SURGICAL OUTCOMES OF FULLY ENDOSCOPIC MICROVASCULAR DECOMPRESSION WITH INTRAOPERATIVE NEUROPHYSIOLOGICAL MONITORING

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Endoscopic microvascular decompression combined with intraoperative neurophysiological monitoring has recently become an advanced technique for treating neurovascular compression syndromes in the cerebellopontine angle. This prospective cohort study included 28 patients-11 with hemifacial spasm and 17 with trigeminal neuralgia-who underwent fully endoscopic decompression at Hanoi Medical University Hospital from September 2024 to October 2025. Neurophysiological monitoring included brainstem auditory evoked potentials, brainstem trigeminal evoked potentials, lateral spread response, and the Zhong-Lee response. In the hemifacial spasm group, the mean preoperative clinical score was 14.0 ± 1.4, which improved to 0 after surgery, and the quality-of-life score decreased from 82% ± 9% preoperatively to 0% postoperatively ($p < 0.001$). All cases involved anterior inferior cerebellar artery compression with complete intraoperative disappearance of lateral spread responses and positive Zhong-Lee responses. In trigeminal neuralgia, 100% achieved Barrow Neurological Institute grade I pain relief at one month. Reported complications included one meningitis, four transient facial palsy, and two transient facial numbness. Fully endoscopic microvascular decompression with intraoperative neurophysiological monitoring proved to be a safe and effective surgical technique that ensures precise decompression, functional preservation, and favorable postoperative outcomes.

Keywords: Trigeminal neuralgia, hemifacial spasm, endoscopic microvascular decompression, Jannetta procedure, intraoperative neurophysiological monitoring.

I. INTRODUCTION

Trigeminal neuralgia and hemifacial spasm are debilitating neurovascular compression syndromes caused by pulsatile vascular contact on the trigeminal or facial nerves at the cerebellopontine angle. The resulting pathological irritation of the nerve root entry zone leads to either paroxysmal facial pain or involuntary hemifacial contractions. Since Jannetta's first description of microvascular decompression (MVD) in 1967, this technique has remained the gold standard for definitive treatment, achieving long-term success rates between 85% and 95% in most series.[1,2]

The evolution of fully endoscopic MVD has significantly improved visualization, offering a panoramic view of the cerebellopontine angle with minimal cerebellar manipulation. Studies by Feng et al. (2020), Jiang et al. (2022), and Li et al. (2019) demonstrated that the endoscopic

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approach reduces surgical trauma and provides equivalent or superior efficacy compared with the microscopic technique. Despite these advances, optimal decompression and nerve preservation remain challenging, particularly when multiple offending vessels are present or the neurovascular conflict involves intricate anatomical configurations.[3]

Intraoperative neurophysiological monitoring (IONM) has emerged as a critical adjunct to enhance the safety and precision of MVD. It enables real-time evaluation of neural function and immediate feedback on decompression adequacy. For hemifacial spasm, the disappearance of the lateral spread response (LSR) and the positivity or resolution of the Zhong-Lee response (ZLR) are strong electrophysiological indicators of successful decompression.[4,5] In trigeminal neuralgia, changes in brainstem trigeminal evoked potentials (BTEP) reflect recovery of sensory pathway conduction after vascular release.[5] The integration of these modalities supports both functional monitoring and prognostic evaluation of outcomes.[3,6]

In Vietnam, endoscopic MVD has been introduced at major neurosurgical centers in recent years, yet published data on fully endoscopic procedures with integrated IONM remain scarce.[7] Therefore, this prospective study was designed to evaluate the clinical and electrophysiological outcomes of fully endoscopic MVD with intraoperative neurophysiological monitoring in the treatment of trigeminal neuralgia and hemifacial spasm at Hanoi Medical University Hospital.

II. MATERIALS AND METHODS

1. Study Subjects

This study included 28 cases of fully endoscopic microvascular decompression (MVD) with intraoperative neurophysiological monitoring (IONM) performed for the treatment of trigeminal neuralgia and hemifacial spasm at the Department of Neurosurgery - Spine Surgery, Hanoi Medical University Hospital, from September 2024 to October 2025.

2. Study Design

This was a prospective clinical trial.

