“Birdlime” technique using TachoSil tissue sealing sheet soaked with fibrin glue for sutureless vessel transposition in microvascular decompression: operative technique and nuances

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OBJECTIVE Microvascular decompression (MVD) is effective for the treatment of trigeminal neuralgia (TN), hemifacial spasm (HFS), and glossopharyngeal neuralgia. The transposition technique is the standard procedure to avoid adhesions and granuloma around the decompression site but is more complex and difficult to perform than the interposition technique. The authors describe a simple and safe MVD transposition procedure they call the “birdlime” technique, which uses a tissue glue–coated collagen sponge soaked with fibrin glue, and the results of this technique.

METHODS The authors retrospectively reviewed the medical charts and radiographic findings of 27 consecutive patients with TN (8 patients) and HFS (19 patients) who, between January 2012 and December 2015, had undergone an MVD transposition procedure utilizing a tissue glue–coated collagen sponge (TachoSil tissue sealing sheet) soaked with fibrin glue (Tisseel 2-component fibrin sealant, vapor heated). Offending arteries among the patients with TN were the superior cerebellar artery (SCA) in 5 patients, the SCA and anterior inferior cerebellar artery (AICA) in 2, and the AICA in 1. Those among the patients with HFS were the vertebral artery (VA) in 3 patients, the VA and AICA in 4, the VA and posterior inferior cerebellar artery (PICA) in 3, the PICA in 4, the AICA in 1, the AICA-PICA in 3, and the PICA and AICA in 1. Operations were performed according to the Jannetta procedure. The offending artery was transposed and fixed to the dura mater of the petrous bone using TachoSil pieces soaked with fibrin glue. Postoperative constructive interference in steady-state MRI was performed to evaluate the change in the position of the offending artery.

RESULTS Transposition of the offending artery was easily and safely performed in all patients. All patients had total remission of symptoms directly after the procedure. No severe complications occurred. The postoperative course was uneventful. No recurrences, adhesions, or dysfunction of the cranial nerves was observed in any of the patients. Postoperative MRI showed that the offending vessels were displaced and fixed in the appropriate position.

CONCLUSIONS The described transposition technique provides an easy and adjustable way to perform MVD safely and effectively. In addition, this transposition and fixation technique is simple and avoids the risk of needle injury close to the cranial nerves and vessels. This simple sutureless technique is recommended for MVD to reduce the risk of intraoperative neurovascular injury.

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KEY WORDS microvascular decompression; vessel transposition; TachoSil; fibrin glue; functional neurosurgery; surgical technique

MICROVASCULAR decompression (MVD) is an effective surgical procedure for the treatment of hemifacial spasm (HFS), trigeminal neuralgia (TN), and glossopharyngeal neuralgia.¹⁰ Recent advances in microsurgical techniques have resulted in further improve-

ments in the outcome of MVD. Therefore, current surgical management for MVD focuses on minimizing recurrence rates and reducing operative morbidity and mortality.

Two different techniques are used for displacing the offending vessels: the interposition method and the trans-

ABBREVIATIONS AICA = anterior inferior cerebellar artery; HFS = hemifacial spasm; ICG = indocyanine green; MVD = microvascular decompression; PICA = posterior inferior cerebellar artery; REZ = root exit zone; SCA = superior cerebellar artery; TN = trigeminal neuralgia; VA = vertebral artery.

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FIG. 1. Illustration showing how to prepare the adhesive material, similar to birdlime, which was trimmed and soaked with fibrin glue between thumb and forefinger. Copyright Naoki Otani. Published with permission.

position method. A favorable surgical outcome following MVD depends on permanent and complete transposition of the offending vessels.²³ However, current transposition procedures are more complicated, more time consuming, and more hazardous than interposition techniques because suturing with a needle is required in the vicinity of the brainstem.^{3,5,15,18,20,25,26}

The TachoSil tissue sealing sheet (CSL Behring K.K.) is a ready-to-use surgical patch consisting of a white collagen sponge coated on one side with fibrinogen and thrombin, which has been used in various neurosurgical procedures to achieve hemostasis⁷ and tissue sealing to prevent CSF leakage.^{8,11} Experience with this material in MVD was first described in 2011 as the “double-stick tape” technique.⁹ We modified this technique to improve ease of handling and performance of TachoSil, which we trimmed and soaked with fibrin glue between thumb and forefinger to create an adhesive material similar to birdlime (Fig. 1), an adhesive and sticky material smeared on twigs to ensnare small birds. We here describe our simple, quick transposition method using TachoSil in MVD and evaluate the outcomes with special emphasis on the clinical and surgical outcomes in a series of 27 consecutive patients. We discuss the surgical advantages and pitfalls of this newly modified, sutureless transposition method for MVD.

