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ORIGINAL ARTICLE - FUNCTIONAL NEUROSURGERY - PAIN

Redo surgery for trigeminal neuralgia: reasons for re-exploration and long-term outcomes

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Abstract

Background To investigate the causes of failure and recurrence after microvascular decompression (MVD) for trigeminal neuralgia (TGN) and to analyze the results of redo surgery.

Methods Sixty-three cases of redo surgery were retrospectively reviewed. Reasons for re-exploration were categorized into 4 groups based on the operative findings. Patient characteristics, outcomes of re-exploration, and operative complications were analyzed by Kaplan–Meier and logistic regression analyses.

Results Reasons for redo surgery were divided into arterial compression in 13 patients (21%), venous compression in 11 patients (17%), prosthesis-related in 25 patients (40%), and adhesion or negative exploration in 14 patients (22%). Immediate pain relief was obtained in 59 patients (94%) postoperatively with newly developed facial numbness in 17 patients (27%). Of these, 48 patients (76%) maintained pain-free 1 year postoperatively. Overall recurrence was noted in 17 patients (27%) during the median 49-month follow-up period. Most recurrences occurred within 1 year after redo surgery, but the prosthesis-related patients showed a continuous recurrence up to 4 years. Patients having vascular compression showed significantly better pain control than those without vascular contact in Kaplan–Meier analyses ($p = 0.0421$). No prognostic factor for pain-free 1 year after redo surgery was found.

Conclusions Redo surgery is effective for patients with remaining vascular compression rather than those without vascular contact. Teflon contact onto the nerve root should be avoided because it is a potential risk for recurrence and causes poor prognosis after redo surgery.

Keywords Microvascular decompression · Trigeminal neuralgia · Re-exploration · Redo surgery · Teflon

Introduction

Microvascular decompression (MVD) is popularized as a safe and effective surgical procedure for medically intractable trigeminal neuralgia (TGN) with a high success rate as well as limited morbidity and mortality [4]. While appropriate decompression of the nerve root provides a high rate of pain relief for patients with a distinct neurovascular conflict, those without vascular contact tend to have less benefit from MVD [8, 26]. Failure or recurrence after MVD is still problematic for neurosurgeons. Considering re-exploration for sustained or recurrent facial pain is unpleasant for patients who underwent MVD previously. In the literature, there is approximately a 2% chance of annual recurrence after an initial MVD, and a high recurrence rate after redo surgery, as much as 58% at 10 years postoperatively, is reported [4]. Avoiding failure and minimizing recurrence remain an issue in this field. Reports of redo surgery for TGN are limited, and individual outcomes from different sources have not yet been a focus [2–5, 7, 9, 10, 12–15, 19–21, 23, 25, 28]. The aim of this study is to review the surgical findings and outcomes in redo surgery and make proposals for improving outcomes in initial MVDs.

This article is part of the Topical Collection on *Functional Neurosurgery - Pain*

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Methods

Patient cohort

Among 625 consecutive MVDs for TGN performed in our institutes from April 2005 to February 2021, 73 patients (11.7%) were redo cases. Of these, 63 patients (10.1%) with a follow-up period longer than 1 year were enrolled in this study (Fig. 1). Nineteen patients (30%) were from our institutes, and the remaining 44 patients (70%) were operated elsewhere for their initial MVDs. Patient characteristics and information regarding TGN were collected from their medical records. The pain-free interval from the previous MVD to recurrence and the duration from recurrence to re-exploration were obtained. Recurrence is defined as any degree of pain recurring after its disappearance and resuming any medication and/or any additional surgical procedures. Failure is defined as no improvement of facial pain postoperatively. The number of patients having multiple MVDs and previous ablative procedures before re-exploration, the number of patients with atypical pain, and those who underwent intraoperative neurolysis were investigated.

