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ORIGINAL ARTICLE

Endoscope Assisted Microvascular Decompression for Trigeminal Neuralgia: Surgical Safety and Efficacy

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ABSTRACT

Background: The cranial nerve (CN) V and adjacent neurovascular structures are crucial landmarks in microvascular decompression (MVD). MVD of CN V is the most effective treatment for patients with drug-resistant trigeminal neuralgia (TN) diagnosis. The endoscope-assisted retrosigmoid approach (RSA) provides better exposure and less cerebellar retraction in the corridor towards the cerebellopontine angle (CPA).
Methods: Five adult cadaver heads (10 sides) underwent dissection of the MVD in park bench position. MVD was simulated using microsurgical RSA, and the anatomical landmarks were defined. Microsurgical dissections were additionally performed along the endoscopic surgical path. Additionally, we present an illustrative case with TN caused by anterior inferior cerebellar artery (AICA) compression. The CN V and its close relationships were demonstrated. Endoscopic and microscopic three-dimensional pictures were obtained.
Results: This study increases the anatomical and surgical orientation for CN V and surrounding structures. The CN V arises from the lateral part of the pons and runs obliquely upward toward the petrous apex. It has motor roots that leave from pons antero-supero-medial direction to the sensory root. The endoscopic instruments provide perfect visualization with minimal cerebellar retraction during MVD.
Conclusion: MVD surgically targets the offending vessel(s) leading to TN and aims to create a disconnected area. The combination of preoperative radiographic assessment with and anatomical correlation provides safe and effective application while facilitating selection of the most appropriate approach. The RSA allows satisfactory visualization for CN V. Endoscope-assisted microsurgery through the CPA is a challenge, it should be performed with advanced anatomical knowledge.

KEYWORDS

endoscopic; anatomy; microvascular decompression; trigeminal; neurovascular

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ABBREVIATIONS

Anterior inferior cerebellar artery = AICA, cerebrospinal fluid = CSF, cranial nerve = CN, cerebellopontine angle = CPA, internal auditory meatus = IAM, magnetic resonance imaging = MRI, microvascular decompression = MVD, posterior inferior cerebellar artery = PICA, retrosigmoid approach = RSA, root entry zone = REZ, superior cerebellar artery = SCA, superior, petrosal vein = SPV, transverse pontine vein = TPV, trigeminal neuralgia = TN

HIGHLIGHTS

- This study assesses to emphasize the aim of the microvascular decompression (MVD) in trigeminal neuralgia.
- To emphasized the endoscope is one the best item for performing MVD surgery.
- To emphasized that the limitations of endoscopic surgery will likely decrease with surgical experience and improved anatomic knowledge.

INTRODUCTION

Trigeminal neuralgia (TN) is sudden lancinating pain on one side of face in the distribution of one or more branches of cranial nerve (CN) V (1, 2). The structures along the lateral cerebellar area to the CPA, including the pons, medulla oblongata, cerebellar lateral surfaces, cerebellar peduncles, tonsils, fissures, and the vessels in the posterior fossa, are course into neurovascular complexes (3, 4). The main reason of the TN is compression of CN V at root entry zone (REZ) by vessel(s) including the superior petrosal vein (SPV), transverse pontine vein (TPV), superior cerebellar artery (SCA), anterior inferior cerebellar artery (AICA), posterior inferior cerebellar artery (PICA) or branches of these vessels. Vascular compression was first mentioned by Dandy in 1920s (1–3). The most common offending arteries have been reported respectively as SCA and AICA and account for 52% and 8% respectively in procedures performed for TN. These arteries usually contact at the target point that known as REZ stays on the superior or superomedial aspect of the CN V (3, 5).

Microvascular decompression (MVD) has been first popularized by Jannetta and proved to be effective as a non-destructive and curative treatment even it is the most invasive operative procedure for TN. It is known as a gold standard surgical procedure in treatment of TN, highly successful (6–10). Surgical treatment is preferred for refractory cases or if pharmacological treatment is not effective. During MVD, full exposure of the REZ is critical and correlated via the success of surgical outcome. This is the main reason why use of the endoscope for better visualization in addition to the traditional microsurgical approaches have been emphasized in late decades (11–14).

Our study uses an anatomical dissection performed by microsurgical and endoscopic techniques to delineate the relevant anatomy of the posterior fossa in particular REZ of CN V. It provides step-by-step demonstration in accordance with endoscope-assisted MVD via retrosigmoid approach (RSA). An illustrative case of TN secondary to AICA compression is also presented for better describing.

The main aim of this study is to increase the surgical orientation, to define the limitations, and to provide better anatomical knowledge for performing procedures with no neurovascular injury.

METHODS

ANATOMIC DISSECTION

Five formalin-fixed silicone-injected cadaver heads (10 sides) without any posterior fossa, cerebellopontine angle (CPA) or brainstem pathology were used. The dissections around the CPA and along the surgical route to the lateral cerebellar region were performed under ×6 to ×40 magnification using a Surgical Microscope (Carl Zeiss AG, Oberkochen, Germany). Three-dimensional photographs of the dissection were recorded. Surgical steps during the RSA were simulated in the remaining cadaveric heads. In addition, all of the surgical interventions of MVD during the RSA were simulated in the remaining cadaveric heads using 0° and 30° rigid straight Storz Endoscopy (Karl Storz SE & Co. KG, Tuttlingen, Germany).

ILLUSTRATIVE CASE

A case presented with right-sided TN, for which a sufficient nerve decompression could be achieved using RSA. The case was operated via the endoscopic assisted-MVD, through a trans- RSA. Along with a brief discussion on the factors influencing the surgical route and approach selection, radiological and anatomical features and intraoperative findings that are evaluated in the preoperative stage were presented.