Methods

Patient Characteristics

This retrospective analysis included 27 consecutive patients, 19 with HFS and 8 with TN, whose ages ranged from 41 to 73 years (mean 62 years) and who had undergone surgical treatment at the National Defense Medical College Hospital between January 2012 and December 2015. Microvascular decompression was performed via a conventional lateral suboccipital retroauricular approach. Medical charts, radiological findings, surgical techniques, complications, and final surgical results were retrospectively reviewed. At discharge, patient outcome was assessed as good recovery, moderate disability, severe disability, vegetative state, and death, according to the Glasgow Outcome Scale. All patients underwent MRI and MR angiography before and after the operation. All patients underwent de-

tailed pre- and postoperative evaluations of hearing function by an otolaryngologist.

Surgical Material

A standard sponge TachoSil tissue sealing sheet was used in all procedures. This product has an active yellow side coated with human thrombin (2.0 IU/cm²) and human fibrinogen (5.5 mg/cm²) and a supportive white side coated with collagen. The sheet was trimmed with surgical scissors and soaked with fibrin glue (Tisseel 2-component fibrin sealant, vapor heated, Baxter Healthcare Corp.) between thumb and forefinger to create an adhesive material similar to birdlime (Fig. 1).

Operative Procedure

All patients underwent a standard retrosigmoid approach under auditory brainstem response monitoring. All patients were placed in the lateral decubitus position, and the head was fixed on the operating table and turned 30° to the contralateral side, with the space of 1 finger breadth between the chin and neck. A retromastoid curvilinear skin incision was made. The mastoid eminence, digastric groove, and inion were identified to define the transverse sigmoid junction.

To treat TN, a craniotomy is performed to expose the border of the transverse and sigmoid sinuses. The spatula is placed over the marginal aspect of the cerebellar surface. With slight elevation of the cerebellum without injury to the petrosal vein, the trigeminal nerve can be seen. Offending vessels are dissected and mobilized away from the trigeminal nerve. To decompress the offending vessels, the adhesive TachoSil material is placed on the tentorial or dural surface of the petrous bone, depending on the required direction of the transposition, and the offending vessels are displaced with microfine forceps for 3 minutes. The surgical procedure is shown in Fig. 2. After all adjustments are completed, the adhesive site is additionally secured with fibrin glue. Finally, indocyanine green (ICG) angiography is performed to confirm patency of the offending vessels and perforators. The dura mater is closed in a watertight fashion. The wound is closed layer by layer.

To treat HFS, the supracondylar area is removed to min-

FIG. 2. Illustrations of transposition using the TachoSil material. **A:** Offending vessels are dissected and mobilized away from the trigeminal nerve. **B:** The adhesive TachoSil (TS) material is placed on the tentorial or dural surface of the petrous bone, depending on the required direction of the transposition, and the offending vessels are displaced with microfine forceps for 3 minutes. **C:** After all adjustments are completed, vessel transposition is confirmed. V = trigeminal nerve; VIII = acoustic nerve. Copyright Naoki Otani. Published with permission.

imize retraction and to approach the root exit zone (REZ) of the facial nerve directly from the caudal direction. The dural incision is curvilinear. The arachnoid membrane of the cisterna magna is incised, and the CSF is drained sufficiently to provide adequate cerebellar relaxation. The spatula is placed over the inferior aspect of the cerebellar surface. With slight elevation of the inferior medial surface of the cerebellum, the entire courses of the ninth and 10th cranial nerves can be seen. Advanced arachnoid dissection of the cerebellomedullary fissure along the proximal portion of the lower cranial nerves toward their origins exposes the choroid plexus of the lateral recess of the fourth ventricle. With slight elevation of the flocculus and the choroid plexus away from the ninth cranial nerve, the REZ of the facial nerve can easily be observed without tension on the eighth cranial nerve. Offending vessels are carefully visualized, dissected, and mobilized away from the REZ of the facial nerve. To decompress the offending vessels, the adhesive TachoSil material is placed on the posterior dural surface of the petrous bone, and the offending vessels are displaced with microfine forceps for 3 minutes. The procedure is completed as described for TN.

