schwannoma (ICVS) is defined as a vestibular schwannoma (VS) that is limited to the internal auditory canal (IAC) without extension into the cerebellopontine subarachnoid space.^{1,2} The incidence of ICVS has increased progressively thanks to the widespread accessibility of magnetic resonance imaging, and now ICVSs account for approximately 8% of all VSs.³ Although the small size of these tumors allows for several management options, including conservative observation and stereotactic radiotherapy, surgical treatment appears to be an excellent approach, considering the possibility of hearing preservation, a high rate of facial nerve preservation, and improved vestibular function after surgery.⁴ However, surgical treatment can be challenging, considering the potential

The efficacy of endoscopic techniques in the surgical management of intracanalicular vestibular schwannomas (ICVSs) has been underlined in recent studies. An endoscopic-assisted retrosigmoid approach (EARSA) appears to be particularly suitable for achieving complete resection of an ICVS. In this study, we describe the surgical treatment of 3 cases of ICVS with an EARSA, highlighting the advantages and limitations of flexible endoscopy in accomplishing a safe radical resection with hearing preservation. Three patients with an ICVS underwent surgery via a flexible endoscopic-assisted microneurosurgical retrosigmoid approach. Flexible endoscopic assistance allowed the identification of residual tumor located in the most lateral portion of the fundus of the internal auditory canal in all cases. Endoscopic controls and further microsurgical resection were attempted, and complete surgical resection was achieved in all cases without the occurrence of postoperative facial or auditory nerve dysfunction. Flexible endoscopy appears to be particularly useful and safe in the surgical management of ICVS by microneurosurgery via an EARSA.

risks of surgical morbidity, since the majority of patients have a good clinical status.

Endoscopic techniques in the surgical management of VS have been well studied and applied, with excellent results.^{5,7} Moreover, a recent study has confirmed the efficacy of an endoscopic-assisted retrosigmoid approach (EARSA) in the surgical treatment of ICVS.⁸ Here we describe the surgical treatment of 3 patients with ICVS via an EARSA, highlighting the advantages and limitations of flexible endoscopy in the accomplishment of radical resection.

METHODS

Patient Characteristics

In a series of 15 consecutive patients who underwent surgery at our institution between August and January 2018 for VS with intrameatal extension of various sizes, 8 patients were treated by microneurosurgical EARSA using a flexible endoscope (4 mm × 65 cm; Karl Storz, Tuttlingen, Germany). According to the international criteria for classification of

VSs proposed by Kanzaki et al. in 2003,¹ using the largest extrameatal tumor diameter on postcontrast axial MRI, there were 3 large, 1 medium, and 3 pure intrameatal schwannomas.

The latter 3 cases are the subject of the present study, focused on the radical resection of ICVS (Figure 1). These patients were initially diagnosed with vestibular dysfunction, with rotational vertigo and dizziness as presenting symptoms. The duration of symptoms ranged from 2 to 24 months. All patients had socially useful hearing at initial presentation, defined as American Academy of Otolaryngology–Head and Neck Surgery class A or B,⁹ which corresponds to both a pure tone audiometry threshold of <50 dB and a speech discrimination score ≥50%, as determined by audiometric assessment. No patient had any signs of facial nerve dysfunction (House–Brackmann 1). Audiologic and facial nerve examination were performed preoperatively as well as at 1 week and 3 months postoperatively. The hospital's Ethics Committee approved this study. Written informed consent for publication of clinical,

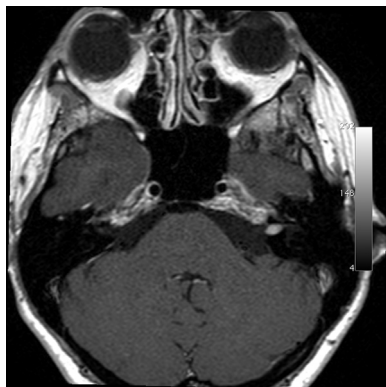


Figure 1. Contrast-enhanced magnetic resonance imaging showing a right pure intracanalicular vestibular schwannoma.

followed by a lateral cerebellomedullary cistern opening for cerebellar decompression by cerebrospinal fluid aspiration. After cutting the dura covering the roof of the IAC using a 2 μ -thulium flexible hand-held laser fiber (RevoLix jr.; LISA Laser Products, Katlenburg-Lindau, Germany),¹⁰ the IAC is opened with a 4-mm extra-coarse diamond burr and/or a SONOPET ultrasonic aspirator (Stryker, Kalamazoo, Michigan, USA) with dedicated bone tips, allowing progressive exposure of the intrameatal dura, which is then cut longitudinally using the flexible laser fiber¹⁰ (Figure 2). Careful tumor resection is performed, avoiding bipolar coagulation in proximity to the intrameatal nerves.

radiologic, and intraoperative data was obtained from all patients.

