The Cornerstone Technique of Microvascular Decompression for Hemifacial Spasm with Vertebral Artery Offender

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■ BACKGROUND: Microvascular decompression surgery is the most effective treatment for hemifacial spasm (HFS). The vertebral artery (VA) is a larger and more elastic vessel, which makes surgical management more difficult. We introduce a surgical technique of proximal Teflon transposition with interposition (PTTI) in the vertebromedullary space for HFS with a VA offender.

■ METHODS: In 112 patients with HFS, 22 patients had a VA offender on the facial nerve exit zone. Six of 22 patients with a VA offender underwent surgery by traditional microvascular decompression at the facial nerve exit zone, and 16 patients underwent the PTTI technique. We compared surgical outcomes of the PTTI technique and the conventional technique for HFS associated with the VA. We also compared surgical outcomes of the PTTI technique with outcomes of other alternative techniques.

■ RESULTS: The PTTI technique was associated with a good operative prognosis and fewer complications. The PTTI technique is an easy, safe, and effective method for treatment of patients with HFS with a VA offender.

■ CONCLUSIONS: The PTTI technique can be considered as another treatment option in addition to the transposition technique reported previously.

INTRODUCTION

Hemifacial spasm (HFS) is involuntary tonic-clonic contraction of unilateral facial muscles mainly caused by a neurovascular contact on the root exit zone (REZ) of the facial nerve.[1,2] Microvascular decompression (MVD) surgery is the most effective treatment for HFS.[2,3] The anterior inferior cerebellar artery (AICA) and posterior inferior cerebellar artery (PICA) are the most common arteries of compression on the REZ. The vertebral artery (VA) rarely compresses the REZ leading to HSF.[4,5] The VA is a larger and more elastic vessel, which makes surgical management more difficult.[1,5] The VA can also be accompanied by dolichoectasia or atherosclerosis, increasing difficulty operating.[6] Unsatisfactory postoperative outcomes have been reported in patients with HFS caused by a VA offender.[7] MVD surgery for HFS with a VA offender has been traditionally challenging for neurosurgeons.[2] The conventional technique of direct insertion of Teflon patties to the REZ can result in surgical failure or unnecessary pressure owing to the large diameter and high pressure of the VA.[8] Many studies have introduced surgical techniques of MVD for patients with a VA offender.[2,5,9-14] These techniques are more difficult with longer operative time than conventional MVD. In addition, these methods are sometimes accompanied by risks. We introduce a surgical technique of proximal Teflon transposition with interposition (PTTI) in the vertebromedullary space for HFS with a VA offender.

MATERIALS AND METHODS

Patient Population
We retrospectively studied 112 patients who underwent MVD for HFS at our hospital between January 2013 and December 2017.

Key words
- Cornerstone technique
- Hemifacial spasm
- Microvascular decompression
- Vertebral artery

Abbreviations and Acronyms
AICA: Anterior inferior cerebellar artery
BAEP: Brainstem auditory evoked potential
HFS: Hemifacial spasm
LCN: Lower cranial nerve
LSR: Lateral spreading response
MRI: Magnetic resonance imaging
MVD: Microvascular decompression
PICA: Posterior inferior cerebellar artery
PTTI: Proximal Teflon transposition with interposition

REZ: Root exit zone
VA: Vertebral artery

Patient data including radiologic images and medical records in our hospital were reviewed. Patient history and symptoms were carefully examined for the diagnosis of HFS. Among 112 patients, 22 patients had a VA offender on the facial nerve exit zone. Six of these 22 patients with a VA offender underwent surgery by conventional MVD at the facial nerve exit zone, and 16 patients underwent the PTTI technique (previous decompression between medulla and VA before direct decompression into facial nerve exit zone). Surgical outcomes of the PTTI technique and the traditional technique for HFS associated with the VA were compared. Surgical outcomes of the PTTI technique were also compared with outcomes of other alternative techniques.

