

Compression Degree of Trigeminal Nerve and Type of Conflicting Vessels Determine Short- and Long-Term Complete Pain Relief in Adult Patients with Primary Trigeminal Neuralgia After Microvascular Decompression: A Three-Year Retrospective Study of 200 Adult Patients with Primary Trigeminal Neuralgia

Zhe-Feng Zhao^{1,*}, Bing-Bing Liu^{1,*}, Jian-Nan Zhang^{2,*}, Ni Shi^{3,*}, Ping Zhang^{1,*}, Gang-Zhi Yang⁴, Yu-Fu Cao⁴, Long-He Tian⁴, Cheng-Cai Qiu⁵, Yang Gao^{6,7}

¹Department of Neurosurgery, The Second Affiliated Hospital of Harbin Medical University, Harbin, Heilongjiang, People's Republic of China;

²Department of Critical Care Medicine, The First Affiliated Hospital of Harbin Medical University, Harbin, Heilongjiang, People's Republic of China;

³Department of Critical Care Medicine, The Second Affiliated Hospital of Harbin Medical University, Harbin, Heilongjiang, People's Republic of China;

⁴Department of Neurosurgery, People's Hospital of Hegang City, Hegang, Heilongjiang, People's Republic of China; ⁵Department of Neurosurgery, Traditional Chinese Medicine Hospital of Jixi City, Jixi, Heilongjiang, People's Republic of China; ⁶Department of Critical Care Medicine, The Sixth Affiliated Hospital of Harbin Medical University, Harbin, Heilongjiang, People's Republic of China; ⁷Institute of Critical Care Medicine, The Sino Russian Medical Research Center of Harbin Medical University, Harbin, Heilongjiang, People's Republic of China

*These authors contributed equally to this work

Correspondence: Zhe-Feng Zhao, Department of Neurosurgery, The Second Affiliated Hospital of Harbin Medical University, Harbin, People's Republic of China, Email know810512@163.com; Yang Gao, Department of Critical Care Medicine, The Sixth Affiliated Hospital of Harbin Medical University, Harbin, People's Republic of China, Email gaoyang0312@126.com

Objective: In this study, we aimed to explore the demographic and clinical factors that could determine short- and long-term complete pain relief (CPR) in adult patients with primary trigeminal neuralgia (PTN) after microvascular decompression (MVD) to guide clinical practice.

Methods: This single-center retrospective study included adult patients with PTN who underwent MVD as their initial neurosurgical procedure in the Department of Neurosurgery at the Second Affiliated Hospital of Harbin Medical University from January 2017 to December 2019 and completed a 3-year post-surgery follow-up. Demographic and clinical information was obtained from medical records. Pain relief of adult patients with PTN at various time points after sufficient decompression of trigeminal nerve (TN) during MVD was determined and classified by the patient's subjective response and medications use. Pain relief of local patients was evaluated by outpatient follow-up at various time points, whereas that of local cases who could not return to outpatient or non-local cases was assessed through telephone or WeChat.

Results: In univariate analysis, compression degree of TN and type of conflicting vessels constantly showed significant differences between the two groups at 3 months, 6 months, 1 year, 2 years, and 3 years after MVD. Compression degree of TN and type of conflicting vessels at various time points after MVD were always the related factors to CPR in logistic regression analysis, with the former having the greatest impact. The areas under the receiver operating characteristic (ROC) curve of CPR at various time points after MVD were 0.937, 0.874, 0.879, 0.864, and 0.869, respectively.

Conclusion: In summary, compression degree of TN and type of conflicting vessels can determine short- and long-term CPR in adult patients with PTN after MVD.

Keywords: compression degree of trigeminal nerve, type of conflicting vessels, microvascular decompression, sufficient decompression of trigeminal nerve, complete pain relief, primary trigeminal neuralgia