Results

The clinical characteristics of the patients are summarized in Table 1. This transposition method was used to achieve MVD in 19 patients with HFS and 8 patients with TN. A tortuous vertebral artery (VA) was transposed in 10 HFS patients, and the anterior inferior cerebellar artery (AICA) or posterior inferior cerebellar artery (PICA) was transposed in 9 patients. Multiple offending vessels were transposed in 2 TN patients, and a single offending AICA or superior cerebellar artery (SCA) was transposed in 6. Fixation of the offending vessels with TachoSil and fibrin glue was performed in all patients. No permanent complications related to the surgical procedure occurred, nor did any infections or allergic reactions. Hemifacial spasm disappeared within 3 months in 18 of the 19 patients. During a follow-up of 17 months, 1 patient suffered a recurrence of HFS due to compression of another offending artery at the distal site of the facial nerve. Trigeminal neuralgia disappeared within 3 months in 7 of the 8 patients. One

patient had slight numbness after surgery caused by the petrosal vein. There were no surgery-related deaths or life-threatening complications throughout the study period.

There were no patients who had recurrence of TN or HFS due to the birdlime technique during a mean follow-up of 28.8 months (9–56 months). Preoperative MRI showed the offending vessels compressing the REZ and/or trigeminal nerve. In all patients, follow-up MRI confirmed that the offending vessels were displaced with the adhesive TachoSil material.

Illustrative Cases

Case 24

Examination

A 66-year-old woman had suffered daily TN for 8 years. Medication gradually became ineffective. Neurological examination on admission showed no abnormalities. Preoperative MRI revealed that the right SCA and AICA compressed the trigeminal nerve at the cisternal portion.

Operation

Microvascular decompression was performed via the lateral suboccipital approach. The entire course of the cisternal portion of the trigeminal nerve was completely exposed, and the SCA and AICA were found to adhere to and compress the trigeminal nerve, resulting in an indentation on the nerve (Fig. 3A and B). TachoSil pieces soaked with fibrin glue were placed on the dural surface of the petrous bone. Until the glue hardened, the SCA was pressed onto the TachoSil on the dura of the petrous bone for 3 minutes. After this procedure, SCA transposition was confirmed (Fig. 3C). In addition, a TachoSil piece soaked with fibrin glue was placed on the tentorial surface. The AICA was pressed onto the TachoSil on the tentorial surface for 3 minutes. After this procedure, AICA transposition was confirmed (Fig. 3D). Electrophysiological monitoring showed no changes during the operation.

Postoperative Course

The postoperative course was uneventful, and the patient's symptoms completely resolved immediately after

TABLE 1. Clinical characteristics of 27 patients who underwent vessel transposition using TachoSil tissue sealing sheet soaked with fibrin glue for MVD

Case No.	Age (yrs)/Sex	Side	Symptom	Offending Artery	Surgical Complication	Surgical Outcome
1	73/F	Lt	HFS	VA & AICA	None	CR
2	49/F	Lt	HFS	AICA	None	CR
3	43/F	Rt	HFS	AICA-PICA	None	CR
4	58/F	Rt	HFS	PICA & AICA	None	CR
5	60/F	Rt	HFS	VA	None	CR
6	70/M	Lt	HFS	VA	None	CR
7	61/F	Lt	HFS	Bilat VA	None	CR
8	41/F	Lt	HFS	AICA-PICA	None	CR
9	53/F	Rt	HFS	PICA	None	50% improvement
10	66/F	Lt	HFS	PICA	None	CR
11	46/F	Lt	HFS	VA & PICA	None	CR
12	43/M	Lt	HFS	VA & AICA	None	CR
13	59/M	Lt	HFS	VA & AICA	None	CR
14	53/M	Rt	HFS	AICA-PICA	None	CR
15	62/M	Lt	HFS	VA & AICA	None	CR
16	57/M	Lt	HFS	VA & PICA, AICA	None	CR
17	60/M	Lt	HFS & GPN	VA & PICA, VA	Transient HD	CR
18	68/F	Lt	HFS	PICA	None	CR
19	59/M	Rt	HFS	PICA	None	CR
20	58/M	Rt	TN (V3)	SCA	None	CR
21	70/F	Rt	TN (V2)	SCA & PV	None	80% improvement
22	47/F	Lt	TN (V3-2)	SCA	None	CR
23	65/F	Lt	TN (V3)	SCA	None	CR
24	66/F	Rt	TN (V3)	SCA & AICA	None	CR
25	68/M	Rt	TN (V3-2)	AICA	None	CR
26	72/M	Lt	TN (V3-2)	SCA & AICA	None	CR
27	60/M	Lt	TN (V3-2)	SCA	None	CR

CR = complete remission; GPN = glossopharyngeal neuralgia; HD = hearing disturbance; PV = petrosal vein.

surgery. The patient was discharged with no neurological deficits.

