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Biomedical Glue Sling Technique in Microvascular Decompression for Trigeminal Neuralgia Caused by Atherosclerotic Vertebrobasilar Artery: A Description of Operative Technique and Clinical Outcomes

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BACKGROUND: **Microvascular decompression (MVD) is the most definitive surgical treatment for trigeminal neuralgia (TN). In the case in which an atherosclerotic vertebrobasilar artery (aVBA) offends the trigeminal nerve, the postoperative outcomes have been reported to be less satisfactory in terms of symptom recurrence and complications. In this study, the authors present their experience using a biomedical sling for MVD in patients with aVBA-associated TN.**

METHODS: **A retrospective study of 22 consecutive patients who underwent the biomedical glue sling technique in MVD for TN with aVBA was conducted between September 2016 and June 2017.**

RESULTS: **Intraoperatively, aVBA was regarded as the direct or indirect offending vessel in 22 patients. In addition to aVBA, other vessels involved in neurovascular conflict included superior cerebellar artery in 12 patients, veins in 1, and anterior inferior cerebellar artery in 6. All 22 patients underwent the biomedical glue sling technique. Postoperatively, TN was completely resolved in 20 (91%) patients and partially relieved in 2 (9%) patients. During the follow-up period of 18–27 months, pain developed severely in those 2 patients but could be relieved with carbamazepine. As for complications, postoperative hypoacusia occurred immediately in 1 case, with complete resolution in 2 months.**

CONCLUSIONS: **The biggest advantage of the biomedical glue sling technique is its simplicity in achieving complete decompression, requiring relatively less space and time. Because the outcome of traditional MVD regarding aVBA-associated TN remains controversial, the biomedical glue sling technique in MVD provides an alternative decompressive method for patients with TN associated with aVBA. However, further studies with a larger series and control group are required to prove the high effectiveness of this method.**

INTRODUCTION

Trigeminal neuralgia (TN) is defined as unilateral disorder characterized by sudden, severe, brief, stabbing, and recurrent pain within the distribution of 1 or more divisions of the trigeminal nerve. It is mainly caused by neurovascular compression on the root exit zone (REZ) of the fifth cranial nerve by 1 or more adjacent blood vessels, chiefly arterial in nature.[1] Microvascular decompression (MVD) may be considered over other techniques as the most definitive and durable treatment for TN.[1,2] However, in some published reports, the postoperative outcomes of patients with vascular conflict arising from atherosclerotic vertebrobasilar artery (aVBA) have been reported relatively unsatisfactory in terms of recurrence and occurrence of complications.[3-5] These unsatisfactory outcomes likely arise from the inability to mobilize atherosclerotic and tortuous vertebrobasilar artery (VBA) away from the trigeminal nerve, thus resulting in a persistent neurovascular conflict. The biomedical glue sling technique in MVD has been reported as a

Key words
- Atherosclerotic vertebrobasilar artery
- Biomedical glue sling
- Microvascular decompression
- Trigeminal neuralgia

Abbreviations and Acronyms
AICA: Anterior inferior cerebellar artery
aVBA: Atherosclerotic vertebrobasilar artery
BNI: Barrow Neurological Institute
MVD: Microvascular decompression
REZ: Root exit zone
SCA: Superior cerebellar artery
TN: Trigeminal neuralgia
VBA: Vertebrobasilar artery

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Table 1. Barrow Neurological Institute Pain Intensity Score

Score	
I	No trigeminal pain, no medication
II	Occasional pain, not requiring medication
III	Some pain, adequately controlled with medication
IV	Some pain, not adequately controlled with medication
V	Severe pain/no pain relief

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simple and effective way to transpose aVBA.[5] In the present study, we describe the technique and analyze the efficacy of a new type of biomedical glue sling technique for TN caused by aVBA.

MATERIAL AND METHODS

A total of 563 consecutive patients with TN were treated by MVD performed by the same surgeon between September 2016 and June 2017 in our department (China-Japan Friendship Hospital), of whom 22 had aVBA-associated TN and underwent the biomedical glue sling technique during MVD. Among the 22 patients, there were 9 males and 13 females, with a mean age of 63 years (range, 44–80 years). Symptom duration ranged from 6 months to 13 years with a mean of 4.2 years. The right side was affected in 8 patients and left in 14 patients. Preoperative magnetic resonance imaging and/or computer tomography examination were carried out to identify offending vessels in all cases. The Barrow Neurological Institute (BNI) pain intensity score, described by Rogers et al,[6] was used to assess facial pain status immediately after surgery and during follow-up (Table 1).