Inclusion Criteria

- Patients were eligible for the study if they met the following criteria:

- Patients presented with typical clinical manifestations of hemifacial spasm, with a disease severity score greater than 2 according to the Jankovic scale.

- Patients presented with typical clinical features of trigeminal neuralgia that were unresponsive to medical therapy, or who were unable to continue medical treatment due to excessive side effects or severe facial pain, and who had failed prior percutaneous trigeminal ganglion lesioning procedures.

- Preoperative magnetic resonance imaging (MRI) excluded secondary causes of trigeminal neuralgia or hemifacial spasm, such as brain tumors, epidermoid cysts, cranial nerve schwannomas, arteriovenous malformations (AVMs), or dural AVMs.

- Underwent fully endoscopic MVD with IONM.

Exclusion Criteria

Patients were excluded from the study if they met any of the following criteria:

- Presence of severe underlying medical conditions posing a high surgical risk.

- Secondary trigeminal neuralgia or secondary hemifacial spasm caused by multiple sclerosis.

- Hemifacial spasm occurring after peripheral facial nerve palsy due to other medical conditions.

Surgical Technique: Fully Endoscopic Microvascular Decompression with Intraoperative Neurophysiological Monitoring

Anesthesia Method: Intravenous general anesthesia.

Surgical Positioning: Park bench position.

General Setup Procedure for Intraoperative Neurophysiological Monitoring

Intraoperative neurophysiological monitoring techniques:

- Hemifacial spasm case: EEG (Electroencephalography), EMG (Electromyography), LSR (Lateral spread response), ZLR (Zhong-Lee response), BAEP (Brainstem auditory evoked potentials), TOF (Train-of-Four for neuromuscular blockade)

- Trigeminal neuralgia case: EEG (Electroencephalography), EMG (Electromyography), BTEP (Brainstem trigeminal evoked potentials), BAEP (Brainstem auditory evoked potentials).

Surgical Procedure

Step 1: Skin Incision and Craniotomy: Skin Incision: A 3-5 cm vertical incision was made 5 mm medial to the mastoid notch of the temporal bone. The muscle and fascia were carefully dissected. Burr Hole Placement: A burr hole was drilled 1 cm inferior and medial to the Asterion. Craniotomy: The lateral limit of the craniotomy was the sigmoid sinus, with a diameter of 2-3 cm. First stimulation was performed to identify LSR/BTEP before dural opening.

Step 2: Dural Opening and Lesion Management: The dura was opened in a C-shaped fashion along the transverse sinus and sigmoid sinus. 30 degree 2.75 mm endoscope was introduced. The surgical instrument entry points was arranged into an isosceles triangle configuration to minimize instrument collision during the procedure: Position A, located at the 12 o'clock position, was designated for the endoscope. Position B, at the 5 o'clock position, was for the dissecting instrument. Position C, at the 7 o'clock position, was for the suction cannula (Figure 1). Second stimulation was performed to identify LSR/BTEP after dural opening. The cerebellum was minimally or not at all retracted. Instead, a small cottonoid was gently placed at the cerebellopontine angle, allowing cerebrospinal fluid (CSF) drainage to reduce brain tension. The arachnoid membrane was carefully dissected to explore the entire course of the facial nerve (cranial nerve VII) from its exit at the pontomedullary junction to the internal auditory canal in cases of hemifacial spasm, and the trigeminal nerve (cranial nerve V) from its anterolateral emergence at the pons to the Meckel's cave in trigeminal neuralgia, to identify neurovascular conflicts. Third stimulation was performed to identify LSR/BTEP and ZLR after arachnoid dissection Microsurgical dissection was performed to decompress the offending artery or vein. Subsequently, a Neuro-Patch® was implanted to insulate and separate all identified neurovascular conflict sites (Figure 1). Fourth stimulation was performed to confirm the absence of LSR/BTEP and ZLR after neurovascular decompression.