Operative technique and grouping the redo surgery

Magnetic resonance imaging with fast imaging employing steady-state acquisition and contrast-enhanced T1-spoiled gradient recalled was performed for all patients. Three-dimensional (3D) bone images of the skull were created to evaluate the previous craniotomy sites. Surgical planning with 3D reconstruction images of the affected trigeminal nerve root and the adjacent anatomical structures using computer software, GammaPlan® (ELEKTA, Stockholm, Sweden), was evaluated as previously described [16, 18]. Surgeries were performed through the retrosigmoid approach in the lateral position. Auditory brainstem-evoked response was monitored in all patients. In the cases with an insufficient or inappropriate craniotomy, these craniotomies were expanded to expose the transverse-sigmoid junction. Intradurally, the neo-membrane was commonly found between the arachnoid membrane and the petrous dural surface in most cases. Great care was taken not to injure the petrosal vein complex, which is frequently entrapped with arachnoid adhesion. Based on the surgical findings, the reasons for re-exploration were divided into 4 groups (Fig. 1): (1) "the arterial compression group", arterial compression is remaining on the nerve root in 13 patients; (2) "the venous compression group", a vein is attached to the nerve root in 11 patients; (3) "the prosthesis-related group", a Teflon felt, a Teflon granuloma, or other foreign materials being a cause in 25 patients; and (4) "the adhesion or negative exploration group", adhesion is considered to be the sole cause and/or no suspicious object causing pain in 14 patients. The vascular compression group is composed of (1) the arterial compression group and (2) the venous compression group. The non-vascular contact group is composed of (3) the prosthesis-related group and (4) the adhesion or negative exploration group (Fig. 1). The offending artery was relocated by thorough dissection of the nerve root from the proximal to distal side. Small veins were coagulated and divided. Large veins, such as the petrosal vein and its direct tributaries, were dissected and relocated. The

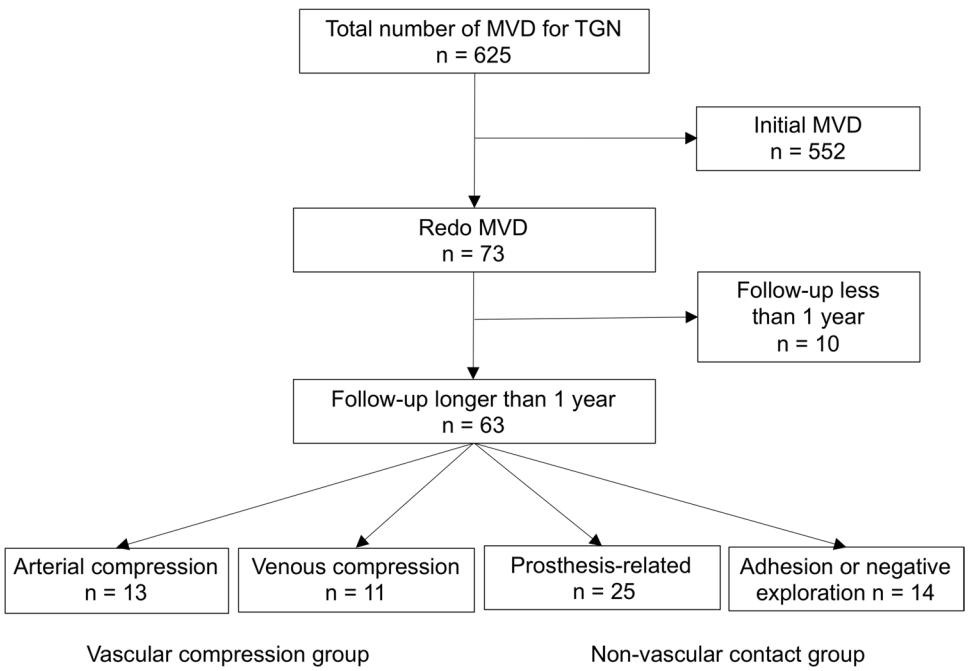

Fig. 1 Participant flow diagram. MVD, microvascular decompression; TGN, trigeminal neuralgia

contacting prosthesis was carefully detached from the nerve root and the brainstem. The arachnoid membrane attached to the nerve root is thoroughly dissected. At the final step of the procedure, the entire cisternal segment of the trigeminal nerve root was freed from any contacting objects.