Preoperative Evaluations

Magnetic resonance imaging (MRI) was performed using a 3.0T MRI system (MAGNETOM Skyra 3.0T; Siemens Healthineers, Munich, Germany) to evaluate offender vessels preoperatively. Sampling perfection with application optimized contrasts using different flip angle evolution imaging and phase-cycled fast imaging employing a steady-state acquisition were mainly used to find the offender vessel. T2-weighted imaging and diffusion-weighted imaging were also used to survey secondary HFS (e.g., due to epidermoid cyst and other tumors).

All patients underwent preoperative nerve conduction study of lateral spreading response (LSR). Electrophysiologic study of brainstem auditory evoked potentials (BAEPs) was performed to obtain baseline data for operation. We also checked lower cranial nerve (LCN) function in the physical examination. The glossopharyngeal nerve and vagus nerve were checked by gag reflex and uvula deviation. The accessory nerve was checked by shoulder shrug and head turn from side to side. Pure tone audiometry, speech audiometry, and impedance audiometry were performed only for patients with hearing loss and tinnitus in the preoperative history.

Confirmation of VA Offender

Selection of patients with VA offenders was primarily based on MRI findings. Patients who were visually confirmed during surgery were assigned into the VA offender group.

Intraoperative Monitoring

All patients underwent intraoperative monitoring such as LSR and BAEPs after positioning. Neuromuscular blockade agents were used only during intubation. LSR was continuously recorded with paired subdermal needles inserted into the frontalis and mentalis muscles. With stimulating needles positioned over the zygomatic branch and buccal branch of the facial nerve, stimulation was evoked using pulse duration of 0.2 ms and intensity of 10−20 mA. Three checkpoints were set to verify the loss or persistence of the LSR: (1) after dura opening, (2) after Teflon patty insertion, and (3) after dura closure. BAEPs were performed at 100 dB (masking 60 dB) stimulation.
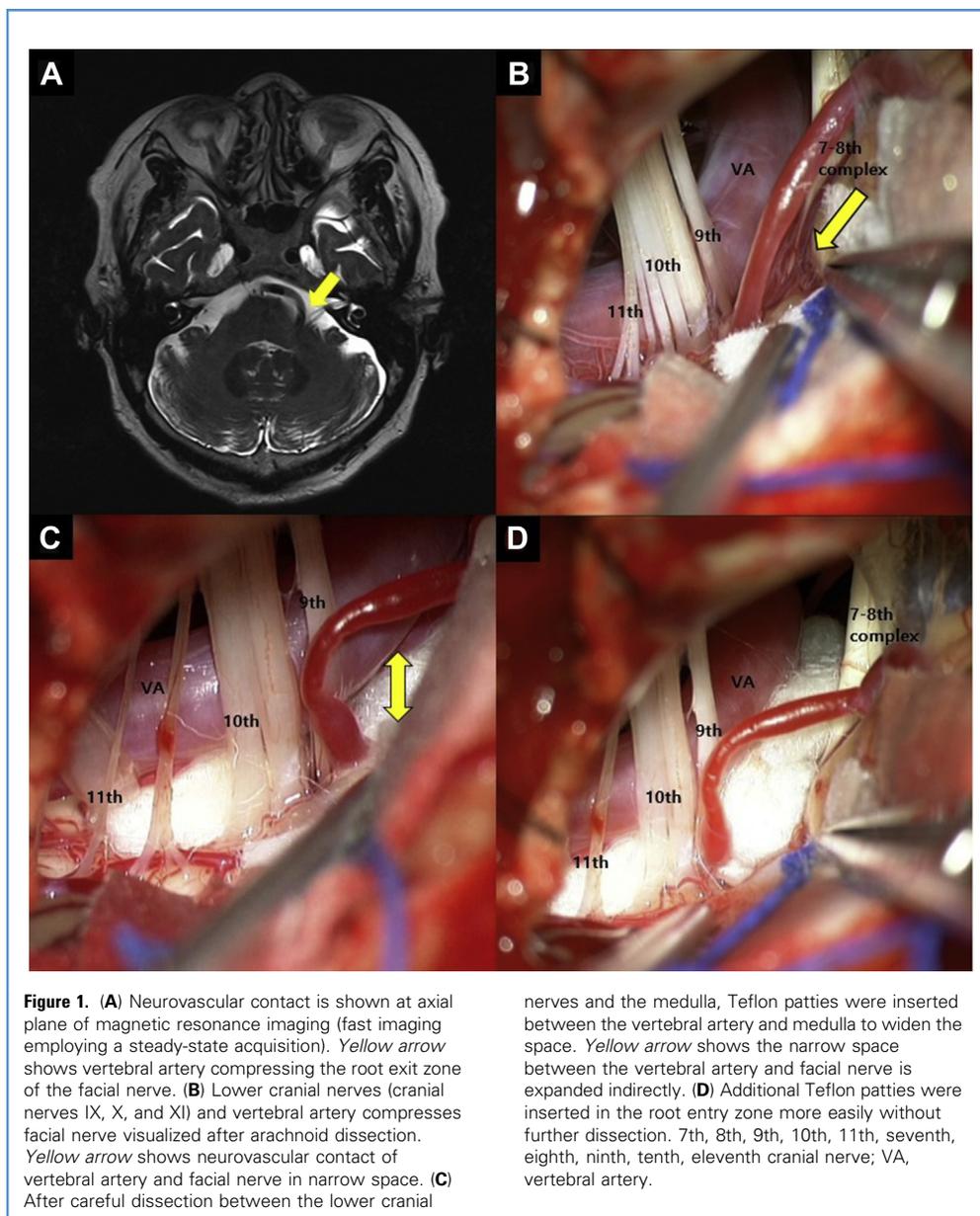
Surgical Procedure (PTTI Technique in Vertebromedullary Space)

