**TITLE:**

The Endoscope-Assisted Minimally Invasive Retro-Sigmoid Approach (EAMIRSA): A Combination of Techniques for Improving Middle Skull Base Surgery

**AUTHORS & AFFILIATIONS**

Arianna Di Stadio1, Giampietro Ricci1, Laura Dipietro3, Puya Dehgani Mobaraki1, Franco Trabalzini1,2, Antonio Della Volpe1,4, Luca D’Ascanio1,5, Jean Jacques Magnan1

1 Permanent Temporal Bone Dissection Laboratory, University of Perugia, Perugia, IT

2 Meyer Children Hospital, Otolaryngology Department, Florence, IT

3 Highland Instruments, Cambridge (MA), USA

4 Santobono Children Hospital, Otolaryngology Department, Cochlear Implant Unit, Naples, IT

5 Ospedale Civile of Mantua, Otolaryngology Department, Mantua, IT

Corresponding Author:

Arianna Di Stadio, (ariannadistadio@hotmail.com)

Email Addresses of Co-Authors:

Giampietro Ricci (giampietro.ricci@unipg.it)

Franco Trabalzini (francotrabalzini@gmail.com)

Puya Dehgani Mobaraki (dehganipuya@gmail.com)

Laura Dipietro (laura.dipietro@gmail.com)

Antonio Della Volpe (antoniodellavolpe@yahoo.it)

Luca D’Ascanio (l.dascanio@gmail.com)

Jean Jacques Magnan (jypmagnan@gmail.com)

**KEYWORDS :**

Hemifacial spasm, Tinnitus, Neurovascular conflict, Minimally invasive surgery, Retro-sigmoid approach, Endoscopic surgery, Nerve decompression, Quality of life

**SHORT ABSTRACT:**

The endoscope-assisted minimally invasive retro-sigmoid approach (EAMIRSA) is a surgical technique that can be used for the treatment of the cerebellopontine angle (CPA) and internal auditory canal (IAC) disease. Here, we describe the material necessary to perform EAMIRSA and illustrate the technique using a step-by-step cadaver dissection.

**LONG ABSTRACT:**

EAMIRSA is a surgical technique that can be used for the treatment of the cerebellopontine angle (CPA) and internal auditory canal (IAC) diseases, as well as for treating schwannoma, for decompression surgeries (*e.g.*, loops of the anterior inferior cerebellar artery (AICA)), and for the vestibular neurectomy in patients with invalidating vertigo. This technique combines the use of an endoscope and a microscope; the former allows a perfect view of the surgical area (CPA, IAC, and brain structures) and the latter ensures safety of the surgery maneuvers. The use of a minimally invasive approach reduces post-surgery headachesand the risk of a Cerebrospinal Fluid (CSF) leak. Our group successfully used EAMIRSA during decompression procedures for treating a hemi-facial spasm and tinnitus. Results were satisfactory in terms of function recovery. Sequelae and surgical complications were observed in less than 1% of patients. In acoustic schwannoma surgery, facial nerve damage was observed in less than 1% of cases and the recurrence rate was 0.3%. This article describes the material necessary for performing EAMIRSA and illustrates the technique using a step-by-step cadaver dissection.

**INTRODUCTION:**

Surgical approaches to the cerebellopontine angle (CPA) and internal auditory canal (IAC) are associated with high risks due to a limited view of the target areas. Techniques that totally rely on endoscopy have been proposed1,2, but the high risk of facial nerve sequelae1, significant learning curves, and the need for a third hand for maintaining the endoscope in position 2 have limited their applicability.

The endoscope-assisted minimally invasive retro-sigmoid approach (EAMIRSA), originally proposed in 19763, was further developed in 19934 by Magnan, who used this approach for endoscope-assisted surgery. The technique was improvedby combining a microscope and an endoscope to safely treat neurovascular conflicts in the CPA/IAC5. Furthermore, different from the totally endoscopic transpromontorial approach1, the retrosigmoid route allows a total preservation of the cochlea and labyrinth2-6; this combined approach reduces the risks that are typically associated with approaches that rely on an endoscope only or a microscope only. EAMIRSA’s major advantage lies in the use of the endoscope, which allows a 360° view and thus a complete visualization of the structures’ relative positions6-8. Additionally, the endoscope allows a minimally invasive approach that reduces the risk of persistent headaches and cerebrospinal fluid (CSF) leak, which are common major complications of this type of surgeries9.