Assessment outcomes

All patients were followed up and evaluated for pain relief, neurological status, and recurrence at our clinic, by mailed questionnaires, or by telephone interviews for remote patients. The period of pain-free without medication is assessed by Kaplan–Meier analyses in the four groups, and further analyses are conducted in the two groups with or without vascular contact. Logistic regression univariate analyses of the following variables were performed in regard to pain-free 1 year after redo surgery: age, sex, affected side, affected division, duration from the last MVD, pain-free interval after the previous MVD, failure at the initial MVD, number of multiple MVDs, previous ablative procedures, preoperative numbness, pain type (typical or atypical), nerve combing in redo surgery, and immediate pain relief after redo surgery. In describing demographic characteristics, p-values were obtained by linear regression for continuous variables and the Mantel–Haenszel test for categorical variables. Each statistical test was set to be significant at $p < 0.05$ (two-sided p-value). SAS software (version 9.4; SAS Institute, Inc., Cary, North Carolina) was used for all statistical analyses.

Results

Patient characteristics, surgical outcomes, and follow-up are summarized in Table 1.

Patient characteristics

The mean age of the patients at re-exploration was 60 years, varying from 28 to 96 years. Female sex and the right side were predominantly affected except that the left side was more affected in the adhesion or negative exploration group. No statistical difference was found in these factors. The second division was significantly affected among the trigeminal nerve divisions ($p = 0.0182$). The pain-free interval after the previous MVD varied from 0 (failure of initial MVD) to 156 months with a median of 9 months and a mean of 20 months. The prosthesis-related group exhibited longer pain-free intervals after their initial MVDs. Failure at the initial MVD was observed in 19 patients (30%) among the redo cases. They represent 38%, 27%, 32%, and 21% in the arterial compression group, the venous compression group, the prosthesis-related group, and the adhesion or negative exploration group, respectively. The median and mean duration between the previous surgery and the re-exploration were 36 and 62 months, respectively. Multiple MVDs of two or more were predominantly performed in the adhesion or negative exploration group (6 patients, 43%). Preoperative ablative procedures, such as radiofrequency thermocoagulation and radiosurgery, were performed in 10 patients (16%) in total. There were no statistical differences in the four groups. Atypical pain was not recognized in the arterial compression group, which was noted more in the venous compression group (27%) and the adhesion or negative exploration group (21%). Intraoperative neurolysis (nerve combing) during redo surgery was predominantly performed in the adhesion or negative exploration group (7 patients, 50%).

Surgical outcomes, follow-up, and data analyses

The follow-up period ranged from 13 to 150 months (median 49 months, mean 57 months). Immediate pain relief was obtained in 59 patients (94%) in total. All 13 patients in the arterial compression group showed postoperative immediate pain relief and maintained pain-free during the entire follow-up period except for one patient (12 patients, 92%). Nine patients (82%) in the venous compression group showed immediate pain relief postoperatively. All of them maintained pain-free for at least 1 year after redo surgery, but one patient had recurrence after 1 year postoperatively. Patients in the prosthesis-related and adhesion or negative exploration groups tended to have more recurrences. Despite 24 patients (96%) in the prosthesis-related group and 13 patients (93%) in the adhesion or negative exploration group showing immediate pain relief, 10 patients (40%) and 5 patients (36%) had a recurrence, respectively, in the entire follow-up period. No significant prognostic factors for pain-free 1 year after redo surgery are found in logistic regression analyses except the affected division of the trigeminal nerve (Table 2). This is due to underlying significant differences in patient characteristics and has no statistical value. Failure at the initial MVD or immediate pain relief after redo surgery is not a significant predictor in this study. Kaplan–Meier analyses of the four groups demonstrated that recurrence mostly occurs within 1 year, except in the prosthesis-related group, which showed a continuous decline of pain-free probability up to 4 years postoperatively (Fig. 2). The comparison between the vascular compression group and the non-vascular contact group showed a significant difference in Kaplan–Meier analyses ($p = 0.0421$) (Fig. 3). The most common complication of redo surgery is facial numbness, which was noted in 17 patients (27%) in total. The patients in the non-vascular contact group tended to develop more facial numbness (28% in the prosthesis-related group, 43%