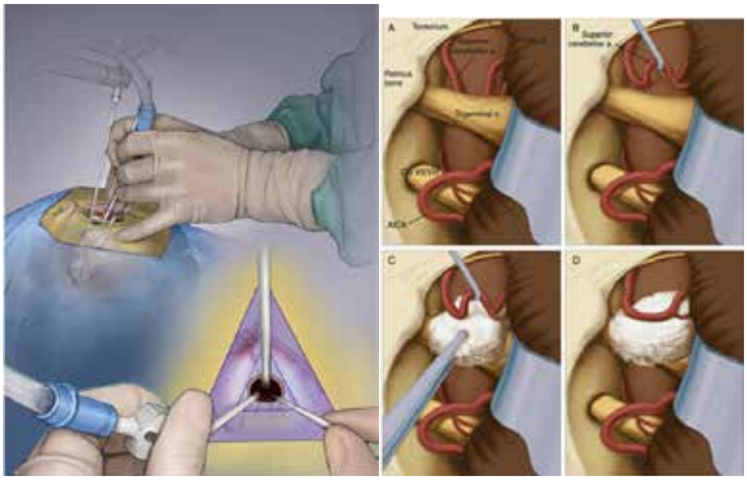

Figure 1. Position of surgical instruments and decompression techniques[1]

Step 3: Dural and Wound Closure: Dural Closure: The surgical field was gently irrigated with warm saline to prevent injury to the cranial nerves. High-pressure irrigation was avoided. Fifth stimulation was performed to identify LSR/BTEP after dural closure. Valsalva Maneuver was performed to check for CSF leakage before watertight dural closure. Bone Replacement and Soft Tissue Closure: The bone flap was repositioned, and the fascia and muscle were sutured before skin closure. Sixth stimulation was performed to identify LSR/BTEP after skin closure.

Data Analysis and Processing

- Data entry was performed using EpiData software (version 4.6.0.6).
- Statistical analysis was conducted using STATA software (version 14.0).

3. Ethical Considerations

- This study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was obtained from the Institutional Review Board of Hanoi Medical University (Approval No. 2071/BB-HMUIRB, dated August 12, 2025).
- Written informed consent was obtained from all participants prior to inclusion in the study.
- Patient confidentiality was strictly maintained, and all data were used solely for research purposes.

III. RESULTS

Table 1. Demographics and clinical features of hemifacial spasm.

Demographics and clinical features	Hemifacial spasm (n=11)
Gender	
Male	5 (45.5%)
Female	6 (54.5%)
Age (mean ± SD) (years)	45.6 ± 11.0

Demographics and clinical features	**Hemifacial spasm (n=11)**
Onset (months)	51.1 ± 29.3
Botulium toxin injection history	7 (63.6%)
Right side	6 (54.5%)
Offending vessels	
AICA	11 (100%)
VA	1 (9%)
NVC classification	
Loop type	6 (54.5%)
Tandem type	4 (36.4%)
Sanwich type	1 (9.1%)
LSR presence	
Orbicularis oris	11 (100%)
Mentalis	8 (72.7%)
Frontalis	2 (18.2%)
LSR disapprearance	
1st stimulation: Before dural opening	0
2nd stimulation: After dural opening	0
3rd stimulation: After arachnoid dissection	2
4th stimulation: After decompression	11
5th stimulation: After dural closure	11
6th stimulation: After skin closure	11
Zhong-Lee response (+) before decompression	100%
Zhong-Lee response (-) after decompression	100%
Complications	
Transient facial palsy	4 (36.36%)
Meningitis	1 (9%)
Hoarseness	1 (9%)

The anterior inferior cerebellar artery (AICA) was the offending vessel in all cases (100%), with vertebral artery involvement in 1 patient (9%). Regarding neurovascular conflict (NVC) configuration, loop type was most common (54.5%). Lateral spread responses (LSR) were recorded in all patients, most frequently in the orbicularis oris (100%), followed by mentalis muscles (72.7%). LSR disappeared in all patients after decompression, with complete disappearance achieved by the fourth stimulation. One meningitis, four transient facial palsy (House-Brackmann grade II and III) and one hoarseness were reported.