RESULTS

ENDOSCOPE-ASSISTED ANATOMICAL MICROSURGICAL DISSECTION

Head positioning and Craniotomy

The cadaveric heads were fixed suitable in accordance with the park bench position using a Mayfield with 3-pin head clamp for RSA. Anatomic dissections along the endoscopic route to the CPA under ×6 to ×40 magnification power from anterior to the deep area. Following the microsurgery, endoscope-assisted RSA provides visualization for relationship between the CN V and associated important neurovascular structures. 10 craniotomies were performed for endoscope-assisted RSA on both sides following standard procedures.

Intradural Stage

After opening the dura with a C-shaped incision, dura mater is fixed anteriorly and reflected against the sigmoid

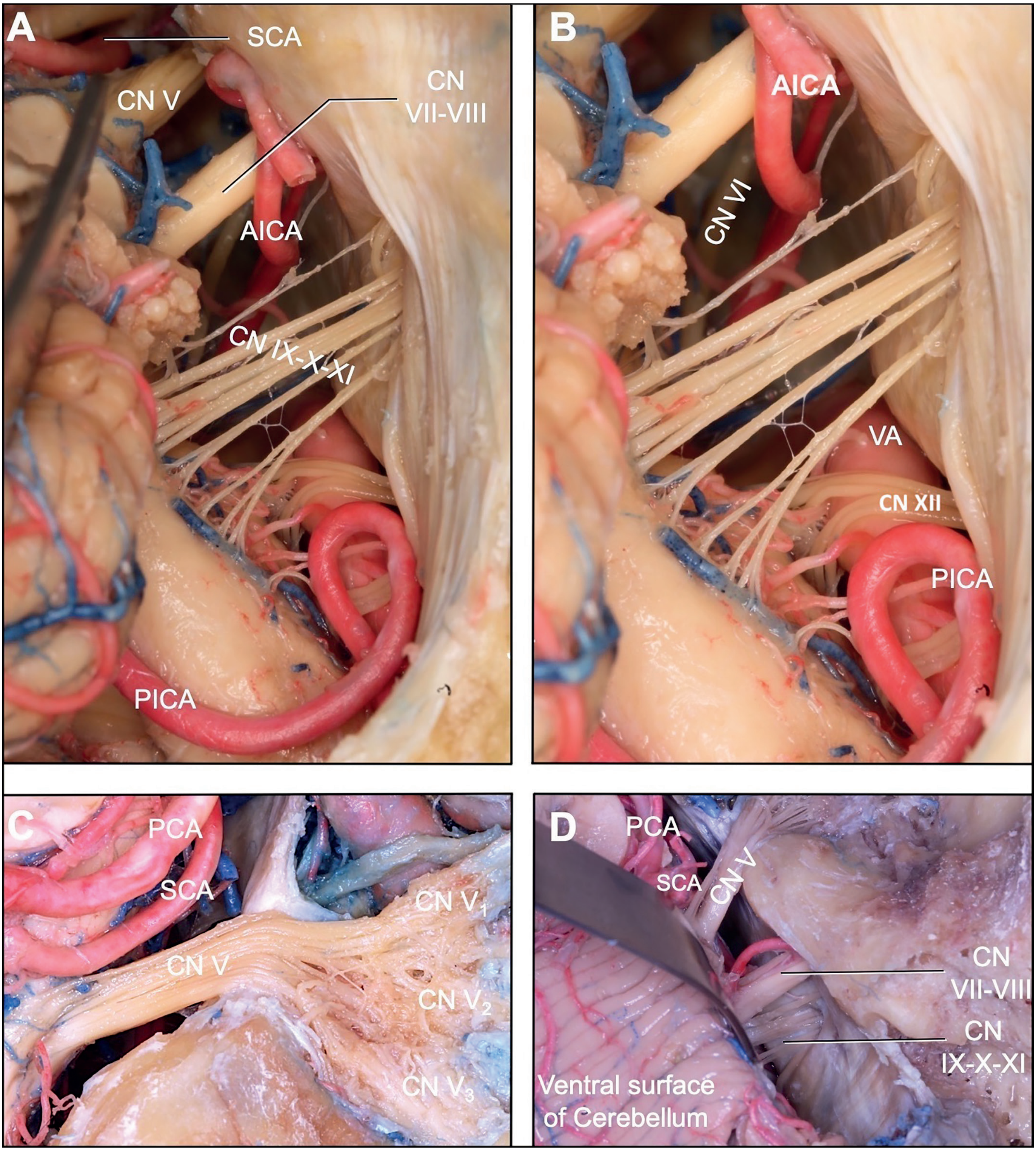

Fig. 1 Using RSA, correlated microsurgical supported cadaver dissection in human specimens to our surgery was performed to obtain better visualization of the targeted area for MVD. (A) Microscopic view of the root entry zone of cranial nerve (CN) V. A suitable surgical exposure for the lower CNs, CN VII–VIII nerve complex and the CN V. The cerebellum has been elevated to expose the CN IX–X–XI are revealed at the level of the dural roof of the JF. IAM when compared with the glossopharyngeal and the vagal meatuses has a deeper characteristic. (B) The intradural exposure on the right side (A and B) structures after removing the arachnoid mater to expose the assessing the surgical window created via RSA along the lateral cerebellum. This approach provides an improved surgical corridor along the lateral cerebellum to the CPA to expose the CN VII, VIII and CN IX–X–XI superiorly. (C) Stepwise dissection for superolateral view by removing the lateral dural wall of the Meckel's cave and the posterior fossa to demonstrate the upper surface of the CN V for better surgical orientation and its origin and relationship with brainstem on right side. (D) The surgical corridor between the posterior fossa and the posterior part of the middle fossa floor. Cerebellar retraction to the medial side provides better exposing the origin of the CNs V, VII, VIII, AICA and lower CNs. The superior surface of CN V is indented by SCA and pontotrigeminal vein.