OPERATIVE PROCEDURES

A standard lateral suboccipital retrosigmoid approach was performed for all patients. The arachnoid around nerves and vessels were opened thoroughly from the caudal nerves to the fifth nerve. The aVBA was slowly dislocated caudally away from the pontomedullary junction toward the skull base, with care to not disrupt associated small perforating arteries. Then, the aVBA was mobilized away from the fifth nerve using Teflon pads placed between the vessel and the brain stem. After the reconfirmation that transposition could be achieved, we further dissected arachnoid membranes around the petrosal apex dura thoroughly and used bipolar cautery to coagulate the petrosal apex, which was helpful in enhancing the adhesion between the insulation and dura. A portion of VBA was chosen to place the biomedical glue where a small piece of dry gelfoam was used as insulation. An aspirator was used to hold the opposite (ventral) side of the aVBA with a small piece of gelfoam until the glue was hardened (Figures 1 and 2). After sufficient transposition of aVBA, other offending arteries such as anterior inferior cerebellar artery (AICA) and/or superior cerebellar artery became quite visible and traditional transposition techniques were then used by inserting strands of Teflon between these branches and the brain stem (Figure 3).

RESULTS

VBA was found to be the offending vessel in all 22 patients through preoperative magnetic resonance imaging and/or computer tomography scan, vertebral artery (VA) in 17 and basilar artery in 5 (Figures 2 and 4). aVBA was discovered to be the only vascular offender in 5 cases. Besides VBA, some smaller vessels were also observed to compress the fifth nerve, including superior cerebellar artery (SCA) in 12, vein in 1, and AICA in 6.

At a mean follow-up period of 22 months (range, 18–27 months), TN was completely resolved in 20 (91%) patients immediately after surgery (BNI score I). Two patients had significant improvement immediately after surgery, with only occasional pain and no medication usage (BNI score II). However, in those 2 patients, the pain worsened severely over time but remained amenable to relief with carbamazepine at 10 and 12 months (BNI

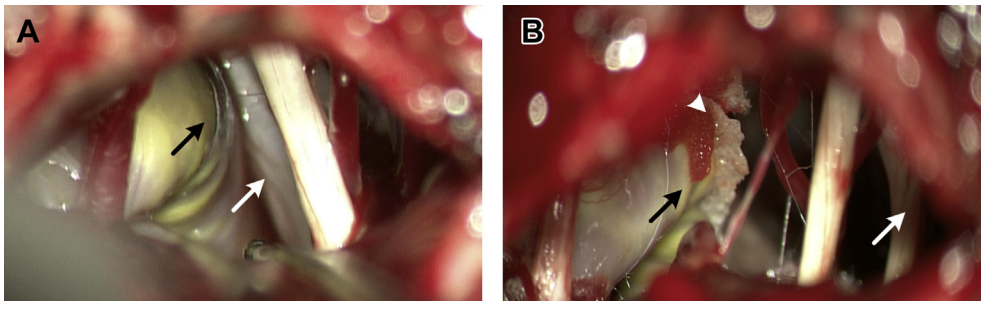

Figure 1. Intraoperative photograph of a patient with left trigeminal neuralgia. (**A**) The trigeminal nerve (*white arrow*) was compressed by the severely calcified atherosclerotic vertebrobasilar artery (aVBA; *black arrow*). (**B**) The aVBA (*black arrow*) was fixed on the coagulated petrous dura by a small piece of dry gelfoam with biomedical glue (*white arrowhead*) and transposed from the trigeminal nerve (*white arrow*).

