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HOW I DO IT - NEUROSURGICAL TECHNIQUE EVALUATION

# How I do it: 3D exoscopic endoscope-assisted microvascular decompression

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## Abstract

**Background** Microvascular decompression (MVD) is an effective treatment for drug-resistant trigeminal neuralgia and hemifacial spasm. However, failure of symptomatic improvement can arise from difficulties in identifying and/or decompressing the offending vessel. Microscopic and endoscopic techniques have been used to improve visualisation and safety of the procedure but there are limitations to each technique.
**Method** A 3D exoscopic endoscope-assisted MVD technique is described, including advice on potential pitfalls.
**Conclusion** Compared with the standard microscope-assisted techniques, the 3D exoscopic endoscope-assisted MVD offers an improved visualisation without compromising the field of view within and outside the surgical field.

**Keywords** Microvascular decompression · 3D exoscopy · Endoscopy

A 3D exoscopic endoscope-assisted technique is described for microvascular decompression (MVD) in patients affected by cranial nerves rhizopathies, such as trigeminal neuralgia (TN) and hemifacial spasm (HFS).

## Relevant surgical anatomy

In TN, the superior cerebellar artery (SCA) is the most frequently offending vessel, followed by the anterior inferior cerebellar artery (AICA) [2]. Compression can occur at the root entry/exit zone or in the lateral cisternal segment of the trigeminal nerve. In HFS, compression can arise from the AICA, posterior inferior cerebellar artery (PICA), vertebral-basilar artery and veins; commonly at the dorsal root exit zone (DREZ), at the level of the supraolivary fossette. More infrequently, the compression occurs in the cisternal portion of the nerve or rarely at the internal acoustic meatus [3]. The site of vascular contact also tends to be more medial in HFS cases compared with TN cases due to the shorter length of the nerve. Hence, the risk of missing the vascular compression is more likely when treating HFS, especially if there is inadequate exposure [8]. Failure to identify the offending vessel and subsequent inadequate decompression can result in poor clinical outcome. Neuroendoscopy and multiscope technique have been described to improve visualisation and outcome [1, 4–7].

## Description of the technique

The patient is positioned supine with the head rotated contralaterally or in park bench position, with the vertex tilted downward. Neuromonitoring (including brainstem auditory evoked responses and lateral spread response (LSR) in HFN cases) is recommended.

The exoscope VITOM® 3D (Karl Storz) is set up in combination with the endoscope. In the authors' opinion, the

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exoscopic visualisation offers a wider and brighter image, compared with the microscope. It is also less cumbersome to use in combination with the endoscope thanks to its 20–50 cm working distance and magnification of approximately ×8–×30, which allows it to be positioned further from the surgical field. The exoscope further provides a bird's-eye view outside the endoscopic view without obstructing the operator.

Positioning is a key for a congruous exoscopic-endoscopic technique. The exoscope holding arm faces the operator's non-dominant hand. Two monitor screens are positioned side by side, facing the operator that concurrently displays the exoscopic and endoscopic view (Fig. 1 and Video).

The skin incision, bony skeletonisation and craniectomy (or craniotomy, according to surgeons' preference and patient's features) are performed under exoscopic visualisation, to allow the surgeon to adapt to the required hand-eye-depth coordination. Following a retroauricular linear incision, a 2–2.5-cm retrosigmoid craniectomy/craniotomy is performed, using anatomical landmarks and/or intraoperative stereotaxy to map the dural sinuses' position (Fig. 2). Dural opening and cerebrospinal fluid drainage from the cerebellopontine angle (CPA) cisterns are performed under 3D exoscopic visualisation. The arachnoid membranes and trabeculations are gently dissected to identify the cranial nerves and vasculature within the CPA. An adequate exposure of the cisterns allows introduction of the endoscope without further retraction of the cerebellum.

A 30°endoscope is used to inspect the anatomy around the nerve and to identify the offending vessel hidden from a perpendicular visual point of view. This is particularly helpful if the conflicting vessel is wrapping or "sandwiched" between the nerves (Fig. 3). If irritation of the nerve is noted on neuromonitoring, surgery is paused and the nerve is washed with cold water until resumption of normal neuromonitoring values.