Table 1 Summary of patient characteristics, surgical outcomes, and follow-up

Patient characteristics	All	Vascular compression group		Non-vascular contact group		p value
		Arterial compression	Venous compression	Prosthesis-related	Adhesion or negative exploration	
No. of patients	63	13 (21%)	11 (17%)	25 (40%)	14 (22%)	
Mean age at redo surgery, years (range)	60 (28–96)	50 (28–85)	67 (41–83)	59 (33–96)	69 (52–80)	0.064
Sex (male/female)	26 (41%)/37 (59%)	6 (46%)/7 (54%)	3 (27%)/8 (78%)	12 (48%)/13 (52%)	5 (36%)/9 (64%)	0.6512
Affected side (right/left)	37 (59%)/26 (41%)	8 (61%)/5 (39%)	9 (82%)/2 (18%)	14 (56%)/11 (44%)	6 (43%)/8 (57%)	0.2691
Affected division						
V1/V2/V3/V1,2/V2,3/V1,2,3	1/16/16/5/19/6	0/7/3/2/0/1	0/3/3/1/4/0	1/3/3/2/12/4	0/3/7/0/3/1	0.0182*
Median/mean pain-free interval after previous MVD, months (range)	9/20 (0–156)	6/16 (0–122)	6/22 (0–72)	12/27 (0–156)	8/13 (0–56)	0.6106
Number of failure cases at the initial MVD (no pain relief after initial MVD)	19 (30%)	5 (38%)	3 (27%)	8 (32%)	3 (21%)	0.8013
Median/mean interval between redo and previous MVD, months (range)	36/62 (2–240)	30/67 (9–180)	48/47 (17–108)	54/80 (11–240)	17/37 (2–240)	0.1604
Number of multiple MVDs (two or more)	15 (24%)	1 (7.7%)	2 (18%)	6 (24%)	6 (43%)	0.1889
Previous ablative procedures	10 (16%)	3 (23%)	2 (18%)	3 (12%)	1 (7.1%)	0.6547
Preoperative numbness	8 (13%)	1 (7.7%)	1 (9.1%)	5 (20%)	1 (7.1%)	0.5759
Atypical pain	7 (11%)	0 (0%)	3 (27%)	1 (4%)	3 (21%)	0.0656
Neurolysis performed at redo surgery	11 (18%)	2 (15%)	1 (9.1%)	1 (4%)	7 (50%)	0.0032*
Surgical outcomes and follow-up						
Median/mean follow-up, months (range)	49/57 (13–150)	19/39 (13–149)	62/66 (18–150)	61/66 (16–136)	29/50 (13–134)	0.1887
Immediate Pain relief after redo MVD	59 (94%)	13 (100%)	9 (82%)	24 (96%)	13 (93%)	0.3007
Pain free at 1 year after redo MVD	48 (76%)	12 (92%)	9 (82%)	18 (72%)	9 (64%)	0.3427
Recurrent pain during follow-up period	17 (27%)	1 (7.7%)	1 (9.1%)	10 (40%)	5 (36%)	0.0777
Median/mean pain-free period after redo MVD, months (range)	21/34 (0–150)	18/28 (10–101)	29/47 (0–150)	24/34 (0–107)	13/28 (0–127)	0.5029
Complications						
Facial numbness (new or worsened)	17 (27%)	2 (15%)	2 (18%)	7 (28%)	6 (43%)	0.3803
Trigeminal trophic syndrome	1(1.6%)	0 (0%)	0 (0%)	1 (4%)	0 (0%)	0.6777
Diplopia	2 (3.2%)	0 (0%)	0 (0%)	2 (8%)	0 (0%)	0.378
Hearing impairment	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	NC
Facial weakness	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	NC
Ataxia	1 (1.6%)	0 (0%)	0 (0%)	1 (4%)	0 (0%)	0.6777

V1, the first division of the trigeminal nerve; *V2*, the second division of the trigeminal nerve; *V3*, the third division of the trigeminal nerve; *MVD*, microvascular decompression; *significant difference; *NC*, not calculable

Table 2 Logistic regression univariate analyses of pain-free 1 year after redo surgery