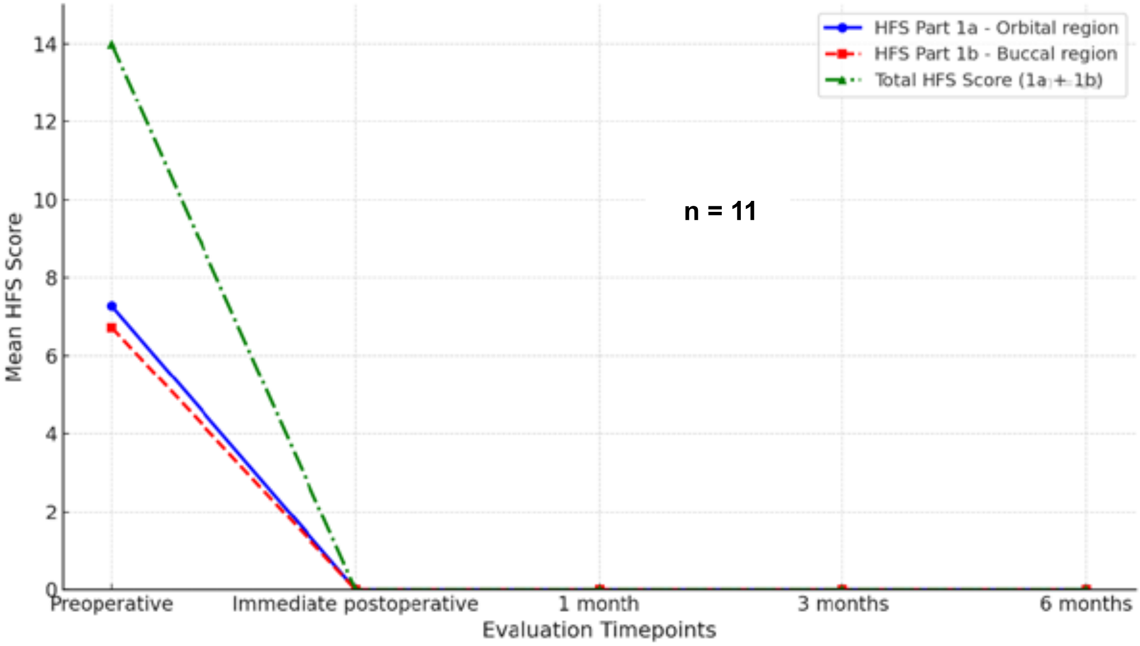

Figure 1. Variation of hemifacial Spasm (HFS) clinical score

Eleven cases of hemifacial spasm had a preoperative mean HFS clinical score of 14.0 ± 1.4, which improved to 0 postoperatively 1-, 3- and 6-month ($p<0.001$, paired t-test). All three curves show a steep reduction immediately after surgery, confirming the prompt resolution of facial spasms. The scores remain close to zero through 6 months, demonstrating sustained and stable postoperative improvement.