Teflon pledgets are placed between the nerve and the vessel all the way to the root entry/exit zone, followed by fibrin sealant to keep the construct in place. The 30° endoscope is used to assess the decompression and rule out any further source of compression. Once satisfactory decompression is obtained, the microscope can be used to compare the quality of the images obtained and to inspect the decompression, although it is not always necessary (Fig. 4).

Closure is performed under exoscopic visualisation in a standard fashion. The dural closure can be reinforced with dural substitutes and/or glue. Cranioplasty is performed.

## Indications

The exoscope-endoscope synergy can be used for deep intracranial or skull base procedures where endoscopic work could be made safer by visualisation of the blind spot in and out of the operating field. Having the addi-

**Fig. 1** The surgeon and the team wear 3D glasses. The left screen shows the 3D exoscopic view, whilst the right one shows the endoscopic image. The exoscopic holding arm and the image pilot, to control the microscopic movements of the exoscope, are on the left of the surgeon

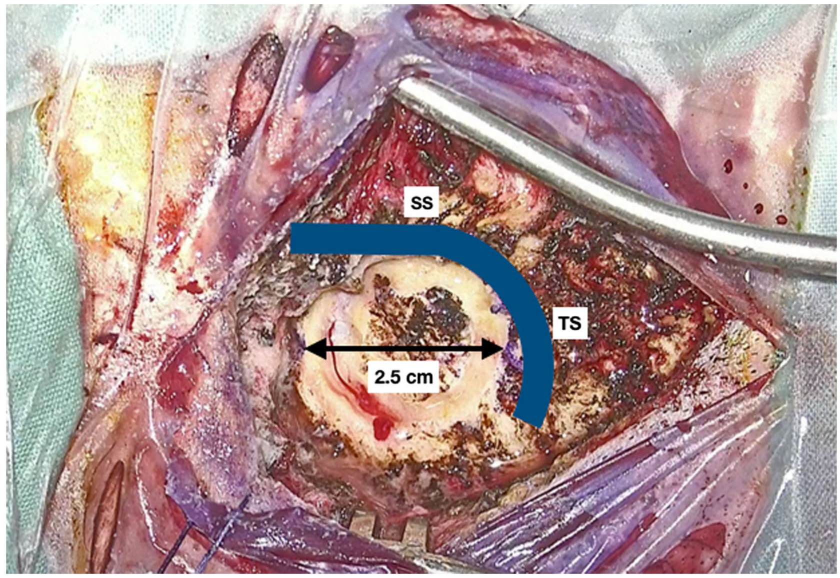


Fig. 2 Exoscopic view of retrosigmoid paracerebellar approach with the VITOM® 3D (Karl Storz). A 2–2.5-cm craniotomy is performed inferiorly to the transverse sinus (TS) and posteriorly to the sigmoid sinus (SS). The resolution of the 3D exoscope can produce sharper, brighter and higher quality images compared with the microscope

tional view with the endoscope to navigate around the neurovascular structures can help ensure all the areas of possible compression are explored (Fig. 5). Moreover, the use of the exoscope from the beginning of the operation (including the skin incision) allows the entire surgical team as well as the observers present in the surgical theatre to follow each step of the procedure in 3D. This makes each operative experience more comprehensive and didactic for all involved.

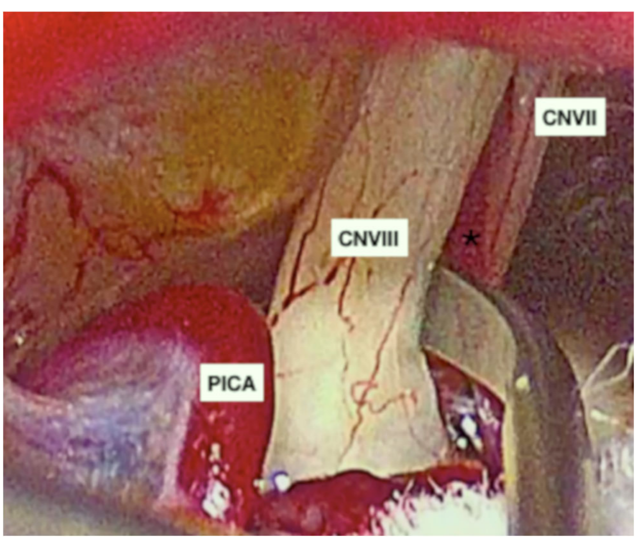


Fig. 3 Exoscopic view of the cerebellopontine angle in microvascular decompression for hemifacial spasm. Multiple areas of nerve compression are illustrated above. Cranial nerves complex VII–VIII has been exposed. A branch from the AICA (*) is seen looping between CN VII and VIII, compressing the facial nerve from the DREZ to the internal auditory meatus