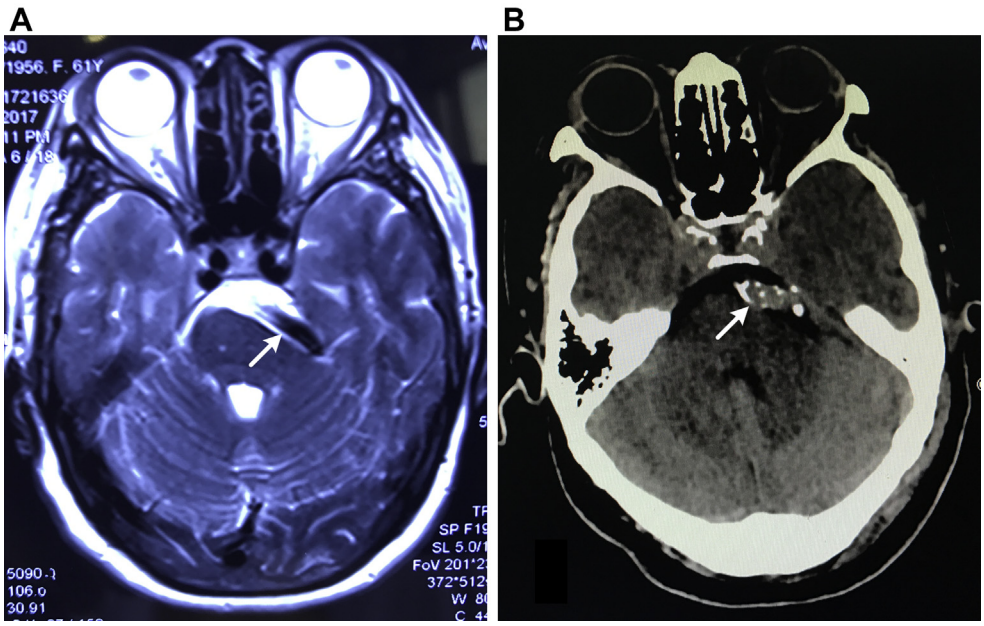

Figure 2. (**A**) The preoperative magnetic resonance image illustrates the atherosclerotic vertebrobasilar artery (aVBA; *white arrow*) deformatively compressed brainstem at pons. (**B**) The computer tomography illustrates the calcified aVBA (*white arrow*), which was now fixed on the coagulated petrous dura and clearly pulled away from pons after operation.

score III). One patient experienced postoperative hypoacusia, which resolved within 2 months (Table 2).

DISCUSSION

TN is mainly caused by neurovascular compression on the REZ of the fifth cranial nerve by 1 or more adjacent arteries.[1] Most frequently, a loop of SCA and/or AICA offends the intracranial segment of the fifth nerve. In rare cases, VBA compresses the trigeminal nerve, accounting for approximately 2%–7.7% of all TN cases.[7-10] In our data, 22 of 563 consecutive patients (3.9%) were found to have TN due to vascular compression of the trigeminal nerve from the VBA. Intraoperatively, all involved VBA are obviously atherosclerotic. However, previous studies on the association of TN with aVBA are rare, and most of them were case reports. No retrospective study of the biomedical glue sling

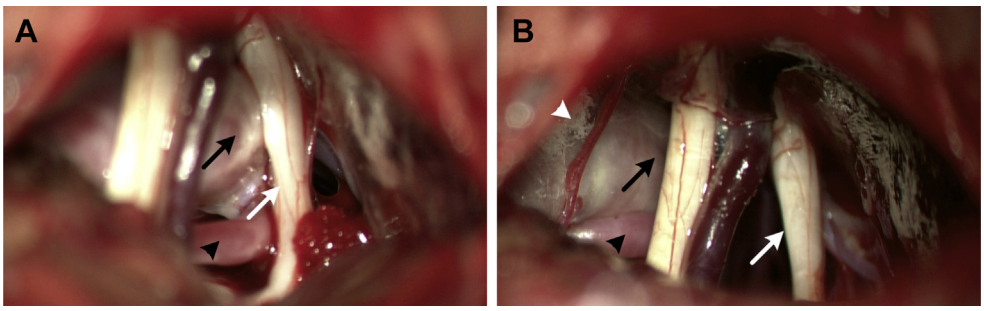

Figure 3. Intraoperative photograph of a patient with left trigeminal neuralgia. (**A**) The root exit zone of trigeminal nerve (*white arrow*) was compressed by atherosclerotic vertebrobasilar artery (aVBA; *black arrow*) and anterior inferior cerebellar artery (AICA) (*black arrowhead*). (**B**) The aVBA (*black arrow*) was fixed on the coagulated petrous dura using a small piece of dry gelfoam with biomedical glue (*white arrowhead*) and transposed from the trigeminal nerve (*white arrow*). The AICA (*black arrowhead*) was transposed from the trigeminal nerve (*white arrow*) by inserting strands of Teflon between these branches and the brain stem.