All MVD surgeries were performed via retrosigmoid craniotomy on the lateral decubitus position. A C-shaped or linear incision approximately 5 mm was made behind the mastoid notch. Additional craniectomy after craniotomy was performed sufficiently until the sigmoid sinus was exposed using a high-speed drill, small rongeur, and Kerrison punch. Craniotomy was done near the foramen magnum so that the proximal portion of the VA could be exposed sufficiently. After dura incision, cerebrospinal fluid relaxation was performed to release the cerebellomedullary space. Arachnoid dissection was carefully carried out to expose the offender vessel and REZ of facial nerve. If the field of view was not good enough, the flocculus was sucked out to secure space. LCNs (cranial nerves IX, X, and XI) were visualized by additional arachnoid dissection. Careful dissection was performed using microscissors and a straight dissector in the space between the LCN and the medulla. First, Teflon patties were inserted between the VA and medulla to widen the space. As the shape of the LCN is different for each person, Teflon patty insertion was performed from the direction that the operator was comfortable in securing the space. If there was no enough space between LCNs and medulla, Teflon patties were inserted at a right angle above cranial nerve IX or under cranial nerve XI. A bigger Teflon patty was then placed between the medulla and VA to widen the space. As a result, the space between the REZ of facial nerve and the offender could be expanded indirectly. In this process, minimizing the manipulation of LCNs is important. Afterward, additional Teflon patties were inserted in REZ with neurovascular contact, which had lower pressure owing to the wider space. Direct compression was resolved, and LSR disappeared. If LSR did not disappear, whether REZ was completely decompressed was checked again. If it was judged that the disappearance of pressure was enough, Teflon was fixed with glue. We confirmed that BAEP latency was recovered when the latency was extended or the amplitude was decreased. The surgical wound was sutured layer by layer to prevent cerebrospinal fluid leakage. **Figure 1** shows MRI and surgical intraoperative views. **Figure 2** shows a schematic diagram of the surgical procedure.