## Limitations

There is limited experience with this technique. There is a different learning curve, which can be quite steep for surgeons used to perform microneurosurgery only with the microscope. The tip of the endoscope should not be too close to the nerves, in order to avoid any thermal injury. Re-adjustment of the exoscope and/or endoscope arms may be required during surgery, slowing down the surgical flow, although a foot pedal switch and robotic systems will overcome such a limitation. Moreover, whilst several surgeons do not remove the 3D glasses whilst looking at non-3D videos, thereby losing brightness and colour definition of the endoscopic image, others prefer to view the endoscopic images without the 3D glasses, which is a step that requires external assistance to both

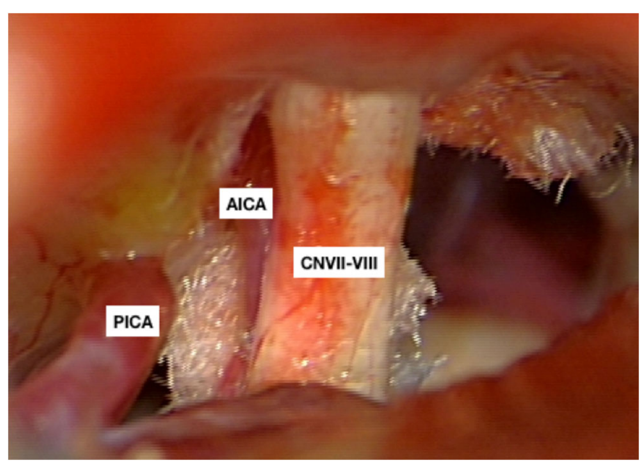


Fig. 4 Microscopic view of the MVD after placement of Teflon pledgets between the nerve and the vessel all the way to the root entry/exit zone. Fibrin sealant is used to stabilise the pledgets