Case 15

Examination

A 62-year-old man presented with a 3-year history of left-sided facial spasm including the orbicularis oculi and orbicularis oris muscles, triggered by cold or effort stimulation. Preoperative MRI revealed a tortuous left VA indenting into the REZ (Fig. 4A and D).

Operation

The patient underwent MVD via the transcondylar fossa approach to gain wide exposure of the REZ of the facial nerve from the caudal side and to minimize cerebellum retraction. The offending VA was dissected away from the pontomedullary junction toward the cranial base, and the AICA and VA were found to adhere and compress the facial nerve, resulting in an indentation on the nerve (Fig. 5A). A TachoSil piece was placed on the petrosal surface of the jugular tubercle, and the VA was pressed onto the TachoSil on the petrous bone (Fig. 5B). Thereafter, VA

transposition was confirmed (Fig. 5C). TachoSil pieces soaked with fibrin glue were placed onto the dural surface of the petrous bone. Until the glue hardened, the VA was pressed onto the TachoSil on the dura of the petrous bone for 3 minutes. After this procedure, complete VA transposition was confirmed (Fig. 5D). In addition, a TachoSil piece soaked with fibrin glue was placed on the VA, and the offending PICA was pressed onto the TachoSil for adhesion with the VA. After this procedure, PICA transposition was confirmed (Fig. 5E). Electrophysiological monitoring demonstrated no changes during the operation. To confirm the patency of the offending vessels and perforators, ICG angiography was performed (Fig. 5F).

Postoperative Course

The patient's postoperative course was uneventful. His symptoms completely resolved immediately after surgery. Postoperative MRI showed the VA was completely transposed away from the REZ (Fig. 4B). TachoSil adhered to the dural surface of the petrous bone (Fig. 4E). The patient was discharged with no neurological deficits, and he remained asymptomatic at his 2-year follow-up visit. In ad-

FIG. 3. Case 24. Microvascular decompression was performed via the lateral suboccipital approach. The entire course of the cisternal portion of the trigeminal nerve was completely exposed, and the SCA and AICA were found to adhere to and compress the trigeminal nerve, resulting in an indentation on the nerve (**A and B**). TachoSil (TS) pieces soaked with fibrin glue were placed on the dural surface of the petrous bone. Until the glue hardened, the SCA was pressed onto the TachoSil on the dura of the petrous bone for 3 minutes. After this procedure, SCA transposition was confirmed (**C**). In addition, a TachoSil piece soaked with fibrin glue was placed on the tentorial surface. The AICA was pressed onto the TachoSil on the tentorial surface for 3 minutes. After this procedure, AICA transposition was confirmed (**D**). V = trigeminal nerve; V of CPA = vein of the cerebellopontine angle.

FIG. 4. Case 15. **A and D:** Preoperative MR images revealing a tortuous left VA (black arrows) indenting into the REZ. **B and E:** Postoperative MR images showing the VA (black arrows) was completely transposed away from the REZ. TachoSil (white arrowheads) adhered to the dural surface of the petrous bone. **C and F:** Follow-up MR images obtained 2 years after surgery, indicating that the VA (black arrows) as an offending vessel was displaced with adhesive TachoSil material (white arrowheads), which showed no infectious and/or inflammatory reaction. VII = facial nerve.

FIG. 5. Case 15. Intraoperative photograph showing the offending VA dissected away from the pontomedullary junction toward the cranial base, and the AICA and VA adhering to and compressing the facial nerve, resulting in an indentation on the nerve (A). A TachoSil (TS) piece was placed on the petrosal surface of the jugular tubercle, and the VA was pressed onto the TachoSil on the petrous bone (B). Thereafter, VA transposition was confirmed (C). TachoSil pieces soaked with fibrin glue were placed onto the dural surface of the petrous bone. Until the glue hardened, the VA was pressed onto the TachoSil on the dura of the petrous bone for 3 minutes. After this procedure, complete VA transposition was confirmed (D). In addition, a TachoSil piece soaked with fibrin glue was placed on the VA, and the offending PICA was pressed to form adhesion with the VA. After this procedure, PICA transposition was confirmed (E). Indocyanine green angiography was performed to confirm the patency of the offending vessels and perforators (F). VIII = acoustic nerve; IX = glossopharyngeal nerve.

dition, follow-up MRI 2 years after surgery indicated that the VA as an offending vessel was displaced with adhesive TachoSil material (Fig. 4C), which showed no infectious and/or inflammatory reaction (Fig. 4F).