Abbreviations: Anterior inferior cerebellar artery = AICA; cranial nerve = CN; cerebellopontine angle = CPA; jugular foramen = JF; internal acustic meatus = IAM; microvascular decompression = MVD; posterior cerebellar artery = PCA; posterior inferior cerebellar artery = PICA; retrosigmoid approach = RSA; superior cerebellar artery = SCA; vertebral artery = VA

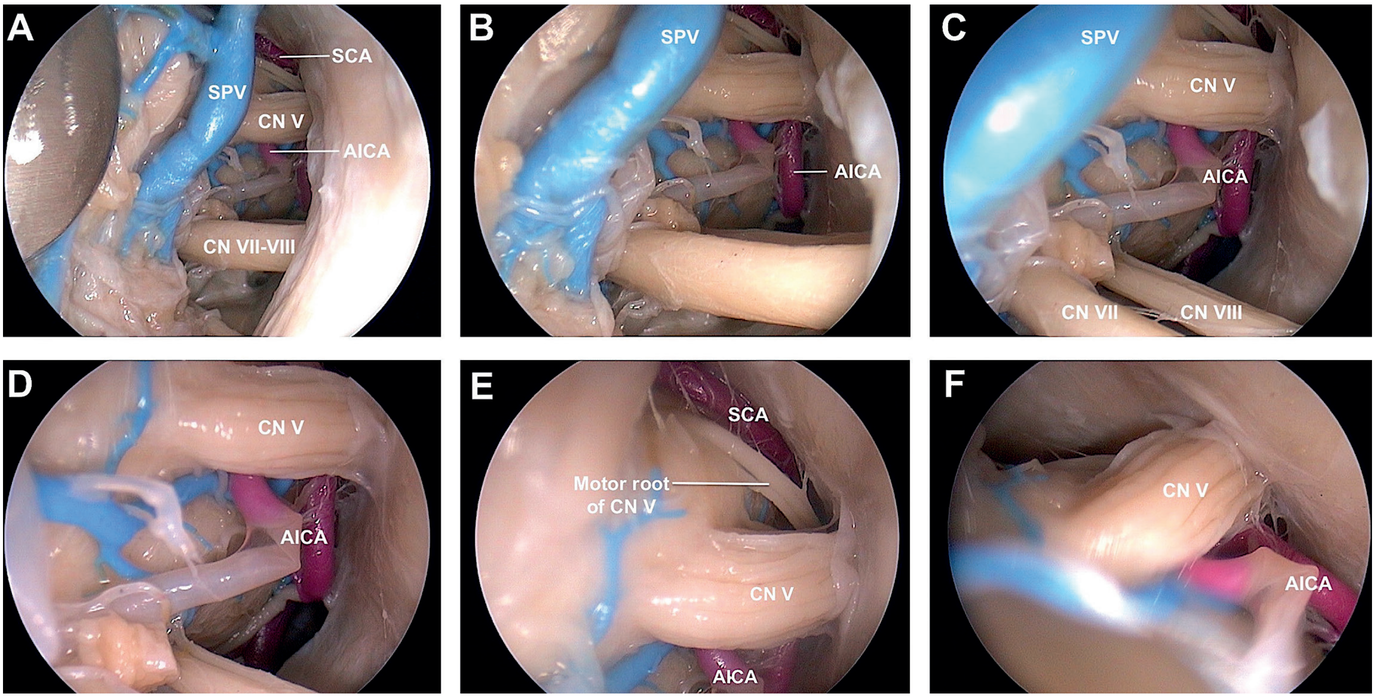

Fig. 2 The RSA has been completed. The intradural endoscopic exposure on left (A–F) has been exposed to assess for MVD and to expose the CN V via a surgical corridor along the lateral ceebellum to the dorsal brain stem. RSA provides an improved surgical corridor to expose the CNs V, VII, VIII and CN IX–XI superiorly.

Abbreviations: Anterior inferior cerebellar artery = AICA; cranial nerve = CN; microvascular decompression = MVD; retrosigmoid approach = RSA; superior cerebellar artery = SCA; superior petrosal vein = SPV

and transversal sinuses for better exposing the corner they meet. This dura mater flap can be fixed anteriorly by using a thin stitch to maximize the volume of working area that is necessary for variable tools, therefore minimizing instrument conflict. CN V and other related structures may be observed with minimal cerebellar retraction. CN V is seen that originates from the lateral part of the pons and travels obliquely upward toward the petrous apex. The motor roots of CN V leave from pons antero-supero-medial to REZ of the sensory root. They are exposed in the adherent area to the basal wall of the cave in its distal portion and course the Meckel's cave inferior to the trigeminal ganglion. Many motor and sensory roots are coursed around the junction of the nerve with the pons. When the CN V in the prepontine cistern is exposed, close relationship with the SPV, TPV, SCA and/or the AICA are seen (Figure 1A, B). CN V crosses the tentorial attachment and joins Meckel's cave which strays on the upper surface of the petrous part of the temporal bone on the way from the posterior fossa to the middle cranial fossa (Figure 1C, D). The endoscopic instruments provide perfect visualization with minimal cerebellar retraction. Placement in the surgical corridor should be put in order in a triangle to prevent for the clashing of the surgical instruments and the endoscope. The apex of the equilateral triangle is represented by the endoscope and it stays at the sigmoid sinus side. Micro instruments should be placed in the right hand at the cerebellar surface and the suction must be lies in the inferior space of the surgical corridor. As we mentioned, the endoscope-assisted procedure in the corridor along with the lateral cerebellum to the CPA with minimal retraction can provide a clear and close view. CN V, VII–VIII, CNs IX–X–XI, internal auditory meatus (IAM), PICA, AICA and deep lateral surface of cerebellum, CPA can be better exposed with using endoscope-assisted RSA. The vascular anatomy around the CN V may be inspected without sharp dissection of the neurovascular structures because the arachnoid around the CN V can be easily lysed. (Figure 2A–F). Sharp dissection can be preferred for the arachnoid mater around the CN V. CSF drainage is applied for optimal visualization of the CN V and CNs VII–VIII in the CPA. The type of vessel causing the neurovascular conflict should be reported. The AICA was alone found in this procedure. We focused on the REZ of CN V and found the 0° endoscope provides the best maneuverability and improved visualization.