Postoperative Evaluations

Postoperative brain computed tomography was performed to evaluate postoperative hematoma. Surgical outcome was judged based on clinical symptoms. Surgical outcome was classified into 4 categories: excellent, complete disappearance of spasm; good, occasional slight spasm; fair, apparently sustained moderate spasm; and poor, no improvement at all.[15] Postoperative complications related to cranial nerve injury, neurosurgical technique, and general problems were also investigated. Nerve complications included facial nerve palsy, cochlea-vestibular nerve injury, and LCN (IX, X, XI, XII) impairment. All patients were checked for immediate complications. Patients were evaluated 6 months later for recovery of symptoms to confirm permanent injury. The intensity of facial nerve palsy was evaluated using the House-Brackmann facial nerve grading scale.[16] Assessment of LCN injury was performed mainly through physical examination as described previously. Neurosurgical complications were surgery-associated problems, such as hematoma, infection, cerebrospinal fluid leakage, and others. General complications were problems related to the patient's condition or anesthesia and were not directly related to the surgery for HFS. All surgical outcomes and complications were compared between the patients who underwent surgery using the PTTI technique and the patients who underwent surgery not using PTTI.

Figure 1. (**A**) Neurovascular contact is shown at axial plane of magnetic resonance imaging (fast imaging employing a steady-state acquisition). *Yellow arrow* shows vertebral artery compressing the root exit zone of the facial nerve. (**B**) Lower cranial nerves (cranial nerves IX, X, and XI) and vertebral artery compresses facial nerve visualized after arachnoid dissection. *Yellow arrow* shows neurovascular contact of vertebrate artery and facial nerve in narrow space. (**C**) After careful dissection between the lower cranial nerves and the medulla, Teflon patties were inserted between the vertebral artery and medulla to widen the space. *Yellow arrow* shows the narrow space between the vertebral artery and facial nerve is expanded indirectly. (**D**) Additional Teflon patties were inserted in the root entry zone more easily without further dissection. 7th, 8th, 9th, 10th, 11th, seventh, eighth, ninth, tenth, eleventh cranial nerve; VA, vertebral artery.

RESULTS

Patient Characteristics

There were 67 men and 45 women. The median age was 54.6 years (range, 22–86 years). Among these 112 patients, 22 had a VA offender on the REZ of facial nerve, and 90 did not have a VA offender. Of the 22 patients with a VA offender, 9 were women and 13 were men. Five patients had only a VA offender; 6 patients had VA and PICA vessel complex offenders; 7 patients had VA and AICA vessel complex offenders; and 4 patients had VA, PICA, and AICA vessel complex offenders. Six patients underwent surgery by non-proximal VA transposition technique into the facial nerve exit zone. Eleven patients underwent the PTTI technique into the facial nerve

exit zone (Table 1). LSR mostly disappeared after decompression, but in one case it disappeared after dura opening. LSR remained after MVD of VA offender in 5 (22.7%) cases.

Surgical Outcomes

The conventional technique group comprised 6 patients, of whom 3 (50%) had an excellent outcome. For the remaining 3 patients, 1 (16.6%) had a good outcome, 1 (16.6%) had a fair outcome, and 1 (16.6%) had a poor outcome. In this group, LSR remained after MVD in 1 patient with an excellent result.