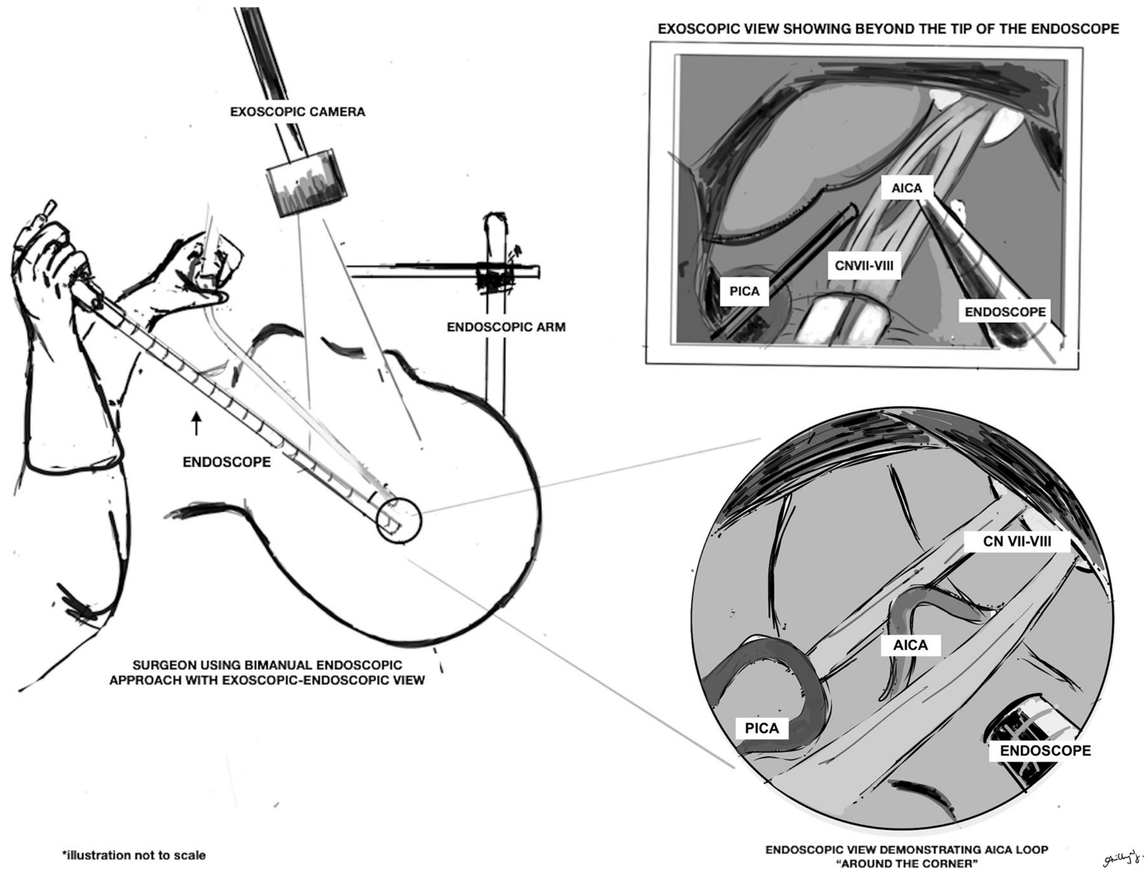


**Fig. 5** Surgeon using bimanual endoscopic approach with dual exoscopic-endoscopic vision. The exoscopic view allows surgeon to have a bird's-eye view of the endoscopic approach and to see beyond the tip of the endoscope. The endoscopic view allows surgeon to see "around the corner" and better identify course of neurovascular compression at a different angle to what can be visualised with the exoscopic view

remove the glasses and put them back on again, thus slowing the flow of the operation. Last but not least, the 3D exoscopic endoscope-assisted technique does not reduce the size of the bony and dural openings. More cases need to be tested to determine generalisation of the approach.

## How to avoid complications

Anatomy lab training and the use of the exoscope along all the surgical steps are of paramount importance. Also, understanding the limits of one's learning curve and reverting back to the microscope if needed is an important lesson when starting out with this approach. The senior author (ADI) has used the VITOM® exoscope since 2010 for anatomical research and for both cranial and spinal surgical applications, and the recent transition from 2D to 3D has fulfilled the previous limitations.

In some cases, the senior author still switches the use of the surgical microscope with the exoscope and endoscope (Fig. 4), to confirm the efficacy of the performed operation and to compare the images obtained with the different visualisation systems.

## Specific information to give patient about surgery and potential risks

Patients should be informed of typical risks related to microsurgical MVD, including but not limited to facial nerve deficit, hearing loss or impairment, stroke, post-operative CSF leakage or infections, pseudomeningocele, lack of benefit from surgery and symptom recurrence requiring further surgery. In so far, no specific risks have been identified that are attributed to the exoscopic/endoscopic technique.

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### Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

**Informed consent** Informed consent was obtained from the patient included in the study.

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Summary of key points

- The combined exoscope-endoscopic technique enhances the operative field of view by its bimodal system and makes inserting or removing instruments from the operative field safer.
- The use of EMG and brainstem evoked potential is recommended.
- The exoscope should be used along each surgical step whenever possible.
- The endoscope is used as an adjunct to enhance visualisation and identification of the offending vessel.
- A post-decompression check can also be performed with the endoscope and confirmed by the use of microscope.
- The nerve should be decompressed along the whole length of the nerve, as multiple areas of compression can be present. Careful pre-operative analysis of the CISS-MRI can help to identify further vascular loops causing cranial nerve compression.
- Teflon pledgets can be kept in place using fibrin sealant at the end of the decompression.
- There is a different learning curve to this technique and the use of the combined approach is recommended for simple procedures when starting out.
- Anatomical training lab is essential for mastering the technique, as well as testing the best ergonomics in terms of positioning of the exoscope and endoscope arms, monitors, etc.
- The endoscope can be used pre- and post-decompression to enhance visualisation of the neurovascular complex.