CASE DESCRIPTION AND INTRAOPERATIVE NUANCES

A 71-year-old woman patient with a history of violent right-sided TN was admitted to the neurosurgery department. Her medical treatment was unsuccessful, with pain exacerbating while swallowing and eating. She had a 5-year history of symptoms that related to right-sided mandibular nerve and showed pathognomonic findings for the diagnosis of TN. The case encountered with AICA during exposure of the REZ underwent MVD is presented and it was fixed in the park bench position using a Mayfield with 3-pin head clamp. Nearly 5 cm straight-line skin incision centered over the estimated craniotomy was parallel to the hairline and stayed nearly 1.5 cm behind it (Figure 3A, B). The craniotomy for RSA was located inferior to the junction of transverse sinus and sigmoid sinus

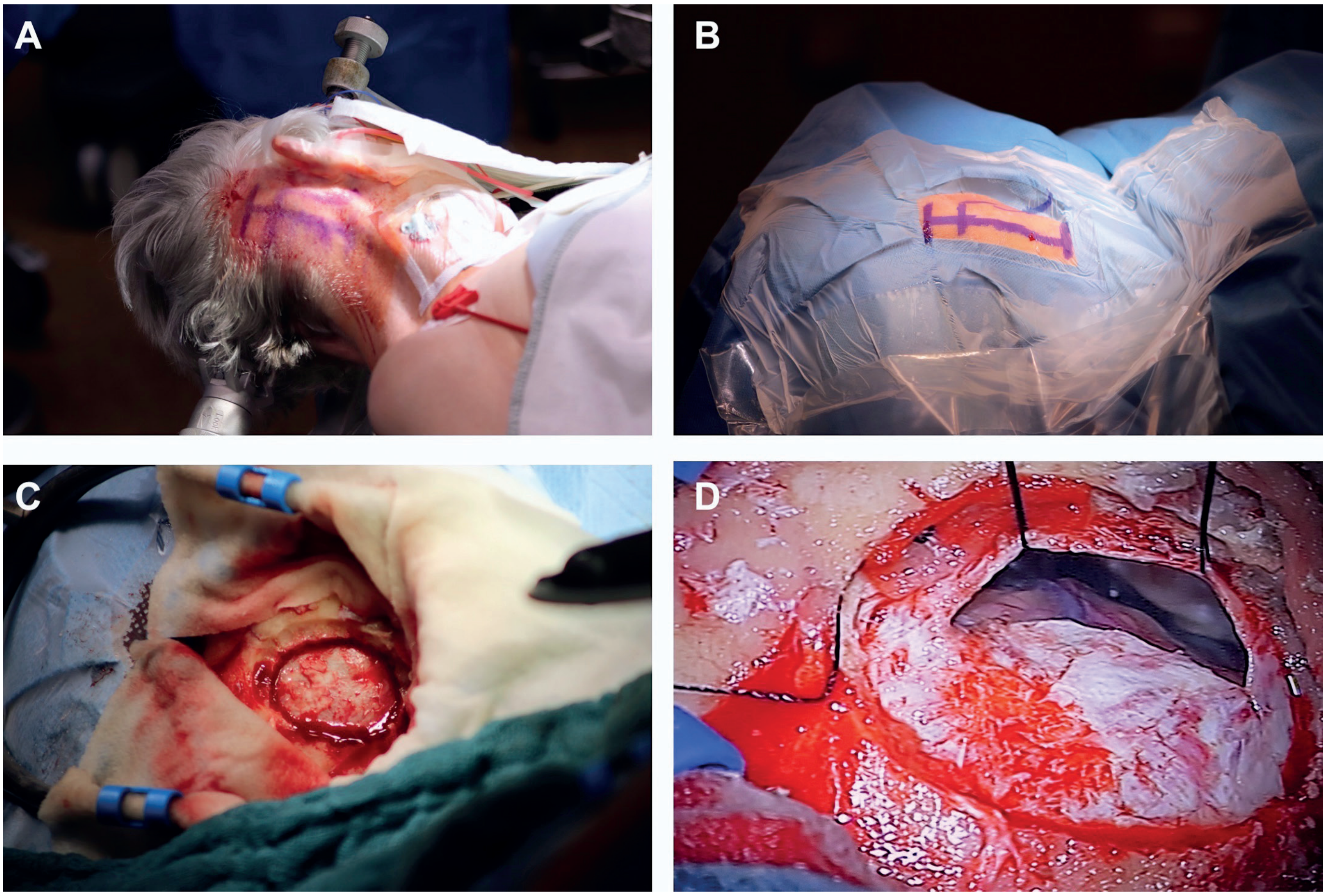

Fig. 3 View of the surgical steps during performing of RSA. (A–B) Head position and linear skin incision inferior to the junction of the transverse and sigmoid sinuses and nearly 3 cm behind the ear. (C) The detail shows the right craniotomy for RSA after the vertical skin incision. (D) Endoscopic overview of the entrance-window following the dural opening.