The endoscope improves visibility of the structures’ relative positions as the instrument goes inside the surgical area, thereby allowing the surgeon to investigate CPA anatomy via careful movements of the surgical instruments. This improved visualization eliminates the need for the extended craniotomy (commonly performed in CPA surgery to increase visibility and eliminate “blind” angles).

In EAMIRSA, the endoscope is first used to view and inspect the target area, which is then dissected with two hands under microscope vision6,7. EAMIRSA can be used in the treatment of different CPA and IAC diseases, schwannoma removal10, and surgical decompression of cochlear6 or facial nerves7. It has been proven to increase both the short and long-term surgical outcomes with a very low incidence (<1%) of major sequelae5-8.

In this article, we describe the material necessary for performing EAMIRSA and illustrate the technique using a step-by-step cadaver dissection.

**PROTOCOL:**

This study was approved by the Human Ethic Committee of University Hospital of Perugia and was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki.

The sample was represented from subject over 18 years, with equal sex distribution.

1. **Preparation of the Patient**
   1. Set up the operating room as shown in **Figure 1**. Place the patient on the surgical table and connect the anesthesia monitoring system.
   2. **Anesthesia**
      1. Pre-medicate with 1-2 mg of Lorazepam Oral intravenously or with 2-4 mg of Lorazepam Oral if using oral suspension.
      2. 5 to 15 min after premedication, induce general anesthesia by combining drugs for total intravenous anesthesia (TIVA) such as Propofol, short-acting opioid, and low- to-moderate levels of inhalational agents11.
   3. Intubation
      1. When the patient sleeps, open his/her mouth with the dominant hand by placing a thumb on the lower jaw and the middle finger on the upper jaw. Extend the patient’s neck.
      2. Open the laryngoscope blade and insert it into the patient’s mouth. Slowly advance the blade along the tongue dorsal surface until the tip of the epiglottis and the vocal folds is seen.
      3. Under the direct vision of the glottic plane, insert an armed endotracheal tube for intubation.
      4. To conclude this procedure, attach the endotracheal tube to the automatic respiratory machine12.

NOTE: This armed endotracheal tube is preferred in order to avoid possible occlusions and narrowing caused by inappropriate jaw contractions by the patient due to stimulation of the cranial nerves in the surgical area13.

* 1. **Surgical Preparation of the Patient**
     1. Cut the patient’s hair 6-8 cm posterior to the ear with a sterile scalpel.
     2. Turn the patient’s head to the side contralateral to the surgical site. Disinfect the skin of the surgical area with a sterile gauze imbibed with iodine-based scrub or chlorhexidine solution and grabbed with sterile gloves; repeat this step at least twice.
     3. Turn the patient head from the lateral position to a frontal position and stabilize him/her in supine position.

NOTE: The head must be turned to the side opposite to the surgical side (45°-60°), with a small flection of his/her head and chin near the clavicle.

* + 1. Protect the patient’s eyes with a lacrimal gel and close the eye with a bilateral ocular bandage. Place electrodes for facial monitoring 1 cm from lateral cantus and 1-2 cm from the mouth angle (**Figure 2a**).
    2. Change the sterile gloves with new ones. By using 4 sterile drapes prepare a sterile area that includes the posterior part of the ear and the mastoid area following the best practice guidelines14, 15.
       1. Start by placing the first drape covering the face, the second one covering the patient’s hair, the third covering the neck and the last one posteriorly to the mastoid area.
       2. Finally cover the field with transparent sterile adhesive surgical patch (**Figure 2b**).

1. **Surgical Technique**
   1. **Skin and Muscle Time**
      1. With a dermographic pen, draw the proposed incision line in the retro-auricular area (**Figure 2c, and Figure 3**).
      2. Inject 5-7 mL of 2% lidocaine with 1: 100,000 epinephrine solution using a 5 mL syringe.
      3. With a cold scalpel (No 11), perform a skin incision of 6-8 cm with an arciform shape. Make the incision with a convex side facing backwards, about 1 cm behind the supposed posterior edge of the craniotomy and 2 fingers behind the helix projection on the retro-mastoid region.
      4. With an electric scalpel, elevate an anterior skin flap. Perform a muscle-periosteal incision with posterior convexity with a monopolar scalpel (**Figure 4a**).
      5. Insert a Beckman orthostatic retractor. Expose the posterior edge of the mastoid in the posterior part of the surgical field, the digastric groove that is under the ear lobe, and the mastoid emissary vein, which bleeds more than the surrounding areas. Coagulate the mastoid emissary vein (**Figure 4b and 4c**).