The PTTI technique group comprised 16 patients, of whom 13 (81.3%) had an excellent outcome. For the remaining 3 patients, 2
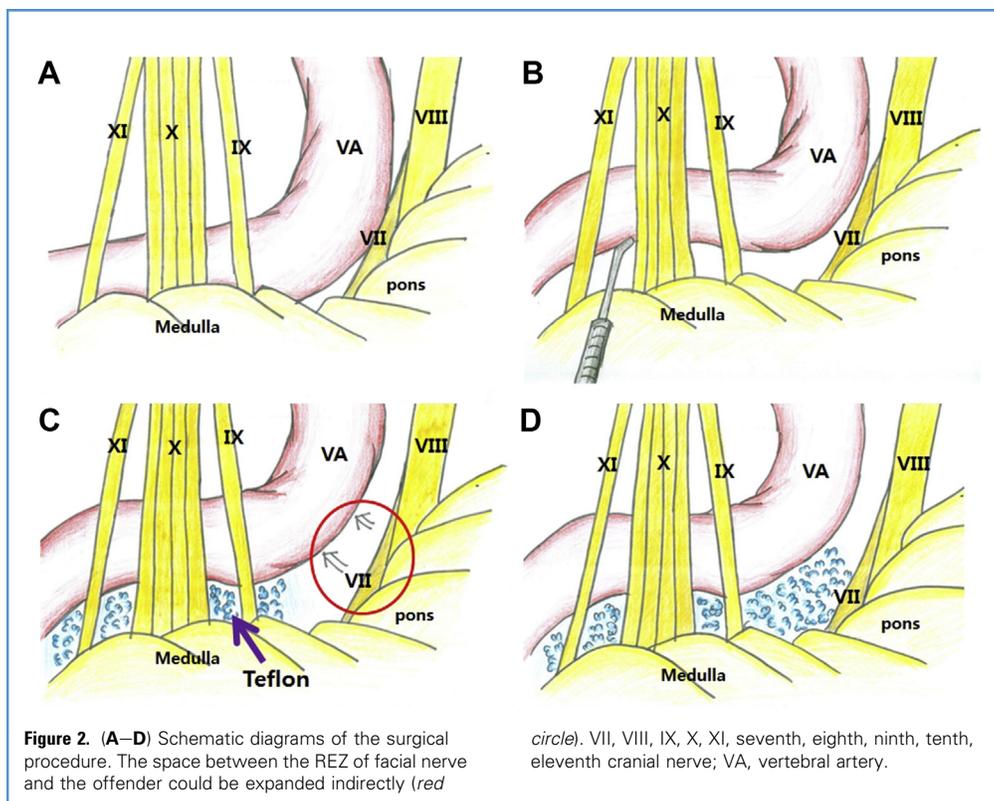
Figure 2. (**A**—**D**) Schematic diagrams of the surgical procedure. The space between the REZ of facial nerve and the offender could be expanded indirectly (*red circle*). VII, VIII, IX, X, XI, seventh, eighth, ninth, tenth, eleventh cranial nerve; VA, vertebral artery.

(12.5%) had a good outcome, and 1 (6.5%) had a poor outcome. In this group, LSR remained after MVD in 4 patients with an excellent result in 3 and poor result in 1. All results were based on follow-up at six months after MVD (Table 2).

Table 1. Characteristics of Patients with Hemifacial Spasm

Characteristic	Value
Number of patients	112
Age, years, mean (range)	54.6 (22—86)
Sex, female/male	67/45
VA offender	22 of 112 (19.6%)
Location of VA offender, right/left/both	1/20/1
Proximal VA transposition, done/not done	6/16
Offenders of VA	
VA	5
VA + PICA	6
VA + AICA	7
VA + PICA + AICA	4

VA, vertebral artery; PICA, posterior inferior cerebellar artery; AICA, anterior inferior cerebellar artery.

Complications

Major complications related to MVD were facial palsy, hearing impairment, and LCN (IX, X, XI) palsy. Facial nerve palsy was classified into early phase and later phase. Early phase was defined as within 1 week after the surgery, whereas late phase was defined as within 6 months of follow-up. In the early phase of the conventional technique group, 2 patients had no palsy, whereas 2 patients had grade 2 facial palsy, and 1 patient each had grade 3 and grade 4 facial palsy according to the House-Brackmann facial nerve grading scale.[16] In the later phase of the conventional technique group, 5 patients had no palsy, and 1 patient had

Table 2. Outcomes of Hemifacial Spasm After Surgery

Outcome	Conventional Technique (*n* = 6)	Proximal VA Transposition (*n* = 16)
Excellent*	3 (50.0%)	13 (81.3%)
Good†	1 (16.6%)	2 (12.5%)
Fair‡	1 (16.6%)	0 (0%)
Poor§	1 (16.6%)	1 (6.5%)

VA, vertebral artery.
*Excellent: complete disappearance of spasm.
†Good: occasional slight spasm.
‡Fair: moderate spasm, apparently persisting.
§Poor: no improvement.