Abbreviations: Retrosigmoid approach = RSA

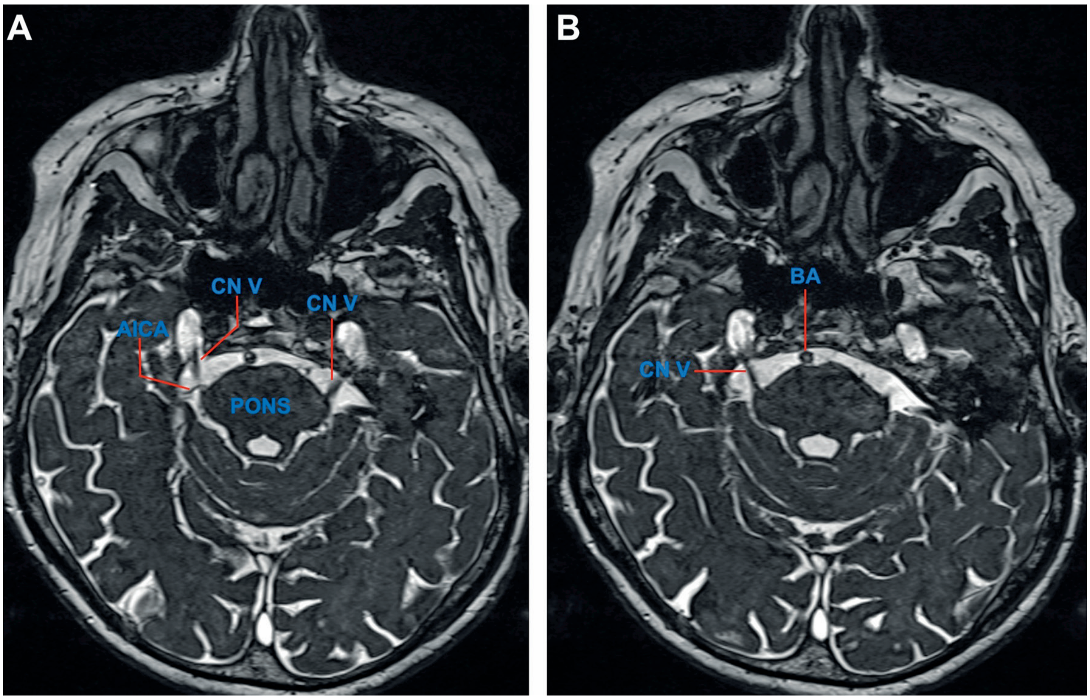

Fig. 4 (A–B) Axial T2-weighted MRI images (0.5 mm). The AICA is the offending artery and responsible for CN V compression in 71 year-old female patient.

Abbreviations: Anterior inferior cerebellar artery = AICA; basilar artery = BA; cranial nerve = CN; magnetic resonance imaging = MRI