NOTE: From now on, the surgical procedures are performed under microscope vision adjusting the magnification (from smaller to higher) to clearly see the anatomical structures.

* + 1. Grab the sterile microscope for otoneurosurgery with two hands and place it close to the operatory area. Focus the microscope by using 1X magnification and adjust it until the operatory area is perfectly in the center. Then use 1.6X magnification to start the bone time.
  1. **Bone Time (Figures 5a, 5b, 5c, 5d)**
     1. Take the drill with a large cutting burr and perform a circular craniotomy of 1.5- 2 cm in diameter posterior to the sigmoid sinus using its emissary vein as a landmark.

NOTE: The sigmoid sinus emissary vein is a synonymous of mastoid emissary vein.

* + 1. Start the dissection with a large cutting burr; then, use a diamond burr when the dura and the sigmoid sinus is approached to preserve their surfaces. Perform the drilling until the sigmoid sinus is completely exposed, leaving a very thin bony shell over it to preserve the venous structure.

NOTE: The sigmoid sinus is the posterior limit of the mastoidectomy area. One can identify it by listening to the sound of the drill during the procedure: the sound of the cutting burr during drilling will become metallic when in contact with the sinus. Change the cutting burr with a diamond one when the sound changes.

* + 1. After exposing the sinus, remove the hard bone from its posterior surface. When only a thin bony shell remains, use a micro bone-dissector to remove the bone without injuring the dura.
    2. Preserve the bone dust that comes out from drilling by collecting it with a spatula and then by putting it in metallic bowl until the closure time.
  1. **Dura Time (Figures 6a, 6b, 6c)**
     1. Before this step, ask all the members of the surgical team to change their sterile gloves.

NOTE: During this surgical step, ask the anesthesiologist to increase the dose of general sedation for increasing the depth of the patient’s sleep.

* + 1. With a micro-scalpel open the dura with a V shape incision, starting just behind the sigmoid sinus to reduce the need for cerebellar mechanical retraction during the access to the IAC.

NOTE: The dura incision needs to be performed without touching the brain and 1-2 mm from the craniotomy edges in order to facilitate dura re-suturing at the end of surgery.

* + 1. Perform the dura hemostasis by holding the bleeding point with a bipolar coagulator forceps and then coagulating by 1-2 shots. After that, fasten the dura to the adjacent tissues with a silk suture.
    2. Ask the anesthesiologist to gradually dehydrate the patient by administering 1 g/kg mannitol and by hyperventilation leading to an arterial pCO2 between 25 to 32 mmHg, which reduces CSF intra-cranial pressure and causes a spontaneous retraction of the cerebellum.
    3. Place a thin neurosurgical micro-cotton or surgical substitute of dura (1.5 cm x 5 cm) over the cerebellum.
  1. **Cerebellopontine Angle (CPA) Approach by Using a Microscope (Figure 6d, 6e, 6f)**
     1. Grab a small piece of cotton patch with a micro clamp without teeth and gently compress the cerebellum posteriorly.
     2. With micro-scissors, open the cisterna magna to complete the access to the CPA. Use an aspirator with hand-suction control.
     3. Under microscope view, dissect the arachnoid surrounding the cranial nerves (acoustic-facial bundle) and around the lower cranial nerves with a smooth micro-dissector.
  2. **Endoscopy Time**

NOTE: This surgery step lasts about 30 min. (**Figure 7a-7b**)

* + 1. Carefully insert a rigid 30° endoscope directing downwards to visualize the CPA.
    2. In the center of the surgical field, first identify the acoustic-facial bundle (central landmark of the CPA) as a group of nerves running from the cerebellum towards the IAC. Then identify the area where the vessel(s) is(are) direct contact with the bundle causing the neurovascular conflict (NVC).
    3. Inspect the area around the facial-acoustic bundle using the 360° view allowed by the endoscope (**Figure 8a, 8b, 8c**).
    4. During this procedure, that takes about 5 min, periodically take out the endoscope from the field and clean its tip by touching it with the cotton patch (this maneuver will help cool down the endoscope’s light); then re-introduce the endoscope into the surgical field.
  1. **Microvascular decompression under microscope with endoscope assistance (Figure 7c, 7d, 7e)**
     1. Take a smooth round micro-dissector and gently separate the vessel (offending) that is attached to the nerve involved in the microvascular compression.