Surgery

The procedure is performed with the patient in a lateral position with the head fixed in a 3-pin clamp. Intraoperative monitoring includes auditory brainstem response and direct intraoperative facial stimulation and electromyography. The skin incision consists of a slightly curved 5- to 6-cm line behind the ear, 1 cm posterior to the mastoid. A free pericranial flap is harvested for dural closure. The rectosigmoid–retromastoid lateral occipital bone is exposed, including the superior and inferior nuchal lines. Using a high-speed drill, a 3 × 3-cm craniotomy, exposing the sigmoid and transverse sinuses and the angle between them, is performed. Then an L-shaped cut is made in the dura mater, in close proximity and parallel to the sigmoid sinus,



Video available at WORLDNEUROSURGERY.org

Identification of the vestibular, cochlear, and facial nerves in the IAC is obtained during microsurgical dissection (See **Supplementary Video**). Facial nerve integrity is assessed using a monopolar stimulator (Nimbus i-Care 100; Innopsys, Carbonne, France).

On completion of microsurgical resection (Figure 3), a 4-mm flexible video endoscope (4 mm × 65 cm; Karl Storz) is inserted in the surgical cavity, handled by the operator. The endoscope is introduced under both microscopic and endoscopic visualization to prevent injury to cerebellopontine angle (CPA) structures, and the endoscopic tip is oriented in the IAC to detect tumor residue hiding in the deeper portion of the IAC (Figure 4). If residual tumor is identified, microsurgical resection is pursued, and further endoscopic controls are repeated until complete tumor resection is accomplished (Figures 5 and 6). Accurate

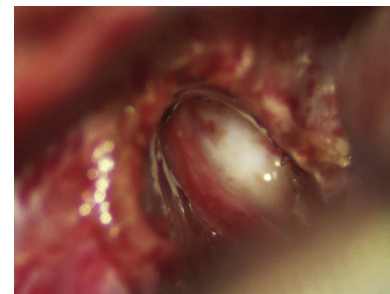


Figure 3. Microscopic view of the internal auditory canal after tumor resection. The microscopic view does not allow inspection of the fundus and determination of the required extent of resection.

hemostasis and tight dural closure using a pericranial graft, hemostatics, and sealants are performed, and a fitted titanium net or bone operculum is placed on the craniectomy with mini-screws.

RESULTS

In these 3 patients, flexible endoscope-assisted microsurgical resection of the ICSV allowed optimal visualization of the entire IAC and identification of residual tumor located in the most lateral portion of the fundus. The flexible endoscope appears to be particularly suitable for exploration of the IAC, enabling orientation of the endoscopic tip inside the IAC.

Extent of Resection

Complete microsurgical resection was achieved in all patients. Nonetheless, after microscopic dissection, endoscopic exploration of the IAC revealed a residual tumor in the lateral portion of the IAC in all patients. Therefore, multiple endoscopic controls and pursuit of further microsurgical resection of these endoscopically visualized residual tumors was attempted. Tumor residual fragments detected in the fundus of the IAC were completely resected in all cases, as confirmed by postoperative MRI (Figure 7).

Functional Outcome

Hearing function was constantly monitored during surgery, and no variations in V-wave amplitude were registered. As expected, all patients exhibited no change in hearing competence in the postoperative

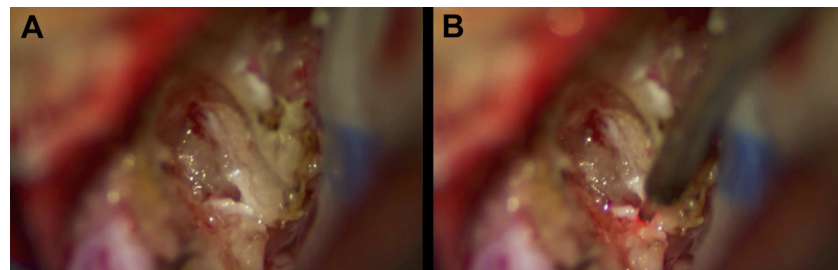


Figure 2. Microscopic view of a retrosigmoid approach. (A) After drilling the posterior wall of the internal auditory canal the intrameatal dura is exposed. (B) The intrameatal dura is cut using a 2 μ -thulium flexible hand-held laser fiber, exposing the tumor surface.