Factor	OR	95% CI	p value
Age at redo surgery	1.024	0.985–1.064	0.2285
Sex	0.643	0.191–2.168	0.4763
Affected side	1.336	0.415–4.293	0.6272
Affected division	0.639	0.410–0.995	0.0475*
Duration from the last MVD	1.008	0.996–1.020	0.2101
Pain-free interval after the previous MVD	1.012	0.987–1.039	0.3414
Failure at the initial MVD	0.824	0.238–2.848	0.7591
Number of multiple MVDs	1.223	0.324–4.614	0.7662
Previous ablative procedures	2.8	0.321–24.424	0.3516
Preoperative numbness	2.15	0.448–10.312	0.3386
Pain type (typical or atypical)	2.75	0.540–13.99	0.2231
Nerve combing in redo surgery	0.272	0.032–2.319	0.2335
Immediate pain relief after redo MVD	< 0.001	NC	0.9669

MVD, microvascular decompression; *OR*, odds ratio; *CI*, confidence interval; *significant difference; *NC*, not calculable

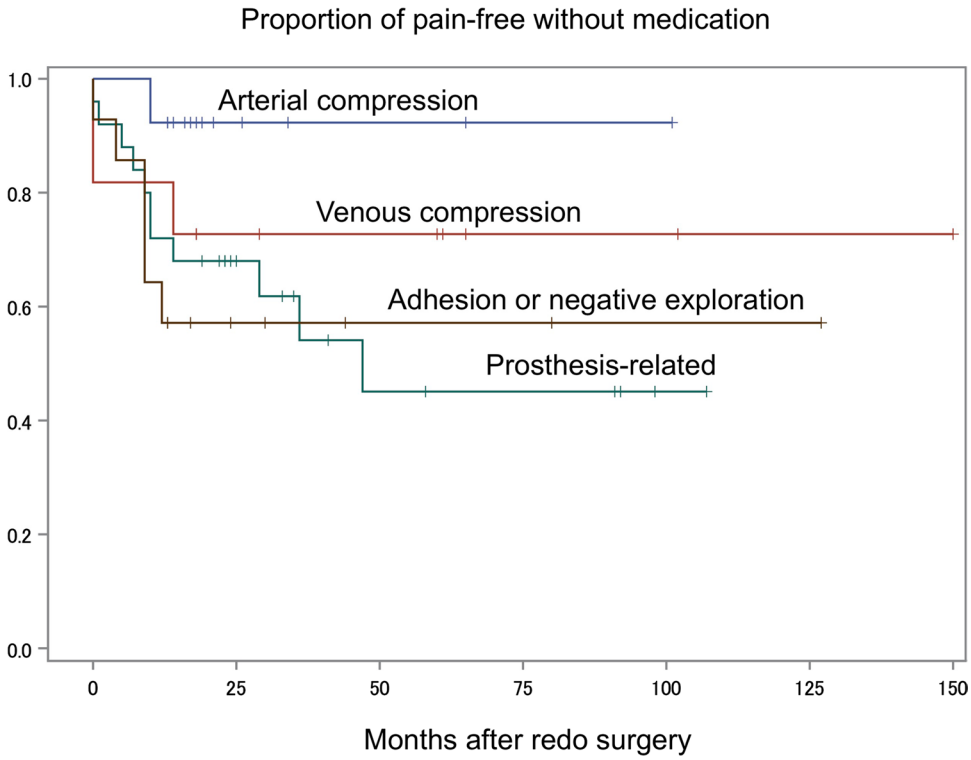

Fig. 2 Kaplan–Meier analysis of the outcomes of redo surgery. The curves represent the proportion of patients with pain-free after redo surgery in each group

in the adhesion or negative exploration group) than the patients in the vascular compression group (15% in the arterial compression group, 18% in the venous compression group). Other neurological complications, such as trigeminal dysfunction, diplopia, and ataxia, were noted only in the prosthesis-related group. Hearing impairment and facial weakness were not noted in this series.