Table 3. Facial Palsy After Surgery

Grade*	Traditional Technique		Proximal VA Transposition	
	Early†	Late‡	Early†	Late‡
1	2	5	12	16
2	2	1	4	0
3	1	0	0	0
4	1	0	0	0
5	0	0	0	0

VA, vertebral artery.
*House-Brackmann grading system.[6]
†Early phase: within 2 weeks after surgery.
‡Late phase: remnant symptoms at 6 months after surgery.

grade 2 facial palsy. In the early phase of the PTTI technique group, 12 patients had no palsy, and 4 patients had grade 2 facial palsy. No facial palsy was observed in any patient at follow-up of 6 months in the PTTI technique group (Table 3).

In the conventional technique group, 1 of 6 patients experienced hearing impairment. This patient had delayed BAEP latency during surgery, which did not completely recover. No patient had hearing impairment in the PTTI technique group. There were no LCN problems in any patient in either group. Operative site infection was observed in 1 patient. The reason was unclear. Cranial nerve VI palsy occurred in 1 case.

DISCUSSION

Nonsurgical treatment for HFS includes botulinum toxin injection treatment. Botulinum toxin has been used for HFS since the 1980s. It is a highly effective treatment for patients with high operative risk or fear of operation. Botulinum toxin has a short-term symptom relief effect of 85%. However, symptom relief lasts only 3–6 months.[17]

MVD is the most effective treatment for patients with HFS. Neurovascular compression by small vessels can be sufficiently effective by direct decompression. However, neurovascular compression by a large vessel such as a VA offender cannot be effectively treated with direct decompression by Teflon. Because VA is larger with stronger pressure than a small vessel offender such as PICA or AICA, MVD is more difficult, and surgical outcome is worse in patients with VA offenders. In addition, patients with HFS with a VA offender have more complications.[10,18] As a result, many surgeons have introduced alternative techniques for MVD in patients with a VA offender, including Teflon sling reposition, dural flap, transposition with synthetic vascular graft, double-stick tape technique, Teflon sling coated with Tisseel (Baxter Healthcare, Deerfield, Illinois, USA) technique, clip-sling-clip technique, anchoring with fenestrated clip, and others.[2,5,9-14,18,19] Previous published alternative treatments are effective. However, they are more complex than the conventional technique. The operative time is also longer than the conventional technique. Therefore, simple methods are constantly being introduced.

Our PTTI technique is technically very simple. It can be performed with mini-craniotomy. We performed craniotomy further downward by approximately 5–10 mm than what is usually done because the medulla must be exposed to the lower portion. After meticulous arachnoid dissection, LCNs are exposed. The arrangement of LCNs is different for each patient. The space between nerves is large enough to insert Teflon patties in some patients, but not in other patients. For the former case, Teflon patties were inserted carefully between LCNs with minimal manipulation using a straight dissector. For the latter case, Teflon patties were pushed down from the top of LCN complex or pushed up from below using a right angle dissector. In our study, this method worked in all patients, and none of them had LCN injuries. Any neurosurgeon familiar with microsurgery can perform the technique without difficulty.

Table 4. Comparison with Other Alternative Techniques

Reference	Patients	Technique	Good Outcome of Spasm (%)		Facial Palsy (%)	Hearing Impairment (%)	LCN Impairment (%)
			Early	Late			
Attabib and Kaufmann, 2007[9]	6	Fenestrated aneurysm clip	83.3	83.3	0	0	0
Ferreira et al., 2011[5]	6	VA pexy by suture	66.7	100	0	16.6	0
Ichikawa et al., 2011[11]	1	Double-stick tape	100	100	0	0	0
Masuoka et al., 2011[12]	5	Stitched sling retraction	100	100	0	0	0
Lin et al., 2012[19]	4	Clip-sling-clip	75	75	0	0	0
Lee et al., 2016[2]	42	Tisseel-coated Teflon sling	85.7	100	0	2.4	2.4
Zhang et al., 2017[18]	174	Biomedical glue sling	96.5	95.7	2.8	0	0
Present study, 2019	16	Proximal VA transposition	93.8	93.8	0	0	0

LCN, lower cranial nerve; VA, vertebral artery.