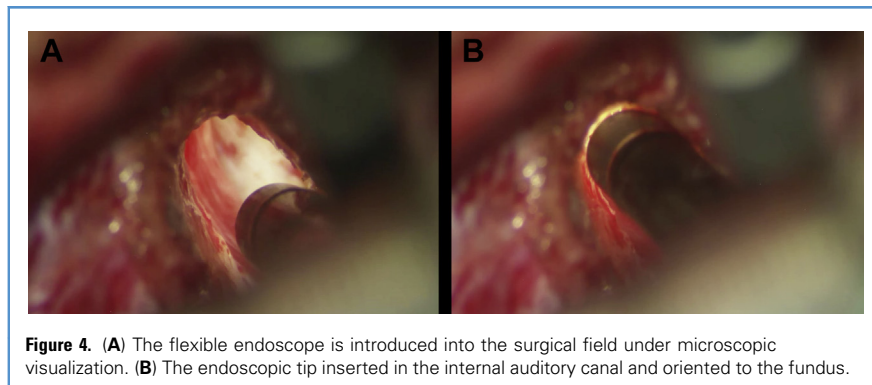


Figure 4. (A) The flexible endoscope is introduced into the surgical field under microscopic visualization. (B) The endoscopic tip inserted in the internal auditory canal and oriented to the fundus.

period. Similarly, the facial nerves were anatomically and functionally preserved, and all patients demonstrated normal postoperative facial nerve function (House–Brackmann grade I).

DISCUSSION

Endoscopic-assisted techniques in the surgical treatment of CPA tumors have been well studied for decades and, more recently, excellent surgical results in achieving safe tumor resection of CPA intrameatal lesions have been reported in the literature.¹¹ However, only 1 recent article has described the utility of the endoscopic technique in the surgical management of ICVS.⁸ In the present study, we emphasize the role of flexible endoscopic assistance in a standard microneurosurgical retrosigmoid approach for the treatment of ICVS.

Hearing Preservation Surgery in ICVS

The treatment of VS has gradually changed over the last several decades. The widespread use of MRI in routine diagnostic

testing of vestibular and hearing disturbances has allowed for detection of VS at early stages. The optimum treatment of ICVS remains a matter of debate, and the most common options besides surgery are “wait and see” and radiosurgical treatment.¹² However, the natural course of auditory function in patients harboring pure ICVSs indicates that a mild but progressive hearing loss is attended, particularly in the first years after diagnosis.¹³ In accordance with experienced and skilled neurosurgeons,^{14,15} we consider microsurgery as the first treatment option in patients suitable for surgery with documented socially useful hearing. Indeed, in patients with good preoperative hearing function, the aim of surgery is to achieve complete tumor removal with preservation of hearing, and hearing competence was unchanged after surgery in all 3 patients reported here.

Opening the IAC

Hearing preservation also implies anatomic respect of the inner ear structures. In a retrosigmoid approach, the

internal auditory meatus cannot be completely opened to expose the fundus to preserve the superior and posterior semicircular canals. Therefore, a straight microscopic view cannot provide adequate visualization of the most lateral part of the IAC, forcing the surgeon to work blind with hooklets and curettes around the meatal bone.

A possible solution to this limitation was recently suggested by Mazzoni et al.,¹⁶ who described the surgical technique of microsurgical retrolabyrinthine meatotomy for reaching the fundus of the IAC via careful exposure of the entrance to the Fallopian canal. The same approach, opening the intrameatal canal with labyrinth preservation, was described in a cadaveric study by Pillai et al.,¹⁷ confirming excellent exposure of the Fallopian portion of the fundus of the IAC. However, even if extensive drilling of the posterior wall of the IAC is performed, the vestibular portion of the fundus cannot be adequately exposed to preserve the labyrinth structures that are crucial to hearing preservation. Nonetheless, the vestibular quadrant is the anatomic region of the IAC where VS usually arises from the inferior or superior vestibular nerves. Thus, residual tumor is frequently encountered in this area, strongly attached to the fundus of the IAC.