Discussion

Redo surgery is frequently challenging due to adhesion and a complex surgical field as compared to initial MVDs. The previous literature regarding outcomes of redo surgery with a number of cases is summarized in Table 3 [2–5, 7, 9, 10, 12–15, 20, 21, 23, 25, 28]. The incidence of redo

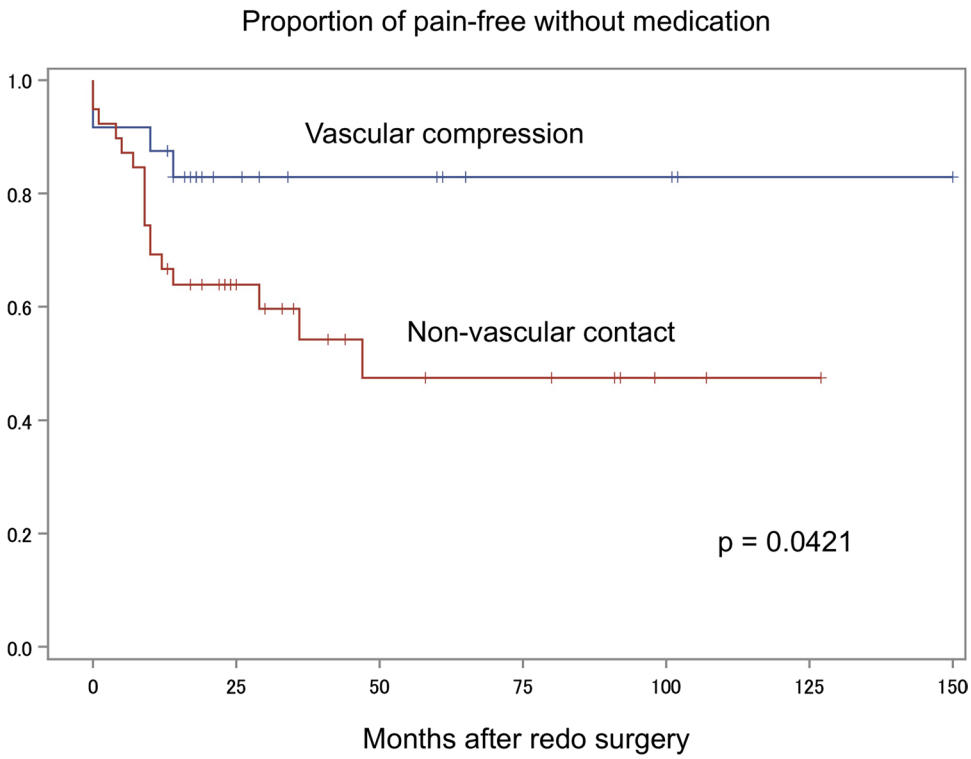

Fig. 3 Comparison between the vascular compression and non-vascular contact groups. Graph indicating the different outcomes between the vascular compression group and the non-vascular contact group. The curves represent the proportion of patients with pain-free after redo surgery in each group

cases among the total number of MVDs ranges from 3.6 to 16%. In most literature, the intraoperative findings of redo surgery are divided into the following categories: missed arterial compression, remaining venous compression, prosthesis-related, and adhesion or negative exploration. Some authors perform their redo surgery following a short period of observation (few days to few months) when the initial MVD is recognized to be a failure [3, 4, 14, 21, 28]. In such instances, the surgeon may find a missed vessel during re-exploration, advocating that a thorough survey along with the nerve root is crucial to avoid failure [14]. However, the timing of redo surgery should be carefully considered because delayed improvement or cure may occur in some cases. Missing a culprit vessel in an initial MVD should be strictly avoided as patients may need to undergo additional surgery, which is unnecessary if the initial MVD is successful. Careful observation using multi-sequence MRI, including 3D T2 high-resolution in combination with 3D time of flight MRA, T1-gadolinium-enhanced spoiled gradient recalled, and further evaluation with 3D reconstruction images, can reduce the risk of missing offending vessels [17, 18, 22].

There are some sites where the missed offenders are frequently found. In the cases with the superior cerebellar artery, causative neurovascular compression is not always located at the root entry zone. The neurovascular compression may be located distally near the porous trigeminus or frequently obscured by the suprameatal tubercle [17]. Among the patients with the anterior inferior cerebellar artery missed, the caudal area of the root entry zone was frequently not inspected in their initial surgeries. This area requires extensive dissection of the petrosal fissure. In the cases with multiple offenders, vessels located at one of these areas might be ignored and not manipulated in the initial surgery. The necessity of exploring offenders in these frequently missed sites can be precisely predicted if careful preoperative evaluation is performed [17, 22].