NOTE: The most common offending vessel is the posterior inferior cerebellar artery (PICA) followed by the anterior inferior cerebellar artery (AICA).

* + 1. 2.6.2. If the offending vessel juts in the first portion of the IAC, drill this bony wall with a very small diamond burr to free the nerve completely.

NOTE: The drilling direction is from the CPA (behind) to the temporal bone (posterior to anterior). During the procedure, drill away only 1-3 mm of bone to prevent damage to the endolymphatic structures (sac and/or duct). It is important to follow the nerve direction to identify the IAC bony wall.

* + 1. If the loop causing the nerve compression is due to a vein, after vessel detachment, coagulate the vein by using 1-2 shots of bipolar forceps coagulator.
    2. Grab a polytetrafluoroethylene sponge with a micro-Hartman alligator forceps and insert the sponge between the offending artery(ies) and the nerve (facial/cochlear/ vestibular) to prevent impingement recurrences.
    3. Move the sponge using a micro-dissector until an appropriate and stable position is reached.

NOTE: The position where no part of the vessel remains in contact with the nerve is considered as an appropriate position. The sponge needs to restore the normal facial-acoustic bundle anatomy, where vessels run close to the nerve(s) without crossing or touching it/them.

* + 1. At the end of the microvascular decompression, use the endoscope to check the sponge perfectly divides nerve(s) and vessel(s) and to double-check the result of the decompression by orienting the endoscope upwards so as to properly visualize the vertebral artery that may cause further impingement of the nerves.
  1. **Closure (Figure 9A-9E)**
     1. With a micro-Hartman alligator forceps remove the neurosurgical micro-cotton from the surgical area and wash the CPA area with abundant saline solution with a syringe.

Note: Abundant irrigation is needed to remove residual blood cloths.

* + 1. Hold a piece of dura substitute with micro-Hartman pliers and place it to fill the posterior cisterna.
    2. With a micro needle-holder, place 6/0 single re-absorbable stitches to close the dura. In order to obtain a waterproof closure, insert some muscular tissue between the stitches and fix it with fibrin glue.
    3. Use a micro-clamp without teeth to place a piece of dura substitute on the dura external surface, then add a slide of absorbable hemostat of adequate size to cover the dura.
    4. With a micro-spatula take the bone dust, preserved during the drilling time, and lay it on the craniotomy area to obtain a homogeneous cover. Then lay some fibrin glue on the top to totally recover and fix the area. Place 2/0 absorbable interrupted sutures to close the muscle-periosteal flap and 3/0 subcutaneous absorbable stitches.
    5. Suture the skin with 2/0 nonabsorbable stitches.
    6. Apply a compression bandage, which will be kept for 4 days.

1. **Post Operatory care**
   1. Ask to the anesthetist to remove the endotracheal tube and wake up the patient.
   2. Prescribe antibiotic treatment with cephalosporins, analgesic and glycerol (if necessary) then send him/her in the intensive care department for 24 h.
   3. After the patient has come back to the otolaryngology department (24-48 h), test the spontaneous nystagmus by looking at his/her eyes during the finger-following test and evaluate if nerve deficits are present. If the patient is comfortable, ask him/her to walk with the person present in the room.
   4. After 7 days suspend medical treatments if no complication occurs and discharge the patient to his/her house.

**REPRESENTATIVE RESULTS:**

EAMIRSA has been successfully used by several surgeons4-7,9. Our group has used this technique on patients suffering from facial hemispasm (HFS) due to a vascular loop compression on the VII cranial nerve (facial) and has achieved satisfactory results in the short- and long-term follow-up, including short recovery time, symptom resolution, and absence of immediate post-operative sequelae7. Immediately after surgery, patients display a reduction of HFS intensity, and in 75% of cases the spasm completely disappears within 24 hours after surgery7. Intraoperative facial monitoring shows immediate improvement of signal transmission when the vessel is detached and the nerve is freed, demonstrating the efficacy of the decompression maneuver.