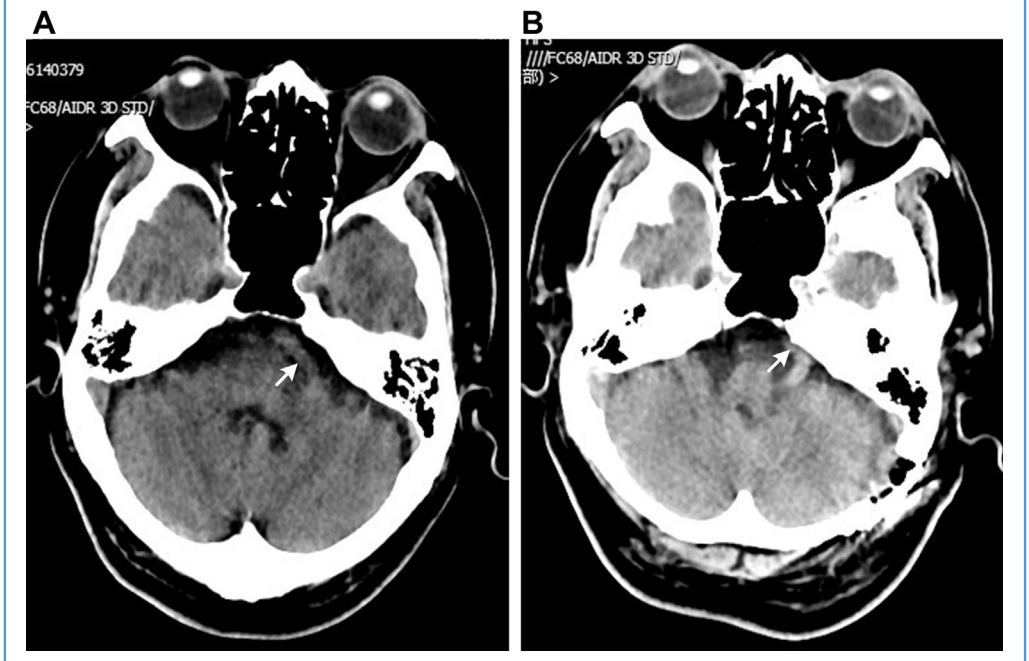

Figure 4. (**A**) The computer tomography illustrates that the atherosclerotic vertebrobasilar artery (aVBA; *white arrow*) was at the pontomedullary junction before operation. (**B**) The slightly calcified aVBA (*white arrow*) was now fixed on the coagulated petrous dura and clearly pulled away from the brain stem after operation.

technique in MVD with a large dataset had been conducted. We present the first such large institutional series on the effect of the biomedical glue sling technique to transpose aVBA during MVD.

The mean age of onset of idiopathic TN is in late 40s with preponderance in oriental women[11,12] and a little higher prevalence of right-sided symptom and pain located in V2 and V3.[11,13,14] However, in our cases, the right side was affected in 8 patients and the left side in 14 patients. The left-to-right ratio was approximately 1.8, which may be attributed to the anatomical asymmetry of the vertebral arteries and hemodynamic factors.[15,16] The majority of the patients in our series had pain lateralized to the V2 and/or V3 dermatome, which can be explained by the somatotopic distribution of the sensory fibers in the trigeminal root. Sindou et al[17] observed that during MVD when pain was in V2 or V3, an offending vessel was more frequently found in a superior-lateral or inferior position relative to the surface of the nerve root.

aVBA is not readily movable due to the following factors: 1) the elasticity of aVBA is poor and the tortuous or ecstatic VBA is relatively too large to dislocate; 2) some less tortuous perforators that originate from VBA usually run directly to the brain stem, which make VBA difficult to be transposed; and 3) atherosclerotic plaques have the potential to break during mobilization, which can serve as a source of emboli and may cause ischemic stroke or cerebral hemorrhage.