Venous involvement as a cause of TGN is not rare. MVD with complete liberation of the entire nerve root from venous compression gives a good probability of long-term pain relief [11]. Veins that are not properly managed can be a cause of failure or later recurrence. Small veins attaching to the trigeminal nerve root can be safely divided [16]. Larger veins, such as the main stem of the petrosal vein and its large tributaries, should be relocated from the nerve root by maintaining venous flow to avoid venous complications [18]. Venous involvement can be detected preoperatively by T1-gadolinium MRI [16, 22]. Precise surgical planning, including venous involvement, is crucial in avoiding failure. Our study revealed that failed patients with remaining vascular compression, by either arteries or veins, can be successfully treated by relocating the vessels in the redo surgery. Avoiding failure, however, by extensive preoperative evaluation prior to the initial MVD, is more crucial rather than undergoing re-exploration for patients suffering from TGN.

Inserting a Teflon pledget between the offending vessels and the nerve root is a widely accepted decompression method. However, Teflon adhesion and relevant

Table 3 Summary of literature regarding redo surgery for trigeminal neuralgia

Author	Year	Number of total patients	Number of redo cases	Interval from previous MVD	Follow-up (months)	Offending object				PNS/INL/RC	Pain-free rate	Facial numbness (new or worsened)	Other neurological complications
						Artery	Vein	Prosthesis	Adhesion				
Jannetta [16]	1985	NS	51	NS	53	10–26 (20–51%)	17–34 (33–67%)	5 (9.8%)	1 (2%)	NS	61% immediate, 51% at last FU	0%	Abducens palsy (1), facial weakness (1)
Bederson [3]	1989	252	20 (7.9%)	NS	48	NS	NS	NS	1 (5%)	90%	75% at last FU	10%	Corneal anesthesia (1), facial weakness (1)
Cho [12]	1994	400	31 (7.8%)	NS (1 week–4 years)	NS	7 (22%)	4 (13%)	4 (13%)	16 (52%)	52%	32% at 1 year, 71%	NS	NS
Barker [2]	1996	1185	132 (11%)	30 days–2 years	(12–120)	79 (60%)	95 (72%)	NS	NS	NS	56% immediate, 42% at 10 years	8.30%	Brainstem infarction (1), facial weakness (6), hearing loss (1)
Rath [27]	1996	135	16 (12%)	Mean 17 months (4–62)	90	9 (56%)	0 (0%)	0 (0%)	7 (44%)	56%	69% at last FU	44%	ICH (1), hearing loss (2), ataxia (1)
Kureshi [18]	1998	331	23 (6.9%)	11 days–12 years	17	1 (4%)	0 (0%)	5 (22%)	16 (70%)	83%	65% at last FU	NS	Hearing loss (3), facial weakness (2)
Chen [7]	2000	89	10 (11.2%)	1–42 months	NS	3 (30%)	1 (10%)	5 (50%)	1 (10%)	NS	100% immediate	0%	NS
Matsushima [22]	2000	82	6 (7.3%)	Mean 19 months (2–48)	36	0 (0%)	0 (0%)	6 (100%)	0 (0%)	NS	100% immediate, 100% at 2 years	50%	Decreased hearing (1)
Amador [8]	2008	186	29 (16%)	Mean 70 months (4 days–29 years)	34	13 (45%)	4 (14%)	7 (24%)	NS	11 (38%)	80% at 1 year, 75% at 3 years	52%	Hearing loss (2)
Zhong [6]	2012	1274	46 (3.6%)	2–5 days	36	46 (73%)	17 (27%)	NS	NS	NS	83% immediate	NS	NS

Table 3 (continued)