Introduction

The main clinical manifestation of primary trigeminal neuralgia (PTN) is touch-evoked sudden unilateral transient burning or shock-like paroxysmal or continuous onset of stabbing pain in one or more divisions of the trigeminal nerve (TN), which seriously lowers patient's quality-of-life (QOL).¹ Long-term suffering from this refractory excruciating neuralgia may result in sleep disturbance, interference in activities of daily living, anxiety, depression, and even suicide in extreme cases.^{2,3} Multiple known genes and the subsequent ion channels and other downstream products they produce may play a role in the genetic predisposition to PTN.⁴ In addition to other unknown etiologies, pathological demyelination along the trigeminal afferent pathway triggered by neurovascular conflict (NVC) with physical compression and morphological changes of TN is the predominant pathogenesis and pathophysiological mechanism of PTN, and subsequent activated neuroimmune cells, released inflammatory cytokines, significant molecular changes, channelopathies, and electrophysiological abnormalities pave the way for a generation of ectopic impulses and ephaptic crosstalk.^{1,5-9} In adult patients with PTN, three-dimensional time-of-flight magnetic resonance angiography (3D-TOF-MRA) prior to surgery has demonstrated a better capacity to identify the presence of NVC with nearby specific offending vessels, and thus neuroimaging using magnetic resonance imaging (MRI) with high resolution can be available as a reliable objective imaging predictor of therapeutic responsiveness and outcome to neurosurgical interventions.^{10,11}

The initial standard management of adult patients with PTN is conventional pharmacotherapy with different action mechanisms, either monotherapy or combination therapy. However, up to half of adult patients with PTN require neurosurgical procedures when it is not sufficiently controlled or poorly tolerated with pharmacotherapies.¹² Microvascular decompression (MVD), one of many different neurosurgical procedures, is currently recommended as the first-line neurosurgical option and gold standard for PTN because it is an efficient and secure neurosurgical intervention to directly alleviate or eliminate NVC.¹³⁻¹⁶ Till now, few clinical trials have focused on potential candidates suitable for MVD and short- and long-term complete pain relief (CPR) after sufficient decompression of TN during MVD in adult patients with PTN. To address the above issue, we aimed to explore the demographic and clinical factors that could determine short- and long-term CPR after sufficient decompression of TN during MVD in adult patients with PTN, which will contribute to better characterizing potential candidates suitable for MVD and thus optimizing the planning and implementation of MVD.

Methods

Study Design

This single-center retrospective study included adult patients with PTN who underwent MVD as their initial neurosurgical procedure in the Department of Neurosurgery at the Second Affiliated Hospital of Harbin Medical University from January 2017 to December 2019 and completed a 3-year post-surgery follow-up. Demographic data, including gender and age, as well as clinical data, involving affected side (left or right) of PTN, duration of PTN and medications use before MVD, compression degree (mild or severe) and location (nerve root or others) of TN, and type of conflicting vessels (artery or vein) during MVD were obtained and collated from medical records. After sufficient decompression of TN during MVD, pain relief of local patients was evaluated by outpatient follow-up at various time points, whereas that of local cases who were unable to return for outpatient follow-up or non-local cases was assessed through telephone or WeChat. This study protocol was reviewed and approved by the Ethics Committee of the Second Affiliated Hospital of Harbin Medical University (IRB number: KY-2022-308). In this study, participants' identities and other relevant data were guaranteed to remain anonymous and confidential. The requirement for written informed consent was waived according to the retrospective nature of this study, institutional requirements and national law.

Study Population

In this study, the inclusion criteria contained age ≥ 18 years old; admission to the Department of Neurosurgery at the Second Affiliated Hospital of Harbin Medical University from January 2017 to December 2019; definitive diagnosis of PTN; explicit NVC through available preoperative 3D-TOF-MRA; implementation of standard MVD as initial neurosurgical procedure; completion of 3-years post-surgery follow-up. Patients who met the following criteria were excluded, including cardiopulmonary dysfunction intolerance to general anesthesia (GA), absence of NVC during MVD, chronic organ failures such as chronic renal failure (CKD) or cirrhosis, simultaneous arterial and venous compression on TN, or incomplete medical records (Figure 1).

Diagnosis of PTN

PTN was discriminated against from all other types of orofacial pain by the patient's medical history, typical clinical manifestations, and physical examination.¹⁷

Implementation of MVD

MVD was implemented in a standard manner as the initial neurosurgical procedure by the same team of skilled neurosurgeons in the Department of Neurosurgery at the Second Affiliated Hospital of Harbin Medical University from January 2017 to December 2019, in which Teflon grafts were used to alter the path of conflicting vessels away from TN rather than directly contacting the compression site of TN.¹⁷

Determination and Classification of Compression Degree of TN

During MVD, compression degree of TN was determined and classified, in which mild compression was defined as TN in contact with a nearby specific offending vessel without local deformation, whereas severe compression not only came into contact with a nearby specific offending vessel but also exhibited significant deformation.