We routinely use EAMIRSA to perform vascular decompression on patients that display a vascular compressive syndrome on the VIII cranial nerve (cochlear)6 and related invalidating tinnitus not responsive to pharmacological treatment. In these cases, we use auditory brainstem response (ABR) and pure tone audiometry (PTA) testing prior and following surgery. ABR testing allows functional investigation of the hearing pathways from the nerve to the cortex and is used to confirm the diagnosis of nerve compression syndromes as well as to quantify the effectiveness of the decompression procedure. Increase in latency and amplitude of ABR waveform after surgery indicates good signal transmission within the cochlear nerve (**Figure 10**). PTA is used to quantify how conservative the EAMIRSA technique has been (and thus to assess to which extent hearing function has been preserved6) (**Figure 11**).

**Figure 12** shows a vessel compressing the cochlear nerve (**Figure 12A**, microscopic view) and the facial nerve (**Figure 12B**, endoscopic view). **Figure 13** shows the new position of the vessel after it has been detached from the nerve and sponge has been inserted to avoid possible recurrences (caused by the vessel moving back to its original position).

**FIGURE AND TABLE LEGENDS:**

**Figure 1:** **Organization of operatory room during EAMIRSA.**

**Figure 2: Patient preparation before surgery.** A) shows the position of patient’s head before preparation of a sterile surgical field, and the asterisks indicate the position of facial monitoring. B) shows the retro-mastoid area with the posterior part of the ear after sterile preparation. C): the image shows the pattern for minimally invasive retrosigmoid approach (right side). The image shows the anatomic landmarks for the surgical access: 1= Frankfurt plane between the external canthus and tragus superior edge; 2=digastric muscle plane; 3= craniotomy site projection; 4=surgical incision. This figure has been modified with permissions7.

**Figure 3: Comparison between retrosigmoid and minimally invasive approaches.** The drawing shows the difference between a standard craniotomy retrosigmoid approach and the minimally invasive one.

**Figure 4: Skin and Muscle times.** A) Preparation of the cutaneous flap. Infiltration with lidocaine/adrenaline, arciform incision with anterior convexity (7 cm long), flap rising from the tip of the mastoid towards the protuberance occipital (the incision is placed a fingertip behind the posterior rim of the mastoid process). B) Incision of the muscular-periosteal tissue with posterior convexity, elevation of muscular-periosteum flap and exposure of the mastoid area. The surgical field is limited by: the posterior edge of the mastoid, the digastric groove, the mastoid emissary vein which is coagulated and sectioned. C) Retraction of cutaneous and subcutaneous tissues with the periosteal dissector, placement of a Beckman orthostatic retractor. The yellow arrow shows the position of the emissary vein.

**Figure 5: Bone Time.** A) bone drilling with a large cutting burr on the retro-mastoid area, below the upper occipital curved line, centered on the emissary vein. B) The circular craniotomy performed by diamond cutting burr has a diameter of 1.5-2 cm and is behind the sigmoid sinus. The blue that appears in transparency is the sigmoid sinus wall and represents the anterior limit in this approach (yellow arrow). The dura is then exposed. C) The residual bone fragments are removed with a small periosteum elevator (yellow arrow) or a dura mater dissector. The yellow star indicates the open mastoid cell. D) The bone dust obtained after bone drilling is preserved to be used during the closure time.

**Figure 6: Approach to CPA.** A) A posterior convexity incision of the dura is carefully performed, after the detachment of bone splinters and closure of the open mastoid cells with Horsley wax. B) Exposition of the cerebellar lobe. C) Suspension of the dura tissue to adjacent subcutaneous tissues by using silk threads. Protection of the cerebellar lobe with substitute of dura (white). D) Slight compression of the cerebellum by using substitute of dura to visualize the CPA. E) Opening of the cisterna magna: the CSF coming out from the surgical field is removed with hand-control suction (thus increasing cerebellum retraction). F) Release of arachnoid adhesions for a better exposure of the acoustic-facial bundle.

**Figure 7: Surgical Decompression.** A) and B) Endoscopic views of the neurovascular impingement (different depths). C) Dissection of the contact area between the vessel and nerve. D) Teflon interposition to divide vessel and nerve and avoid recurrence. E) Endoscopic view after nerve decompression.

**Figure 8: Endoscope investigation of structures.** The images show the vessel and the acoustic-facial bundle from three different points of view.

**Figure 9:** **Closure time.** A) Filling of posterior cisterna, insertion of substitute of dura, and closure of the dura by stiches with interposition of glued muscle fragments. B) Insertion of substitute of dura on the external surface of the sutured dura. C) Bone dust glued with fibrin glue and shaped as the craniotomy. D) Apposition of glued bone dust on the craniotomy. E) Closure of skin with interrupted stitches.