Author	Year	Number of total patients	Number of redo cases	Interval from previous MVD	Follow-up (months)	Offending object				PNS/INL/RC	Pain-free rate	Facial numbness (new or worsened)	Other neurological complications
						Artery	Vein	Prosthesis	Adhesion				
Bakker [26]	2014	376	33 (8.8%)	30 day–2 years	12	7 (21%)	6 (18%)	16 (48%)	4 (12%)	2 (6%)	67% at 1 year	27%	Hearing loss (1)
Gu [15]	2014	321	12 (3.7%)	Mean 57 months (10–144)	55	6 (50%)	1 (8.3%)	4 (33%)	1 (8.3%)	NS	83% immediate, 67% at last FU	8.30%	Facial palsy (1), transient psychosis (1)
Feng [14]	2018	NS	15	NS	26	9 (29%)	2 (6.5%)	14 (32%)	6 (19%)	6 (40%)	80% immediate, 80% at last FU	40%	None
Hussain [20]	2018	400	32 (8%)	NS	(6–48)	4 (13%)	6 (19%)	3 (9.4%)	6 (19%)	11 (34%)	47% immediate, median pain-free 36 months	0%	None
Cheng [10]	2019	NS	41	Mean 55 months (18–144)	42	15 (37%)	6 (15%)	8 (20%)	12 (29%)	12 (29%)	88% immediate, 75% at last FU	32%	Hearing loss (2)
Huang [19]	2020	205	8 (3.9%)	6 days–3 months	17	7 (88%)	1 (13%)	0 (0%)	0 (0%)	0 (0%)	100% immediate, 100% at 1 year	13%	None
Present study	2021	625	63 (10%)	Mean 62 months (2–240)	57	13 (21%)	11 (17%)	25 (40%)	14 (22%)	11 (18%)	94% immediate, 76% at 1 year	27%	Trigeminal dysfunction (1), diplopia (2), ataxia (1)

MVD, microvascular decompression; *PNS*, partial nerve section; *INL*, intraoperative neurolysis; *RC*, trigeminal nerve root compression; *FU*, follow-up; *NS*, not stated; *ICH*, intracerebellar hemorrhage

granulomas are reported to be a cause of recurrent TGN in the long term [3, 7, 12, 13, 23, 27]. Sindou et al. reported the importance of a non-compressive technique without Teflon contact to the nerve root. It provides a higher cure rate than Teflon prosthesis implantation with contact to the nerve root [27]. Further, even though the contacting Teflon is removed in redo surgery, our study demonstrated that there is a continuous risk of recurrence up to 4 years postoperatively, suggesting that Teflon contact may have a negative impact on trigeminal pain in the long term, even after re-exploration. Two hypotheses to explain this continuous risk of recurrence are considered. One is the persisting inflammatory reaction that remains in the nerve root even after removing the Teflon felt. Chen et al. demonstrated an inflammatory response by a Teflon felt placed on the dura mater and the cerebellar tentorium [7]. The photomicrographs of the sections showed numerous fragments of Teflon in the foreign body giant cell granulomatous tissue. Similarly, Teflon contact on the nerve root may provoke inflammatory changes that may cause persistent TGN. Arachnoiditis is reported to be associated with poorer outcomes than typical vascular compression [24]. Teflon contact may provoke arachnoiditis of the nerve root, which may persist in the long term. The other speculation is that some patients in whom vascular compression is not a true pathogenesis might be treated with Teflon insertion in their initial surgeries. Vascular conflict is not always a cause of TGN because vascular conflict is commonly found on MRI of those without TGN [1, 19]. An individual anatomical variation of the root, such as angulation of the trigeminal nerve, may be involved in the pathogenesis of trigeminal neuralgia [6]. In such cases, unnecessary Teflon insertion may be carried out to ensure nerve decompression in the initial surgery. Our observation revealed that Teflon felt in contact with the nerve root may be harmful because it may cause poor prognosis, even after redo surgery.

Limitations of this study include the nature of the retrospective design with a small number of patients. Another limitation includes the reliability of grouping based on the surgeon's observation during surgery. A larger number of patients with a longer follow-up period are needed to confirm our conclusions.

Conclusion

Redo surgery is effective for those who have remaining vascular compression. An extensive preoperative evaluation is more crucial so as not to miss the responsible vessels as in the initial MVD. Teflon contact on the nerve root should be avoided because it may cause recurrence and have poor outcomes, even if removed.

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Declarations

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

Conflict of interest All authors declare no competing interests..

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