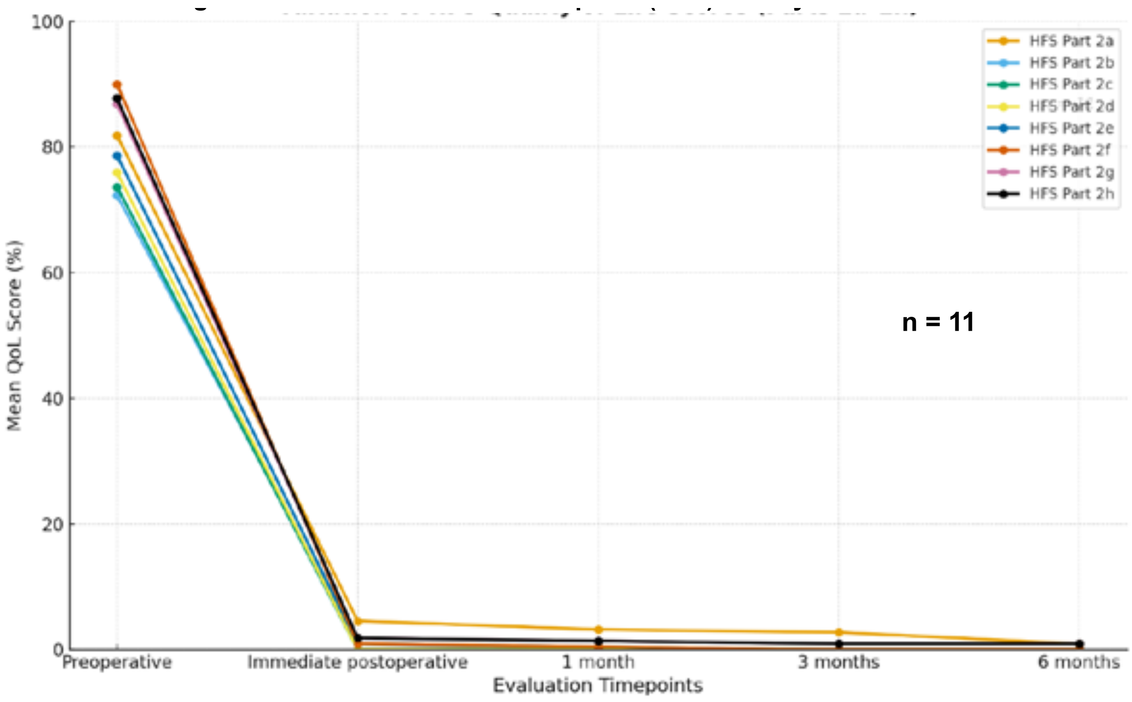

Figure 2. Variation of hemifacial Spasm (HFS) Quality of life score

The preoperative quality of life (QoL) of 82% ± 9%, improving to 0% postoperatively 1-, 3- and 6-month ($p<0.001$, paired t-test). All Quality-of-Life (QoL) components showed a marked decline immediately after surgery. The 2a curve (overall QoL evaluation) remained below 5% at 3 months and approached 0% at 6 months, indicating sustained and durable recovery. The emotional and social domains (2e, 2f, 2g, 2h) followed a similar deep decline and stayed close to the 0% axis throughout follow-up.

Table 2. Demographics and clinical features of trigeminal neuralgia

Demographics and clinical features	Trigeminal neuralgia (n=17)
Gender	
Male	9 (52.9%)
Female	8 (47.1%)
Age (mean±SD)	58.4 ± 7.4
Onset (months)	58.8 ± 34
Tegretol® 200mg dose	4.07 ± 1.22
Percutaneous Gasserian rhizotomy history	2 (11.76%)
Right side	10 (58.8%)

Demographics and clinical features	Trigeminal neuralgia (n=17)
Trigeminal neuralgia classification	
Type I (typical)	15 (88.24%)
Type II (atypical)	2 (11.76%)
Trigeminal branches	
V1	4 (23.5%)
V2	13 (76.5%)
V3	9 (52.9%)
Offending vessels	
SCA	15 (88.2%)
Dandy vein	5 (29.4%)
AICA	2 (11.8%)
VA	1 (5.9%)
Brainstem trigeminal evoked potentials (BTEP): waves changes	
V1	0
V2	7 (41.2%)
V3	4 (23.5%)
No changes	9 (52.9%)
Complications	
Facial numbness	2 (11.76%)
Surgical site infection	1 (5.8%)

Typical Type I trigeminal neuralgia was predominant (88.2%), while Type II accounted for 11.8%. Regarding nerve distribution, V2 involvement was most common (76.5%), followed by V3 (52.9%) and V1 (23.5%). Intraoperatively, the superior cerebellar artery (SCA) was the main offending vessel (88.2%), followed by the Dandy vein (29.4%). Brainstem trigeminal evoked potentials (BTEP) demonstrated waveform changes most frequently in V2 (41.2%) and V3 (23.5%), while no change was detected in 52.9% of patients. Two facial numbness and one SSI were reported.