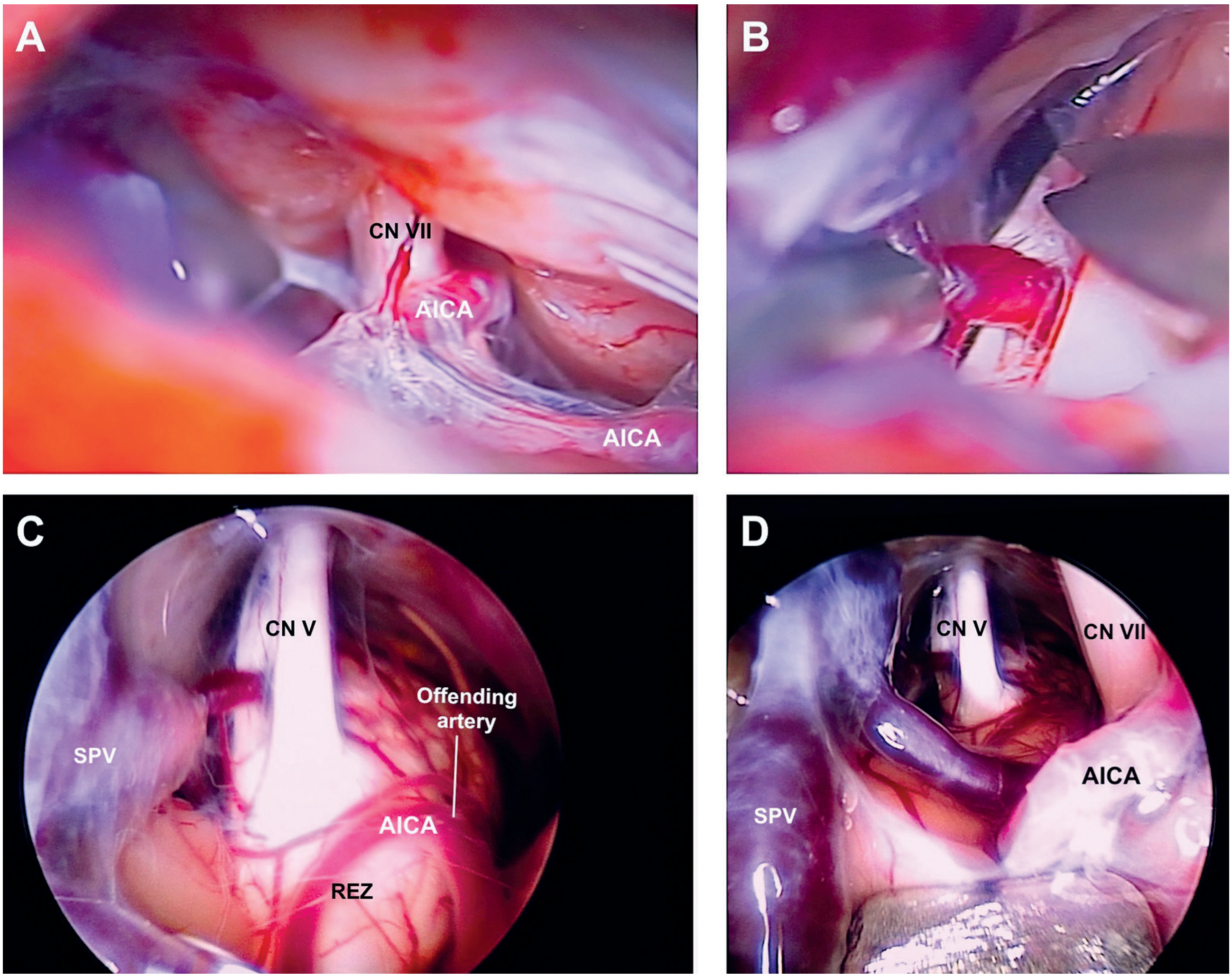

Fig. 5 The RSA has been completed. (A) Microscopic views of the superior quadrant of the root entry zone and some of the cisternal portion of the CN V. Notice how well visualized is the inferomedial part of the CN V that compressed by loop of AICA. The arachnoid mater was removed and AICA was exposed using sharp dissection technique. (B) SPV is separated from the CN V. (C–D) Endoscopic views. The entry zone of CN V is better visualized using endoscope. SPV formed by the union of the transverse pontine, pontotrigeminal, and anterolateral marginal veins and the vein of the cerebellopontine fissure. Its close relationship has been exposed.

Abbreviations: Anterior inferior cerebellar artery = AICA; CN = cranial nerve; retrosigmoid approach = RSA; root entry zone = REZ; superior petrosal vein = SPV

(Figure 3C). The burr hole for the needed craniectomy in RSA is located close the point in the posterosuperior aspect of the insertion of the digastric muscle. While the diameter of the craniotomy for RSA is 2.5 cm and then may be extended in the direction to the sigmoid and transverse sinuses for better orientation. The mastoid drilling should be performed with attention to prevent any entering to the mastoid air cells and rhinorrhea due to drilling. After opening dura, cerebrospinal fluid (CSF) was gently released from the CPA cistern to make the cerebellum slack, to decrease then pressure of the associated corridor of the RSA and in particular to allow the visualization of the CN V and lateral part of cerebellum (Figure 3D). Magnetic resonance imaging (MRI) revealed a large dorsomedial running (AICA) with a potential conflict at the REZ of the CN V (Figure 4A, B). The symptoms must be correlated to the radiologic findings as in our case. Endoscope-assisted microsurgical procedure was preferred as a surgical method (Figure 5A–D). 0° and 30° rigid endoscopes and microscopy are used special elaboration should be paid to directing the endoscope towards the "blind spots". We then repeated the sharp dissection, first using the microscope and then using the endoscope (Figure 5C, D). The endoscope is used for the final check, teflon pledget to separate the offending vessel from REZ of CN V is placed, simulating the standard MVD. Endoscopic inspection provided clearer view than the microscopic inspection of the REZ of the CN V (Figure 6A–D). In conclusion, completeness of the decompression was confirmed using endoscope during the surgery (Figure 6D). As it is known, nearly 25% cases of vascular compression of the CN V are caused by the AICA like our case. The RSA, partial mastoidectomy, microsurgical and endoscopically supported neuro-vascular decompression according to Jannetta of a vascular-nerve conflict between the root entry zone of the trigeminal nerve and the AICA transition were performed. The TPV is a part of SPV and can cause additional symptoms for TN. If it has a close relationship with motor root or REZ of CN V, should be coagulated and checked endoscopically (Figure 7). She had complete recovery and less pain when compared to the preoperative examination was discharged with no postoperative neurologic deficit.