**Figure 10:** **Auditory Brain Response.** The left and right panel shows ABR recorded prior and after decompression with EAMIRSA, respectively. The red arrow indicates a change in waveform indicative of improvement in electric signal transmission.

**Figure 11: Pure tone Test.** Results of PTA testing performed on a patient after left cochlear nerve decompression surgery. The auditory threshold in the affected (left) side (x and black line) is similar to that in the normal (right) side (circle and red line), which indicates total preservation of auditory function and absence of intra-operative lesions.

**Figure 12: Comparation between microscopic and endoscopic view before surgery.** The left panel (A) shows a microscopic view (20 x) of a loop impingement with the cochlear nerve on the left side. The right panel (B) shows an endoscopic view of the Anterior Inferior Cerebellar Artery (AICA) compressing the facial nerve in the Root Entry Zone (REZ) on the right side. This figure has been modified with permissions7.

**Figure 13: Endoscopic versus microscopic view after decompression:** Panel A (left ear) and Panel B (right side) show respectively a microscopic view (20X) and endoscopic view of the CPA after surgical decompression surgery and Teflon interposition. This figure has been modified with permissions7.

**DISCUSSION:**

Loops in the CPA and IAC ultimately manifest with a number of symptoms/signs, including HFS and tinnitus. In our previous studies6,7, we quantified the correlation between the loop presence and the occurrence of HFS (or tinnitus) on the ipsilateral side. We also found that in cases where tinnitus was due to a loop impingement involving the cochlear nerve, the minimum caliber of the impinging vessel was 0.8 mm6.

Traditionally, loops in the CPA and IAC are treated with microvascular decompression (MVD), a technique first introduced by Jannetta and colleagues in 197716 specifically for treating vessels impinging on CPA and/or IAC nerves. MVD consists of detaching the offending vascular loop(s) and securing it (them) with a nonabsorbent synthetic sponge with no intentional trauma or disruption of the nerve. Unfortunately, MVD has several limitations, which have led to failures, recurrences, and complications16-23. It has been reported that MVD has a mortality rate of 0.2%, and an overall complication rate that ranges from 5% to 25% for temporary dysfunction and from 2% to 10% for permanent neurologic impairment16-23. Auditory or facial nerve structures are at high risk of damage: the auditory nerve is reported to be temporary damaged in 3%-5% of cases after surgery, while a permanent damage (hearing loss or deafness) is reported in 2%-3% of cases12-20. A facial nerve impairment occurs temporarily in approximately 4% of patients, whereas 1%-2% of patients show permanent facial nerve deficit16-23.

Precise localization of all nerve-vessel conflicts and confirmation of complete nerve decompression at the end of the procedure are key steps to a successful decompression surgery. However, in MVD, as reported by Jannetta *et al.*16, the anatomy of the posterior fossa and the limited size of the craniotomy make it difficult to visualize the whole facial nerve course and the porus portion using a microscope only16-18. These limitations can be overcome using EAMIRSA, which combines the advantages of microscope with those of endoscope.

Endoscopy allows an excellent direct vision of target structures, but hand movements are limited by the lack of specific neuro-otoendoscopic instruments and the need to hold the endoscope with one hand (which means that surgical maneuvers need to be performed with one hand only). On the other hand, using a microscope during a decompression maneuver allows the surgeon to work in wide areas with two hands, even though the view of the impingement site and neuronal/vascular structures is limited. In EAMIRSA, the combined use of the endoscope and microscope allows one to overcome such limitations. First, the endoscope is used by the surgeon to completely inspect the surgery area and to precisely identify the target structures. Then, during surgery, the endoscope allows the surgeon to minimize hands movements and remove pressure on the cerebellum, thereby reducing the risk of neurological complications. In surgeries that involve decompression of loops in the CPA or loops partially or totally jutting into the IAC, the angled vision offered by the endoscope allows the surgeon to better visualize the impingement site and perform the decompression maneuvers safely. In loops jutting into the IAC, partial drilling of the canal is an additional surgical step needed to completely free the nerve from the conflict. This step increases the surgical space and allows easy detachment of the structures before the final step. Thanks to the endoscope, the surgeon can easily see the position of the vessel relative to the nerve, after which she/he can proceed safely under microscope view and finally insert a small piece of thin polyester urethane sponge between the vessel and the facial or cochlear nerve.