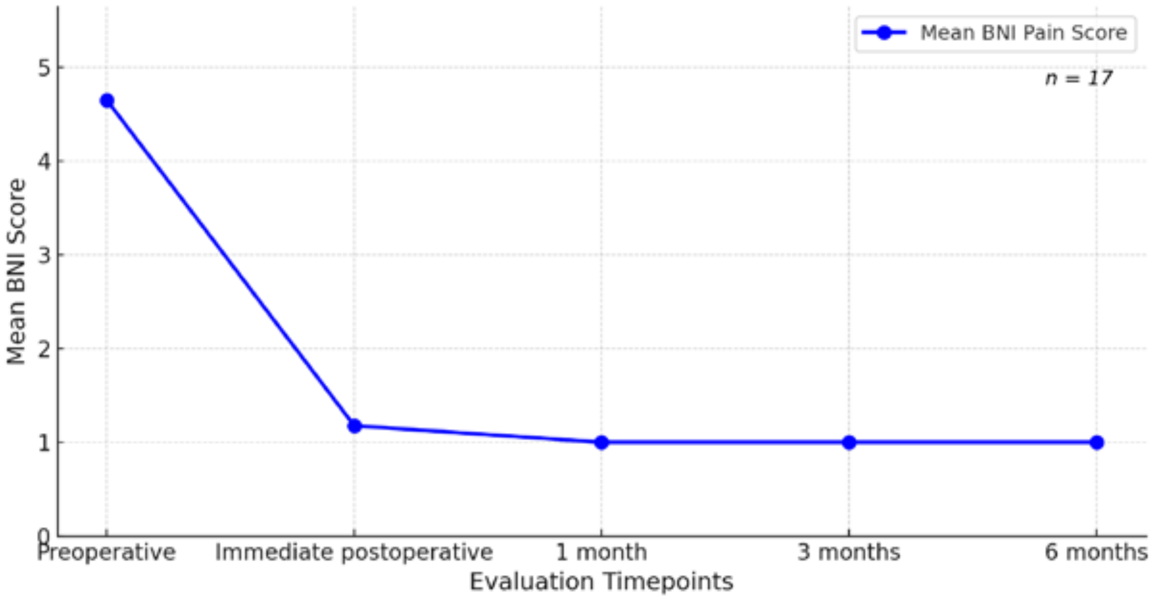

Figure 3. Variation of BNI pain intensity score[8]

Seventeen cases of trigeminal neuralgia were classified as BNI grade IV (35.3%) and V (64.7%) preoperatively, with immediate postoperative improvement to BNI grade I (82.4%) and grade II (17.6%) and at 1-month follow-up to BNI grade I (100%). The BNI pain score shows a dramatic decline immediately after surgery, reflecting near-complete pain relief following decompression. Mean scores remain low and stable through 6 months, indicating sustained postoperative pain control.

IV. DISCUSSION

MVD is recognized as the definitive and most effective surgical method for the curative treatment of HFS.[1,9] Our cohort of 11 HFS patients exhibited highly successful clinical results. The mean HFS clinical score improved dramatically from 14.0±1.4 preoperatively to 0 postoperatively at 1, 3, and 6 months. Correspondingly, the Quality of Life (QoL) score, which measures the psychosocial and functional burden of the condition, improved from 82%±9% preoperatively to 0% postoperatively ($p<0.001$).[1,10] This rate of resolution supports the established efficacy of MVD, with long-term cure rates reported globally to range between 84% and 98%.[1,9] Regarding the etiology, all cases in this study (100%) involved compression by the Anterior Inferior Cerebellar Artery (AICA). While AICA is frequently identified as the primary culprit vessel in HFS, typically reported in 43% to 67.9% of cases, the 100% involvement rate observed in our small cohort is higher than average, although AICA involvement rates up to 79.3% have been noted in some studies.[7,9]

The integrity of the facial nerve was verified using the Lateral Spread Response (LSR), which is considered the electrophysiological hallmark of HFS.[4,11] The LSR was recorded in the orbicularis oris (100%), mentalis (72.7%), and frontalis muscles (18.2%), a pattern consistent with known pathological lateral spread across facial nerve branches.[12,13] Critically, the LSR disappeared intraoperatively in 100% of cases following decompression. The immediate abolition of the LSR is recognized as the electrophysiological gold standard for successful MVD, predicting long-term spasm resolution. In specific studies, the resolution of the LSR has been linked to a 7-fold higher chance of achieving greater than 50% spasm-free relief.[14] Furthermore, all cases demonstrated a positive Zhong-Lee Response (ZLR) (100%). The ZLR is a complementary monitoring technique used, especially when multiple offending vessels are suspected, to verify adequate decompression when the LSR is inconclusive or absent.[14] The uniform presence of ZLR alongside the complete abolition of LSR provides strong intraoperative confirmation of definitive neurovascular decompression across the entire cohort.