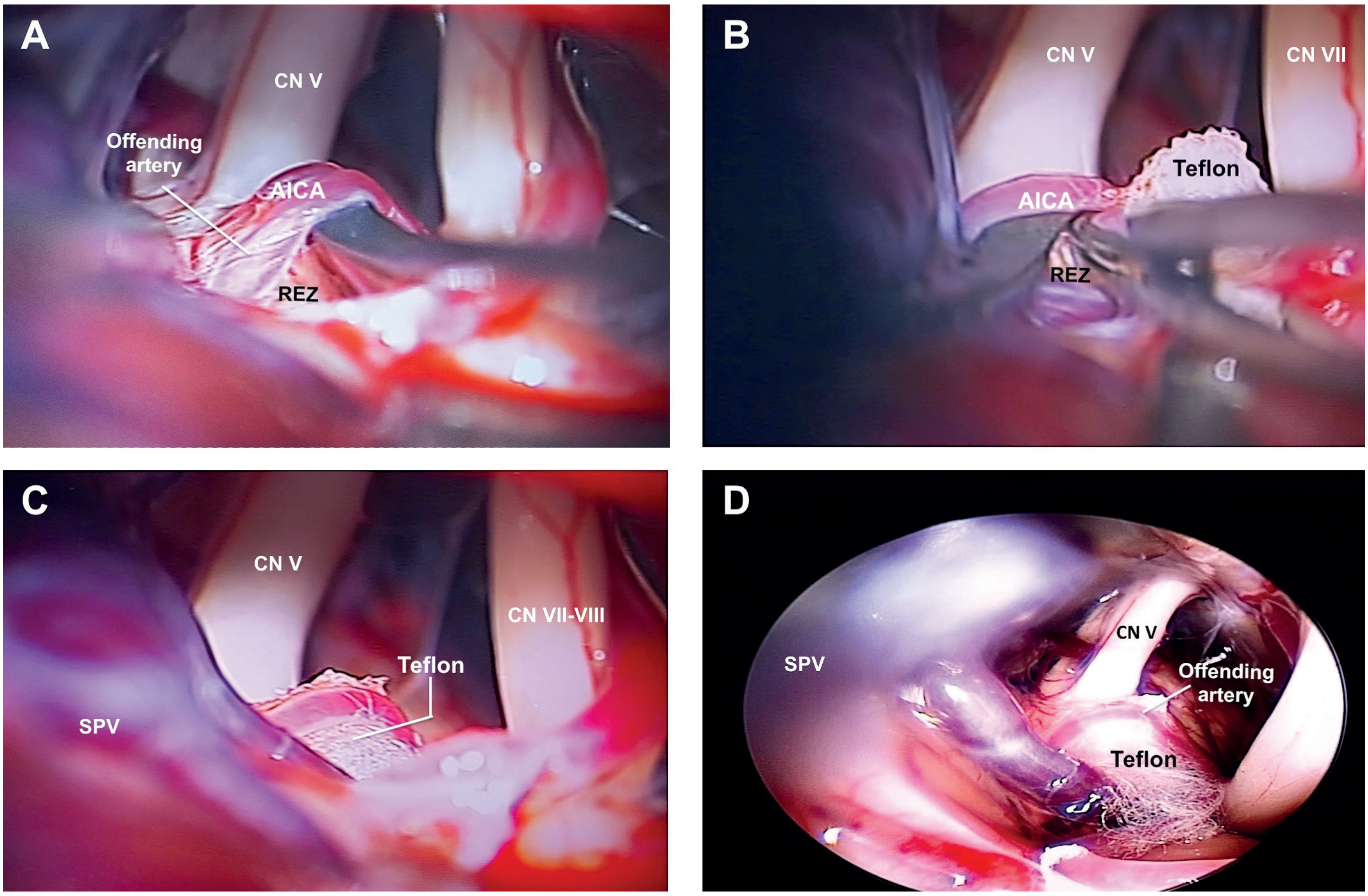

Fig. 6 (A–C) Microscopic views of the insertion of a teflon pledget between the AICA and the CN V and showing limited visualization of the teflon pledget at the root entry zone. (D) Endoscopic view. However, the same area has better visualization using an endoscope and with endoscope can be performed complete neurovascular separation at the entry zone. The insertion of the same area may be better visualized.

Abbreviations: Anterior inferior cerebellar artery = AICA; cranial nerve = CN; root entry zone = REZ; superior petrosal vein = SPV

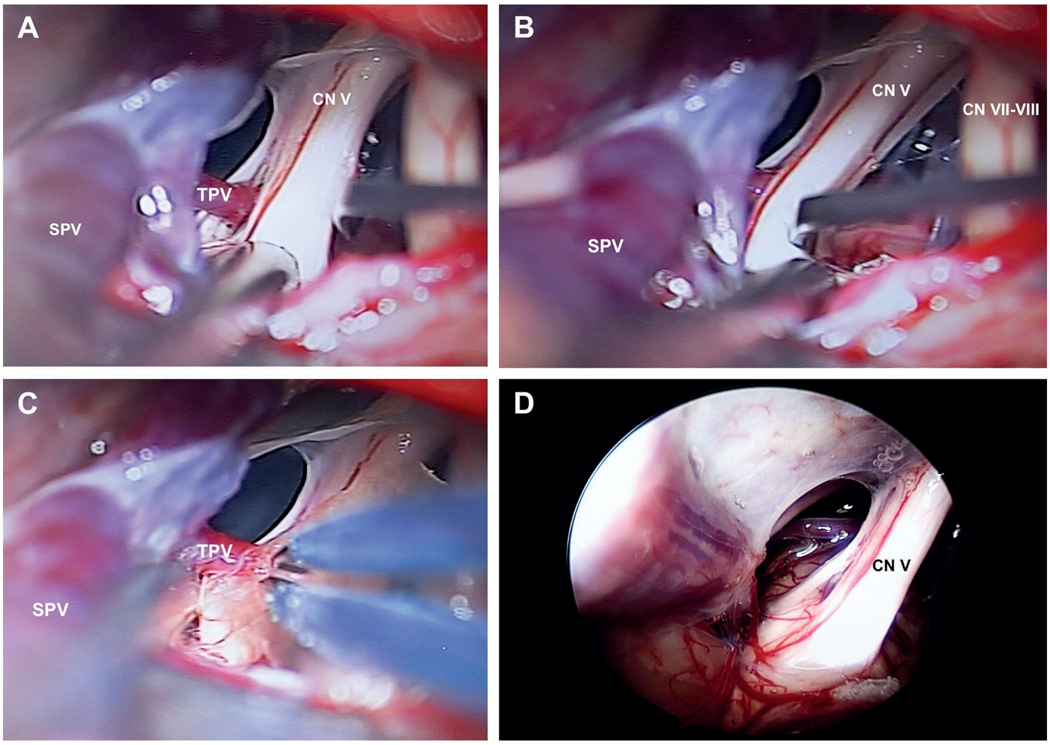

Fig. 7 (A–C) Microscopic views during coagulation of the TPV. This vein causes to additional symptoms for TGN that part of the SPV. (D) Large view can be obtained with endoscope for final control after all of the steps of the MVD.