In traditional MVD, we decompress the REZ of the fifth nerve caused by aVBA only through placing a prosthesis without repositioning aVBA. In some previous reports, the authors held the view that traditional MVD was effective for TN caused by an ectatic, prolongated, tortuous, and sclerotic VBA system with regard to high pain-free rate and low occurrence of complications.[7,18,19] There have also been unsatisfactory results in published reports; however, in terms of recurrence, various degrees of cranial nerve palsy and other surgical complications were observed.[3,20] The traditional MVD placing a prosthesis between the offending artery and nerve may increase the compression, and inflammatory responses to this prosthesis can result in granuloma formation, which leads to recurrence and failure of MVD.[21,22] To reposition the offending artery away from the nerve and avoid rebound of a tortuous VBA, some neurosurgeons have reported adhering aVBA to the petrous bone with vascular tapes, strips, threads, and aneurysmal clips or glue.[3,23] The methods using tapes, strips, and clips require a wider working space, whereas the methods using glue are elegant in their simplicity and require relatively less operative corridor. Although the authors have reported that chemical vasculitis may potentially cause arterial occlusion, biomedical glue does not cause any intimal damage and should theoretically not be associated with this complication.[24] A published study found that the biomedical glue sling technique of MVD was more effective than the traditional technique in patients with hemifacial spasm associated with VA, with no difference in the incidence of complication.[25,26] In our study, in patients undergoing MVD with the use of a biomedical glue sling as their initial decompressive procedure, TN completely resolved in 91% patients at the last follow-up. Despite the high cure rate, this study has limitations because of the lack of control group and because it was carried out in a small series. To assess the effectiveness of this technique more precisely, further studies

Table 2. Clinical Summary of the 22 Trigeminal Neuralgia Patients Caused by Atherosclerotic Vertebrobasilar Artery Who Underwent Microvascular Decompression Through the Biomedical Glue Sling Technique with Dry Gelfoam

Cases	Age (Years)/Sex	Side	Trigeminal Divisions Involved	Duration (Years)	Offending Vessels	Preoperative Symptom (BNI)	Outcome (BNI)	Complications/Other Outcomes
1	60/M	L	III	3	VA + SCA	V	I	None
2	74/F	L	II, III	13	VA + SCA	V	I	None
3	44/M	L	II, III	5	VA	V	I	None
4	68/M	R	II, III	1	BA + AICA	V	I	None
5	80/F	L	II, III	8	VA + SCA	V	I	None
6	78/M	L	II, III	4	BA + SCA	V	I	None
7	74/F	R	II, III	5	BA	V	I	Hypoacusia
8	64/M	L	II, III	1.5	VA + vein	V	III	None
9	50/F	L	II	1	BA	V	I	None
10	62/F	L	II, III	2	VA + SCA	V	I	None
11	75/M	R	II, III	7	VA + SCA	V	III	None
12	67/F	R	II, III	8	VA + SCA + AICA	V	I	None
13	66/F	L	II, III	2	VA + AICA	V	I	None
14	64/M	L	I, II, III	4	VA + AICA	V	I	None
15	56/F	L	II, III	4	VA	V	I	None
16	55/F	R	II, III	2	VA + AICA	V	I	None
17	61/F	L	II, III	10	VA	V	I	None
18	57/F	L	I, II, III	3	VA + SCA	V	I	None
19	65/F	R	I, II, III	3	VA + SCA	V	I	None
20	51/M	R	II, III	2	BA + SCA	V	I	None
21	45/F	L	II	0.5	VA + SCA + AICA	V	I	None
22	64/M	R	II	3	VA + SCA	V	I	None

AICA, anterior inferior cerebellar artery; BA, basilar artery; BNI, Barrow Neurological Institute; F, female; L, left; M, male, R, right; SCA, superior cerebellar artery; VA, vertebral artery.

with a larger series and control group are required to prove the high effectiveness of this method. Because the outcome of traditional MVD with regard to aVBA-associated TN remains controversial, the biomedical glue sling technique provides an alternative decompressive method for patients with TN associated with aVBA.