Compared to the microscopic straight linear view (typically used in MVD), EAMIRSA offers a superior vision of the course of the offending vessel thanks to the endoscope (which allows a 360° vision of the surgical field). In particular, the 30° endoscope, which we recommend, offers the best “around-the-corner” visualization of the IAC. Compared to a fully endoscopic surgery, EAMIRSA offers better control of bleeding in presence of anomalous vessels in the CPA, and easy switching to a traditional surgery under microscope in case of emergency.

We previously reported6,7 that EAMIRSA is a safe and well tolerated procedure7 without relevant immediate6 and long term post-operative sequelae6. EAMIRSA allowed us to safely and successfully treat HFS and tinnitus without the complications that typically affect the nerves when surgery is conducted under microscope only16-23. The patients we operated on with EAMIRSA did not present any neurological complications immediately after surgery and several years post-surgery7. EAMIRSA allowed us to perform surgery even on elderly subjects, commonly more at risk of complications than young subjects due to associated comorbidities (*e.g.,* hypertension), without increased postoperative sequelae7 thanks to the following advantages: a direct view of the nerve-vessel contact, which makes the dislocation of the acoustic-facial bundle and relevant cerebellum retraction unnecessary24-27; and a minimally invasive opening window (< 3 cm) in the sigmoid area, which maintains normal intracranial pressure and limits the chance of bacterial infection, thus reducing the risk of CSF leak and of headaches after surgery. Furthermore, EAMIRSA has been successfully used for treating schwannoma9 with very low complication rates compared to the fully endoscopic technique28. Finally, it should be noted that EAMIRSA allows the surgeon to improve her/his skills, especially microsurgery manual dexterity, and knowledge of normal and pathologic anatomy of CPA and IAC, which in turn can help improve management and planning of decompression surgeries.

Limitations of EAMIRSA when used in the CPA include a relative slow learning curve, and risk of structure damage, potentially caused by the use of an endoscope in such small areas. In conclusion, our studies suggest that EAMIRSA is effective for surgeries involving CPA and IAC, and in particular for those aimed at treating vascular impingements in these areas.

**ACKNOWLEDGMENTS:**

Special thanks to the surgery team of Dr. E. Zanoletti and Dr. G.P. Ricci for their support in the study. Thanks to all collaborators of the Permanent Temporal Bone Laboratory of University of Perugia.

**DISCLOSURES:**

The authors have nothing to disclose.

**REFERENCES:**

1. Marchioni, D*., et al.* Expanded Transcanal Transpromontorial Approach: A Novel Surgical Technique for Cerebellopontine Angle Vestibular Schwannoma Removal. *Otolaryngology Head and Neck Surgery.* **158** (4), 710-715 (2018).

2.Setty, P., Babu, S., LaRouere, M.J., Pieper, D.R. Fully Endoscopic Retrosigmoid Vestibular Nerve Section for Refractory Meniere Disease. *Journal Neurological Surgery Basic Skull Base.* **77** (4), 341-9 (2016).

3. Bremond, G., Garcin, M., Magnan, J. Progres en otoneurochirurgie: l’abord a minima de l’angle pontocerebelleux par la voie retrosigmoide *Acta oto-rhino-laryngologica Belgica* **30**, 127-144 (1976).

4. Magnan, J., *et al.* Apport de l’endoscopie de l’angle pontocerebelleux par voie retrosigmoide: Neurinomes et Conflits vasculo-nerveux *Ann OtoLaryngo. Chir Cervicofac* *(Paris)*; **110**, 239-265 (1993).

5. Badr-El-Dine, M., El-Garem, H.F., Talaat, A.M., Magnan, J. Endoscopically assisted minimally invasive microvascular decompression of hemifacial spasm. *Otology and Neurotology*. **23** (2), 122-8 (2002).

6. Di Stadio, A*., et al.* Microsurgical decompression of the cochlear nerve to treat disabling tinnitus via an endoscope-assisted retro-sigmoid approach: the Padua experience. *World Neurosurgery.* pii: S1878-8750(18)30378-4 (2018).

7. Ricci, G.P., *et al.* Endoscope-assisted retrosigmoid approach in hemifacial spasm: our experience. *Brazilian Journal Otolarhynolaryngology* pii: S1808-8694(18)30179-4 (2018).