Discussion

Vascular compression in patients with HFS was first described by Campbell and Keedy in 1947.⁴ Vascular decompression for the treatment of HFS was proposed by Gardner and Sava.⁶ Jannetta et al. suggested that the etiology of HFS was vascular compression at the REZ of the facial nerve.¹⁰ During the last decades, advances in mi-

crosurgical techniques have improved MVD's outcomes and reduced its operative morbidity and mortality. Previously, the incidence of permanent cranial nerve injury was 10% in patients treated with MVD.¹⁹ And, MVD in 648 patients with HFS resulted in postoperative permanent facial palsy in 22 patients (3.4%) and hearing loss in 21 patients (3.3%).² These complications from conventional MVD may be related to the mass effect introduced by the interposed prosthetic material positioned during surgery.

The 2 techniques for shifting the offending vessels are the interposition method and the transposition method. Favorable surgical outcomes of MVD depend on permanent

and complete transposition of the offending vessels.²³ Sindou et al. suggested that the significant, better long-term cure rate when an implant is not in contact with the nerve root favors the pure decompressive effect of the MVD procedure rather than a conduction block mechanism. In terms of the outcome, foreign material touching the nerve may produce a harmful neocompressive effect and hamper the long-term efficacy of the procedure.^{21,22} The first transposition method for treating HFS used Teflon tape.⁵ Various materials have since been employed in transposition procedures, including strips of dura,^{3,12} fascia,¹⁷ sutures,^{3,18} tapes,¹⁶ fibrin tissue-adhesive collagen fleece product,¹⁴ silicone (polydimethylsiloxane) tube,²⁵ fenestrated aneurysm clip,¹ or expanded polytetrafluoroethylene.^{18,20} However, these transposition procedures are more complicated, more time consuming, and more hazardous than interposition techniques because suturing with a needle is required in the vicinity of the brainstem.^{3,5,15,18,20,25,26}

Transposition in the present series utilized the TachoSil tissue sealing sheet, classified as a topical hemostat, sealant, and adhesive,²⁴ which is a fixed combination of collagen matrix coated with 2 coagulation factors, fibrinogen and thrombin, and indicated as a supportive treatment for the improvement of hemostasis to promote tissue sealing. Kivelev et al.¹³ retrospectively analyzed 100 consecutive patients who had undergone microneurosurgical procedures utilizing TachoSil and reported that no patient showed any signs of allergic reaction or infection. Microvascular decompression using TachoComb was first described by Ichikawa et al.⁹ in 2011. TachoSil has several advantages for MVD given its elasticity, ease in manipulating it into various shapes and configurations, and easy application. In addition, this material only requires adhesive attachment to the dura of the petrous or clival bone and to the tentorium. Therefore, our technique can avoid the risk of injury from both suturing and excessive cerebellar retraction and is less complex, less hazardous, and quicker than previously reported techniques. The application of TachoSil as we describe it here requires careful attention to prevent vascular kinking or stenosis of the transposed vessels and preservation of the brainstem perforators, which can be assessed by direct observation as well as by intraoperative Doppler flow and ICG video angiography. If the transposed vessel is seen to be in a sub-optimal position, for example, causing vessel kinking, the vessels can be easily separated from the implant material and repositioned without tissue damage, even numerous times. Therefore, we can reposition the offending vessels until we find their optimal placement without causing vessel kinking and/or stenosis.

In particular, the characteristics of this material have been beneficial for transposition of the VA. In the present series, 10 patients underwent safe transposition of the VA as an offending vessel. This material can be easily applied and even stacked because of its elasticity and the ease in manipulating it into various shapes and configurations (Fig. 5B–E) in deep and narrow operative sites, such as the jugular tubercle, through the inferior cranial nerves. Therefore, meticulous VA transposition can be achieved with the natural shape and direction of the vessel with as little tensile force at the localized vessel wall as possible.

Conclusions

A series of 27 consecutive patients with HFS were treated with MVD using TachoSil soaked with fibrin glue, which has several advantages in terms of its elasticity, ease in manipulating it into various shapes and configurations, and easy application. Our modified, simple, quick method can be used to perform vessel transposition easily and precisely, minimizing postoperative complications. We recommend this sutureless technique for vessel transposition in MVD to reduce the risk of intraoperative neurovascular injury.

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Otani. Acquisition of data: Takeuchi. Analysis and interpretation of data: Fujii. Drafting the article: Tomiyama, Kumagai. Statistical analysis: Toyooka, Nakao, Yamamoto. Study supervision: Wada, Mori.

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