Our 17 TN patients presented with severe medically refractory pain, classified preoperatively as BNI Grade IV (35.3%) and V (64.7%). Following MVD, pain relief was excellent, improving immediately postoperatively to BNI Grade I (82.4%) and Grade II (17.6%), and achieving 100% BNI Grade I status at the 1-month follow-up. These immediate success rates are consistent with global literature, which reports efficacy rates between 85% and 98% for pain relief after MVD for TN[15]. [15] The Superior Cerebellar Artery (SCA) was the most frequent offending vessel (88.2%). This high incidence is consistent with SCA being identified as the most common offending artery in TN worldwide[16]. Dandy's vein was involved in 29.4% of cases, supporting the observation that veins, including Dandy's vein, contribute to the pathogenesis of TN.[9,15] Additionally, 41.2% of cases involved multiple neurovascular conflicts (NVCs). This rate aligns with previous reports that indicate multiple vessel involvement is common in TN, often ranging from 36% to 50% of cases.

Brainstem Trigeminal Evoked Potentials (BTEP): we observed that BTEP waves in the V2 and V3 branches were reduced in 8/17 cases, and subsequently emerged following decompression. This technique is utilized for evaluating the sensory pathways of the trigeminal nerve.[5] The observed pattern, where a reduced signal improves or emerges post-decompression, suggests that relieving the mechanical compression restored physiological conduction in the trigeminal sensory pathway, correlating well with the profound clinical pain relief achieved.

The overall complication profile for the 28 patients (11 HFS and 17 TN) included: 1 case of meningitis (3.6%), 4 cases of transient facial palsy (House-Brackmann Grade II and III), and 2 cases of transient facial numbness. Transient Facial Palsy (FNP): The incidence of temporary FNP (approx 14.3% of 28 patients) falls within the commonly reported range for temporary deficits (typically 4% to 25% of patients) following MVD for HFS/TN.[15,17] Transient FNP usually has a favorable prognosis. Meningitis: The occurrence of 1 case of meningitis (approx 3.6%) is a recognized, albeit rare, potential complication of MVD. One study reported a comparable rate of 2.2% for intracranial infection/meningitis in their series of endoscopic MVD.[9] Transient Facial Numbness: The 2 cases of transient facial numbness (approx 7.1%) are minor and commonly reported sensory findings, especially following MVD for TN.[18]

The fully endoscopic approach also presents several technical challenges that require considerable experience and adaptation. First, endoscopic decompression necessitates the simultaneous use of three instruments within a narrow operative corridor-the endoscope, the suction tube, and a dissecting instrument such as microscissors, dissectors, or forceps. This setup increases the risk of instrument collision and restricts maneuverability compared with the microscopic technique.

Therefore, specialized slim-profile instruments are essential, including a 2.75-mm endoscopic optic and single-shaft microsurgical tools commonly used in keyhole surgery, which help minimize instrument interference. In addition, optimal positioning of instruments is critical for maintaining a stable operative field: the endoscope is placed at the 12-o'clock position, the suction cannula at 7-o'clock, and the dissecting instrument at 5-o'clock. Another challenge is the requirement for a robust and well-fixed endoscope-holding system to ensure stability; even slight movement of the endoscope may obscure the operative view or increase the risk of neural injury. As endoscopic visualization is limited to structures located directly in front of the optic, surgeons must exercise extreme caution when introducing instruments into the field, as vessels or nerves located behind the lens may be inadvertently injured during insertion.

This study has several limitations. The sample size was relatively small, which may limit the statistical power and generalizability of the findings. Furthermore, the follow-up period was short thus did not fully evaluate long-term outcomes, including recurrence rates of trigeminal neuralgia or hemifacial spasm after endoscopic microvascular decompression. Longer follow-up with larger cohorts is necessary to confirm the durability of symptom relief and to better define prognostic factors associated with long-term surgical success.

V. CONCLUSION

Fully endoscopic microvascular decompression combined with intraoperative neurophysiological monitoring provides an effective and safe surgical option for the treatment of trigeminal neuralgia and hemifacial spasm. The integration of electrophysiological techniques such as LSR, ZLR, and BTEP enables precise intraoperative identification of offending vessels and real-time confirmation of successful decompression.

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