8. Guevara, N., Deveze, A., Buza, V., Laffont, B., Magnan, J. Microvascular decompression of cochlear nerve for tinnitus incapacity: pre-surgical data, surgical analyses and long-term follow-up of 15 patients. *European Archives of Otorhinolaryngology.* **265** (4), 397-401 (2008).

9.Tolisano, A.M., Littlefield, P.D. Adverse Events Following Vestibular Schwannoma Surgery: A Comparison of Surgical Approach. *Otology and Neurotology.* **38** (4), 551-554 (2017).

10.Shahinian, H.K., Eby, J.B., Ocon, M. Fully endoscopic excision of vestibular schwannomas. *Minimally Invasive Neurosurgery.* **47** (6), 329-32 (2004).

11. Eriksson, L.I., Fleisher, L.A., Miller, R.D. Miller Anesthesia. *Saunders Elsevier.* ISBN: 9780702052835 (2015).

12. Whitten, C. The Airway Jedi. <https://airwayjedi.com/2016/10/10/intubation-step-by-step/> (2018).

13. Fàbregas, N., Craen. R.A. Anesthetic Techniques in Endoscopic Sinus and Skull Base Surgery. *Current Opinion in Anesthesiology.* **23**(5), 568–575 (2016).

14. Winnipeg Regional Health Authority. Best Practice Guidelines. <http://www.wrha.mb.ca/extranet/eipt/files/EIPT-005-001.pdf> (2018).

15. Surg Sidhwa, F., Itani, K.M. Skin preparation before surgery: options and evidence*. Surgical infections.* **16** (1), 14-23, doi: 10.1089/sur.2015.010 (2015).

16.Jannetta, P.J., Abbasy, M., Maroon, J.C., Ramos, F.M., Albin, M.S. Etiology and definitive microsurgical treatment of hemifacial spasm. Operative techniques and results in 47 patients. *Journal of Neurosurgery.* **47**, 321-8 (1977).

17. Feng, B.H., *et al.* Management of vessels passing through the facial nerve in the treatment of hemifacial spasm. *Acta Neurochirurgica.* **157**, 1935-40 (2015).

18. Sharma, R*., et al.* Microvascular decompression for hemifacial spasm: A systematic review of vascular pathology, long term treatment efficacy and safety. *Neurologic India.* **65**, 493-505 (2017).

19. Liu, J*., et al.* Microvascular decompression for atypical hemifacial spasm: lessons learned from a retrospective study of 12 cases*. Journal of Neurosurgery.* **124**, 397-402 (2016).

20.Campero, A*., et al.*Microvascular decompression in hemifacial spasm: 13 cases report and review of the literature. *Surgical Neurology International.* **7**, S201-7 (2016).

21.Fukushima, T. Microvascular decompression for hemifacial spasm: result in 2890 cases. In: Neurovascular surgery. *New York: McGraw Hill, Inc;* 1133-45 (1995).

22.Hanakita, J., Kondo, A. Serious complications of microvascular decompression operations for trigeminal neuralgia and hemifacial spasm*. Neurosurgery.* **22**, 348-52 (1988).

23.Kureshi, S.A., Wilkins, R.H. Posterior fossa re-exploration for persistent or recurrent trigeminal neuralgia or hemifacial spasm: surgical findings and therapeutic implications. *Neurosurgery.* **43**, 1111-7 (1988).

24.Rak, R., Sekhar, L.N., Stimac, D., Hechl, P. Endoscope-assisted microsurgery for microvascular compression syndromes. *Neurosurgery.* **54**, 876-81 (2004).

25.Magnan, J., Caces, F., Locatelli, P., Chays, A. Hemifacial spasm: endoscopic vascular decompression. *Otolaryngology Head Neck Surgery.* **117**, 308-14 (1997).

26. Badr-El-Dine, M., El-Garem, H.F., Talaat, A.M., Magnan, J. Endoscopically assisted minimally invasive microvascular decompression of hemifacial spasm. *Otology and Neurotology.* **23,** 122-8 (2002).

27.Magnan, J*., et al.* Role of endoscopy and vascular decompression in the treatment of hemifacial spasm. *Annales of Otolaryngologie et Chirurgie Cervicofaciale.* **111**, 153-60 (1994).

28.Marchioni, D*., et al.* Transcanal Transpromontorial Acoustic Neuroma Surgery: Results and Facial Nerve Outcomes. *Otology and Neurotol.* **39** (2), 242-249 (2018).