Advantages of Endoscopic Assistance

Endoscopic assistance provides optimal views of the fundus of the IAC, allowing access to the most lateral part of the tumor under visual control.^{18–20} Therefore, use of the endoscope decreases the amount of bone drilling in the posterior wall of the IAC and, consequently, the risk of injury to the superior and posterior semicircular canals.

Moreover, as recently demonstrated by Abolfotoh et al.,⁵ endoscopic assistance also improves the ability to evaluate the extent of resection intraoperatively. Indeed, the exclusive use of microscopic views has poor reliability in intraoperatively evaluating the extent of resection of CPA tumors with deep IAC extension.⁵ Our study corroborates these findings, showing the presence of residual tumor in all the examined cases. Furthermore, endoscopic visualization of the fundus of the IAC allows detection of

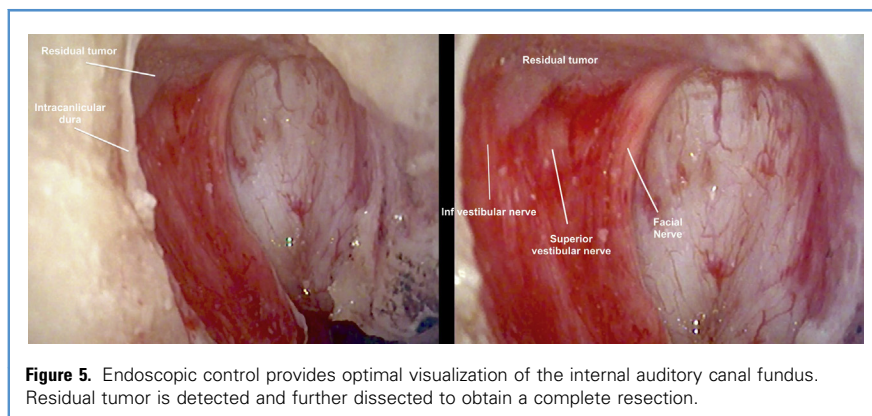


Figure 5. Endoscopic control provides optimal visualization of the internal auditory canal fundus. Residual tumor is detected and further dissected to obtain a complete resection.

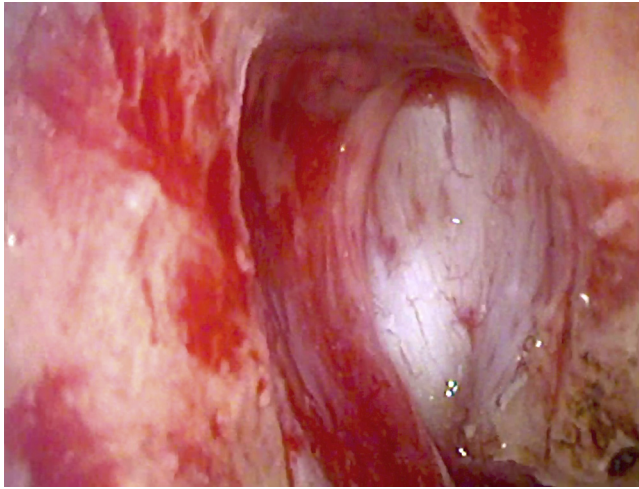


Figure 6. The second endoscopic control confirms complete resection.

the exact position of the residual tumor into the IAC, guiding the microsurgical dissection and enabling complete tumor resection.

Advantages and Limitations of Flexible Endoscopic Assistance

In our experience, the flexible endoscope appears particularly suitable for surgical management of the ICVS. The main advantages include the ability to orient the endoscopic tip directly into the IAC (Figure 4) to obtain optimal visualization of the fundus, along with the appropriate dimensions (4 mm × 65 cm) for insertion into the IAC after drilling.

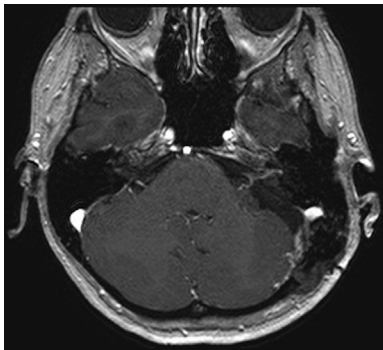


Figure 7. Postoperative magnetic resonance imaging confirming gross total resection of the intracanalicular vestibular schwannoma.