This method can reduce the pulsatile force of the REZ because the proximal VA is raised first. One of the causes of failure in patients undergoing conventional MVD is that pulsatile force stimulates the facial nerve constantly by high pressure despite decompression. If the pressure is constant, the larger the contact surface, the less the transmitted force. This is similar to building a large number of columns when building a bridge to reduce pressure transmitted to 1 column. Thus, the PTTI technique can reduce the offender pressure delivered to the REZ of facial nerve. This can result in good prognosis of surgical patients as seen in our study.

Another benefit of pre-decompression of the proximal site is reduced manipulation of the facial nerve. The VA is a relatively large vessel. It tends to be deeply embedded in the cerebellopontine cistern. More cerebellar retraction is required to detach the VA offender from the REZ of facial nerve, and more force is needed. Therefore, facial nerve manipulation is generally inevitable in conventional MVD for patients with a VA offender. The PTTI technique can compensate for these problems because offenders are raised in advance. The offender falls off the pontomedullary junction before direct decompression of REZ of the facial nerve. For the same reason, hearing impairment can be reduced by reducing the traction of cranial nerve VII. As a result, this method can prevent retraction injury of cranial nerve VII–VIII complex. In our study, 1 (16.6%) patient experienced hearing impairment in the traditional MVD group. However, no hearing impairment occurred in the PTTI technique group. Facial palsy also showed better results in the PTTI technique group. In the follow-up at 6 months after surgery, HFS was recovered for most cases in both groups. However, in the early phase immediately after operation, fewer patients had facial palsy in the PTTI group. This means that manipulation of cranial nerve VII–VIII complex is less in the PTTI group.

Alternative surgical methods published in other articles are also effective as shown in **Table 4**. Although the number of patients with a VA offender varied among studies, the overall surgical outcome was reported to be 66.7%–100%. Complications such as facial paralysis, hearing loss, and LCN impairment were also reported in 0%–16.6% of cases.[2,5,9,11,12,18,19] In our study, based on postoperative HFS symptoms, 15 (93.8%) patients had good outcomes (all but 1 patient). For the patient whose symptoms did not improve, the offender was involved in complex intertwining of VA, PICA, and AICA to the REZ of facial nerve. We thought that we had decompressed the REZ of facial nerve visually enough and finished the operation. However, there was no loss of LSR. There may be a hidden offender invisible to the microscopic view. The exact cause was unknown. Short-term facial palsies were present in our patients. However, neurologic deficits were absent at long-term follow-up. These results were good compared with results of other published methods (**Table 4**).

Some may think that our technique is unstable compared with the way it is tied on dura and transposition. Some may also think that the pulsatile force of the VA may make Teflon more susceptible to displacement. We reduced the possibility of Teflon displacement by inserting Teflon patties so that the direction of the VA and the direction of the Teflon patties were perpendicular. The glue was sprayed on the Teflon insertion site to prevent its displacement. We waited until it was completely hardened. It was sprayed 1 more time on the hardened glue. As a result, no patient has shown recurrence of HFS so far. However, a longer follow-up period is needed.

This study has some limitations. First, the number of patients was relatively small. The proportion of patients with HFS with VA offenders was also small. Patients undergoing the conventional MVD technique in the early stage were at the period when the operator was in the learning curve. Therefore, there is a possibility of selection bias. However, the PTTI technique was used owing to poor results of the early period, resulting in good outcome and low rate of complications. To the best of our knowledge, this is the first report of using the PTTI technique for MVD without anchoring to dura or transposition. This method is simple and effective. Neurosurgeons who are not yet expert in surgical techniques can easily access it. It is important to ensure that sufficient decompression is performed so that pulsatile force can completely be extinguished. It is also important to fix Teflon firmly with glue so that it does not fall out.

CONCLUSIONS

The PTTI technique is an easy, safe, and effective method for treatment of patients with HFS with a VA offender. The PTTI technique can be considered as another treatment option in addition to the transposition technique reported previously.

REFERENCES

1. Lu AY, Yeung JT, Gerrard JL, Michaelides EM, Sekula RF Jr, Bulsara KR. Hemifacial spasm and neurovascular compression. *ScientificWorldJournal.* 2014;2014:349319.