Abbreviations: Cranial nerve = CN; microvascular decompression = MVD; superior petrosal vein = SPV; transverse pontine vein = TPV; trigeminal neuralgia = TGN

DISCUSSION

Patients with TN are presented with an episodic pain related to the CN V branches' distribution. Vascular compression of the CN Vis one of the most common reasons and has been first described by Walter Dandy in 1920s (1, 2, 10). Diagnosis is made mainly by clinical history and physical examination. Advanced MRI imaging techniques, high-resolution sequences allow us to prove neurovascular conflict with high specificity and sensitivity. Nevertheless, MRI can miss the neurovascular conflict while apparent compression is seen during surgery. MRI and angiography is essential in the preoperative period for clear visualization of the vascular structures. Preoperative evaluation with these radiological imagines is absolutely necessary for an effective surgical planning. It also helps to detect the presence of diseases such as CPA tumors, multiple sclerosis or schwannomas. Diffusion tensor imaging is recommended in cases of neuralgia to examine changes in central nervous system structure. In cases of trigeminal neuralgia, disruption of white matter integrity in the anterior cingulate cortex, insular cortex, somatosensory cortex, hippocampus, premotor area, temporal lobe and corpus callosum has been observed. As a result, preoperative MRI is used to determine whether there is neurovascular compression, which vascular structure is the cause, and the prognosis of MVD (15–19). As MVD become an optimal treatment option for TN nowadays, throughout the whole 20th century the efforts of neurosurgeons have the greatest impact on it (20). Peter Jannetta was able to produce evidence for the vascular compression hypothesis by use of surgical microscope (8, 9, 21). The first case series for MVD has been published in 1967 (8, 9, 21). However, most neurosurgeons were not ready for this and did not approve his theory. Only in 1990s he was able to convince his peers that using microscope clearly visualized offending arteries and veins. In 1996, a challenging paper including long-term outcome of 1185 patients treated with MVD was published by Jannetta (8, 9). While consensus in MVD is not very long time ago, recently surgeons have gone a step further with endoscope use during vascular decompression (11, 12). In 1993, a cadaveric study of cerebellopontine angle emphasized the advantages of the endoscope (22). Yet, first use of the endoscope in posterior fossa surgery performed by Doyen for trigeminal root neurectomy in 1917 (23).

MVD requires better anatomical knowledge to perform required approach without complication. Dandy's vein, the tentorium, the transverse-sigmoid junction, and the superior petrosal sinus at one end and CNs VII and VIII with the subarcuate artery are known as landmarks for maximum exposure in MVD. They are the main anatomical structures that constrain deeper insertion endoscopic instruments in MVD procedure (24). The lateral endoscopic approach through the RSA craniotomy for MVD is optimal route. After opening the dura, the arachnoid mater has to be opened between the IAM and CN V and its superior area (24, 25). Neurovascular structures surrounding the CPA may be divided according to "rule of three": CN V and SCA are located in upper neurovascular complex (26). Being close to each other makes a caudal loop of SCA the most frequently offending vessel of TN followed by AICA (3, 5). SCA has contact usually while passing superomedial aspect of CN V. More than 50% of cases compression occur at proximal third of the nerve in other words REZ (27). Even so exploration entire root from Meckel's cave to REZ is necessary because there might be several compressive vessels in the same patient (27, 28). Looping down between medial side of nerve and pons SCA may even lead to visible distortion of the fascicles of the nerve due to compression. This can be explored much easier with an angled endoscope because arterial loop in the axilla may not be visible behind CN V from retrosigmoid view solely with a microscope (29). If AICA has high origin with looping upward contact CN V inferomedially (3).

One of the most undesirable results of MVD is recurrence of the symptoms in long-term. This is strongly associated with the inadequate visualization of the entire nerve length during decompression from offending vessel(s) (7, 30). To improve this outcome with its superb illumination and enhanced panoramic visualization without any brain retraction, endoscope becomes a lifesaving tool. Minimal skin incision and retrosigmoid craniotomy are enough for endoscopic surgery. However, accuracy in identifying the junction between transverse and sigmoid sinuses is crucial (7).

Even some authors suggest full endoscopic MVD, the limitations of using solely endoscope cannot escape the attention (31). These limitations have some difficulties in holding and manipulating the scope and losing bimanual dexterity is possible. Humidity, blood and CSF can obscure the lens and cause the lack of three-dimensional view. One of the most important disadvantage is unexpected-critical neurovascular injuries in the blind zone-between tip of endoscope and dural opening-prompting some surgeons to use of exoscope (32, 33). In our opinion endoscope-assisted MVD is the best option in patinents with TN. Because it benefits the advantages without having disadvantages of endoscope used. Good to mention that switching from microscope to endoscope and back to microscope from endoscope can be a little time consuming (29). The method of decompression is also important to avoid recurrence (34). Adhesion and granuloma formation after inserting teflon etc. between nerve and vessel cause recurrence (35, 36). These leading neurosurgeons to do transposition technique: moving offending vessel away from the nerve and fixing to adjacent cerebellar tentorium or petrosal dura mater (34, 37).

CONCLUSIONS

The relationship between the AICA and CN V may be variable and can be responsible for TN. MVD aims the sufficient neurovascular decompression and to provide a disconnected area between the offending vessel and the neural tissue with synthetic materials. Performing anatomical stepwise in-manner dissection and improving the endoscope-assisted microsurgical experience are essential for surgical orientation. Better orientation is necessary to avoid cerebellar retraction, neurovascular damage and to expose the nerves along their entire length for decompression. Use of the endoscopic instruments supported the hypothesis about helping in visualization and maneuverability for associated neurovascular structures during the MVD. It is provided an opportunity to perform a minimally invasive procedure than the standard operative techniques. Also, the surgical procedures are quickly improving to obtain the optimal conditions without complication.

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