The flexible endoscope has further advantages when introduced along the corridors between the cranial nerves. In particular, we appreciate the possibility of arranging the configurational shape to obtain a safe corridor between the dorsal

neurovascular structures of the posterior fossa. Furthermore, it can be easily adapted in a comfortable position, helping to keep the microscope in place. Therefore, the endoscope is always inserted and manipulated under direct microscopic view to avoid injuring neurovascular structures within the CPA during in-and-out movements. This technique provides a tandem endoscopic and microscopic view, improving the prediction of residual tumor and extent of resection while at the same time improving the safety of endoscope manipulation in the surgical field.

Endoscopic assistance using a flexible endoscope carries some disadvantages, including the need to hold the endoscope with both hands. In contrast to the rigid endoscope, which can be held by the assistant in one hand as described for the “freehand endoscope holding technique”²¹ routinely used in surgical practice, the flexible endoscope must be manipulated with both hands, one hand to insert the endoscope in the surgical field and the other to orient the endoscopic tip in the correct position (Figure 8). This limitation can be easily managed via

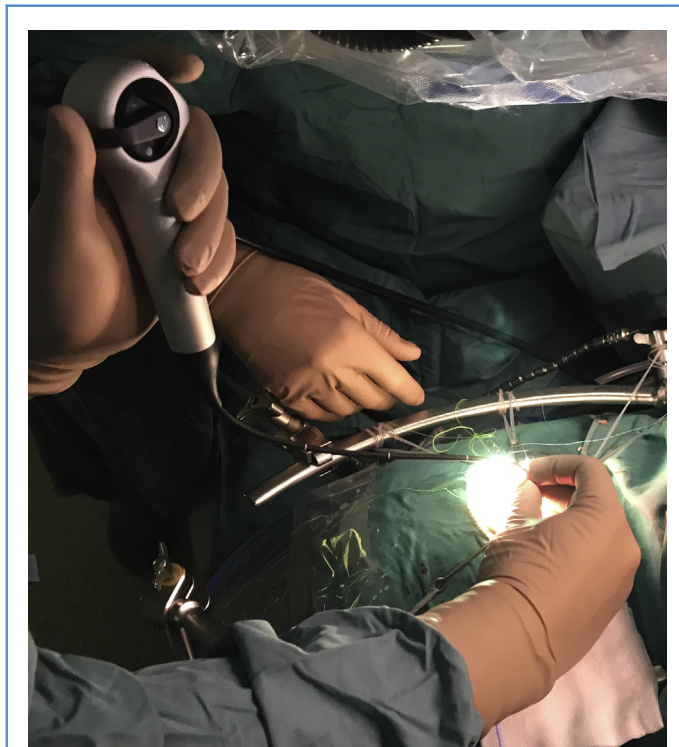


Figure 8. Bimanual holding of the flexible endoscope.

good cooperation and synchronicity between the 2 surgeons. Further advances in endoscopic structure, such as the recently described ultrathin flexible endoscope with integrated irrigation and suction, could further improve the handling of the surgical endoscope and facilitate visualization of the deep position of the IAC.²²

In our experience, even though it is limited to 3 cases, we have found that use of the flexible endoscope provides excellent support in detecting residual tumor after microsurgical removal, allowing the pursuit of complete tumor resection and contributing to safe manipulation of the endoscope and surgical instruments in the surgical field to prevent injury to the neurovascular structures.

CONCLUSIONS

Endoscopic assistance in the micro-neurosurgical treatment of ICVS has recently been applied with excellent surgical results. In the present study, we emphasized the application of flexible endoscope in the surgical management of ICVS treated with a microsurgical EARSA. The endoscopic assistance provides an optimal view of the fundus of the IAC, allowing visualization of residual tumor otherwise not detectable with only a microscopic view and thus improved intraoperative evaluation of the actual extent of resection. The flexible endoscope appears to be particularly suitable for intraoperative exploration of the IAC, guiding microsurgical dissection, improving the ability to achieve additional safe tumor resection, and allowing for complete tumor resection.

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