2. Lee SH, Park JS, Ahn YH. Bioglue-coated Teflon sling technique in microvascular decompression for hemifacial spasm involving the vertebral artery. *J Korean Neurosurg Soc.* 2016;59:505-511.

3. Dannenbaum M, Lega BC, Suki D, Harper RL, Yoshor D. Microvascular decompression for hemifacial spasm: long-term results from 114 operations performed without neurophysiological monitoring. *J Neurosurg.* 2008;109:410-415.

4. Barker FG 2nd, Jannetta PJ, Bissonette DJ, Shields PT, Larkins MV, Jho HD. Microvascular decompression for hemifacial spasm. *J Neurosurg.* 1995;82:201-210.

5. Ferreira M, Walcott BP, Nahed BV, Sekhar LN. Vertebral artery pexy for microvascular decompression of the facial nerve in the treatment of hemifacial spasm. *J Neurosurg.* 2011;114:1800-1804.

6. Kwon HM, Lee YS. Dolichoectasia of the intracranial arteries. *Curr Treat Options Cardiovasc Med.* 2011;13:261-267.

7. Kurokawa Y, Maeda Y, Toyooka T, Inaba K. Microvascular decompression for hemifacial spasm caused by the vertebral artery: a simple and effective transposition method using surgical glue. *Surg Neurol.* 2004;61:398-403.

8. Shimano H, Kondo A, Yasuda S, Inoue H, Park YT, Murao K. Microvascular decompression for hemifacial spasm associated with bilateral vertebral artery compression. *World Neurosurg.* 2015;84:1178.e1175-1178.e1179.

9. Attabib N, Kaufmann AM. Use of fenestrated aneurysm clips in microvascular decompression surgery. Technical note and case series. *J Neurosurg.* 2007;106:929-931.

10. Bejjani GK, Sekhar LN. Repositioning of the vertebral artery as treatment for neurovascular compression syndromes. Technical note. *J Neurosurg.* 1997;86:728-732.

11. Ichikawa T, Agari T, Kurozumi K, Maruo T, Satoh T, Date I. "Double-stick tape" technique for transposition of an offending vessel in

microvascular decompression: technical case report. *Neurosurgery.* 2011;68(2 Suppl Operative): 377-382 [discussion: 382].

12. Masuoka J, Matsushima T, Kawashima M, Nakahara Y, Funaki T, Mineta T. Stitched sling retraction technique for microvascular decompression: procedures and techniques based on an anatomical viewpoint. *Neurosurg Rev.* 2011;34: 373-379 [discussion: 379-380].

13. Rawlinson JN, Coakham HB. The treatment of hemifacial spasm by sling retraction. *Br J Neurosurg.* 1988;2:173-178.

14. Zaidi HA, Awad AW, Chowdhry SA, Fusco D, Nakaji P, Spetzler RF. Microvascular decompression for hemifacial spasm secondary to vertebrobasilar dolichoectasia: surgical strategies,

technical nuances and clinical outcomes. *J Clin Neurosci.* 2015;22:62-68.

15. Kondo A, Date I, Endo S, et al. A proposal for standardized analysis of the results of microvascular decompression for trigeminal neuralgia and hemifacial spasm. *Acta Neurochir.* 2012;154:773-778.

16. House JW, Brackmann DE. Facial nerve grading system. *Otolaryngol Head Neck Surg.* 1985;93:146-147.

17. Rosenstengel C, Matthes M, Baldauf J, Fleck S, Schroeder H. Hemifacial spasm: conservative and surgical treatment options. *Dtsch Arztebl Int.* 2012; 109:667-673.

18. Zhang X, Zhao H, Zhu J, et al. Outcome of the biomedical glue sling technique in microvascular decompression for hemifacial spasm involving the vertebral artery. *World Neurosurg.* 2017;104:186-191.

19. Lin CF, Chen HH, Hernesniemi J, et al. An easy adjustable method of ectatic vertebrobasilar artery transposition for microvascular decompression. *Clin Neurol Neurosurg.* 2012;114:951-956.