Technically, several key points must be considered during glue transposition. First, thorough dissection of arachnoid membranes around the nerves and vessels should be performed through the caudal nerves to the fifth nerve, which is important to fully inspect the course of VBA and to get an adequate working corridor. The aVBA is usually transposed caudally to dislocate the offending vessel away from the REZ of the nerve, and it is conducive to attach the offending vessel to the pyramidal dura mater. Second, the dislocation must be slow and careful because excessive dislocation may lead to VBA occlusion or injury to perforating arteries. Third, Teflon is inserted between the brainstem and aVBA. The effects are as follows: 1) the inserted Teflon serves as an indicator of tension in VBA as to whether the artery is fit to perform the biomedical glue sling technique, which avoids the risk of arterial injuries by rough handling and strenuous retraction; 2) Teflon reduces the rebound force of VBA, which allows the transposition of the artery to the pyramidal dura mater smoothly and moderately and prevents the offending vessel falling off from the pyramidal dura mater; 3) it is of benefit to move VBA caudally away from the trigeminal nerve (**Figure 5**). Next, arachnoid membranes at the pyramidal dura mater must be dissected thoroughly, and we usually use bipolar cautery to coagulate the pyramidal dura, which is helpful in enhancing the adhesion between the insulation and dura mater. Then, for only involving VBA as the offending vessel in TN, the nonatherosclerotic part is usually chosen as the target for attachment to the pyramidal dura mater, and a small piece of dry gelfoam with glue is used as an insulation between the offending vessel and dura, which is likely to reduce the amount of glue.[5] We use the aspirator with a small piece of gelfoam to hold the ventral side of aVBA, until the glue is hardened, so as to keep the offending vessel away from the brain stem and

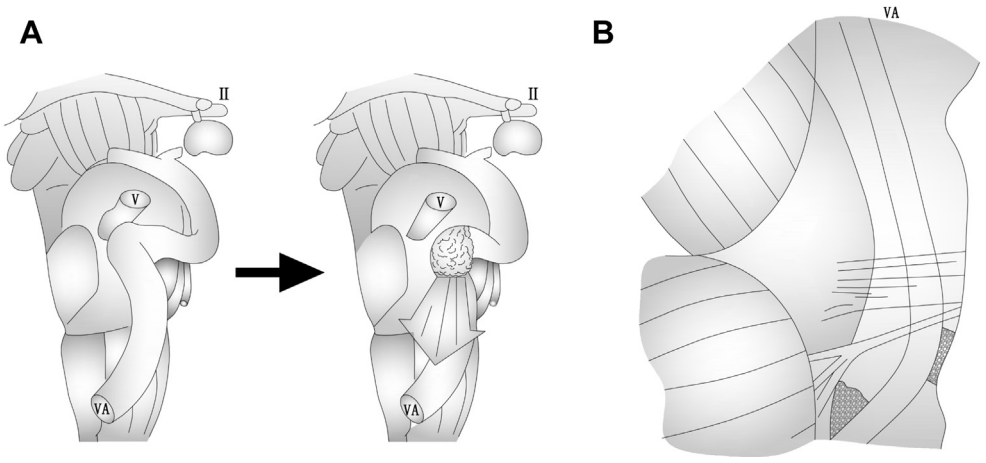

Figure 5. (**A**) Schematic drawing showing that atherosclerotic vertebrobasilar artery (aVBA) can be pulled both in posterolateral and caudal directions by gelfoam with biomedical glue, which leaves the nerve entry zone and the nerve free. (**B**) Teflon is inserted between the brainstem and aVBA. aVBA is attached to the coagulated pyramidal dura mater using a small piece of dry gelfoam with biomedical glue leaving the nerve free. VA, vertebral artery.

prevent the glue spread. Lastly, it is important to remember to decompress other offending arteries such as AICA and/or SCA, becoming quite visible after the completion of transposition of aVBA.

However, during the follow-up, 1 patient experienced postoperative hypoacusia, which was resolved within 2 months, which may be attributed to the vasospasm caused by traction.

CONCLUSIONS

This study represents the largest series of patients with aVBA-associated TN who were treated using a decompressive biomedical glue sling technique. The greatest advantage of the biomedical glue sling technique is achieving complete decompression with the simplicity of the procedure requiring relatively less space and less time. Technically, several key points mentioned in our article must be considered during glue transposition to ensure the success of operation. Despite the high cure rate, further studies with a larger series and control group are required to prove the high effectiveness of this method. Because the outcome of traditional MVD with regard to aVBA-associated TN remains controversial, the biomedical glue sling technique in MVD provides an alternative decompressive method for patients with TN associated with aVBA. We plan to assess the efficiency of the biomedical glue sling technique in MVD for patients with aVBA-associated TN with a larger series to further prove its high effectiveness.

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