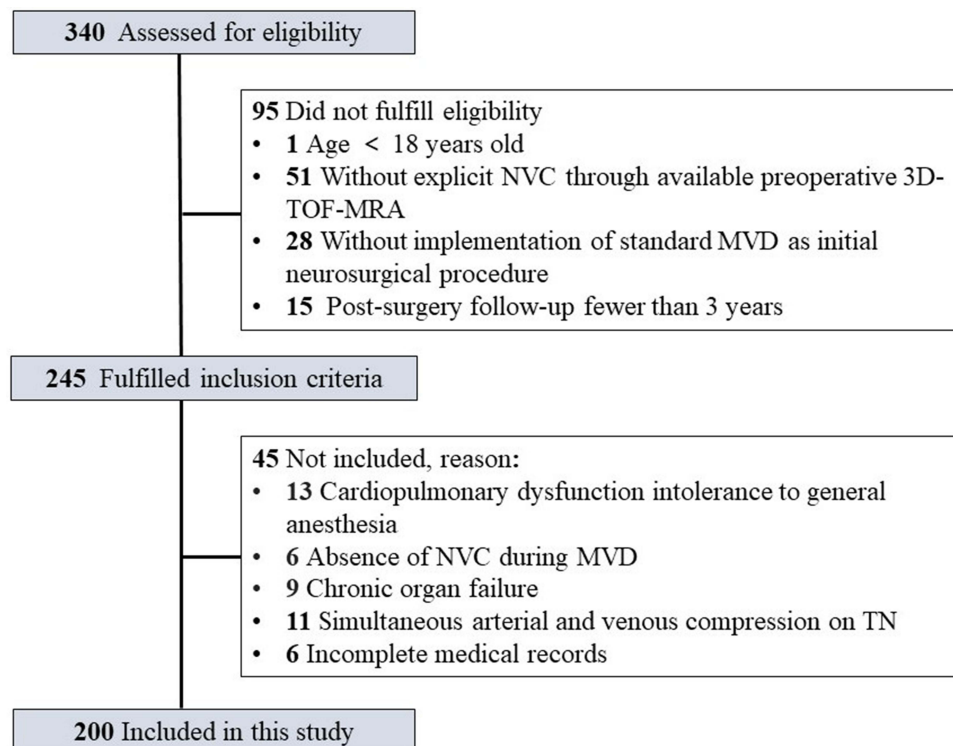


Figure 1 Flowchart of the study participants.

Abbreviations: NVC, neurovascular conflict; 3D-TOF-MRA, three-dimensional time-of-flight magnetic resonance angiography; MVD, microvascular decompression; TN, trigeminal nerve.

Determination and Classification of Pain Relief

Pain relief of adult patients with PTN at 3 months, 6 months, 1 year, 2 years, and 3 years after sufficient decompression of TN during MVD was determined and classified by the patient's subjective response and medications use as follows: CPR (no pain without medications use); nearly CPR (no pain with small doses of medications use, or 90%–99% pain relief with or without medications use); partial pain relief (50%–89% pain relief with or without medications use); poor pain relief (<50% pain relief).¹⁸ In this study, adult patients with PTN after sufficient decompression of TN during MVD were divided into two subgroups for statistical analysis: the CPR group and the other group, with the latter consisting of those with nearly CPR, partial and poor pain relief.

Data Collection

Demographic information, involving gender and age, as well as clinical information, including affected side of PTN, duration of PTN and medications use before MVD, compression degree and location of TN, and type of conflicting vessels during MVD were obtained and collated from medical records during hospitalization, whereas pain relief of adult patients with PTN at 3 months, 6 months, 1 year, 2 years, and 3 years after sufficient decompression of TN during MVD was followed up and recorded by dedicated personnel in our research team. Other than what was required for this study, none of the other members in our research team had access to the personal data of the enrolled patients.

Statistical Analyses

SPSS 22.0 (SPSS, Inc., Chicago, IL, USA) was used for statistical analyses. Quantitative data without normal distribution were presented as interquartile ranges (IQRs), and Mann–Whitney *U*-test was adopted for inter-group comparisons. In univariate analysis, Chi-square test was employed for inter-group comparisons of qualitative data. The significant

Table 1 The Remaining Demographic and Clinical Data of Adult Patients with PTN

		Frequency	Percentage
Gender	Female	122	61.00
	Male	78	39.00
Affected side	Left	73	36.50
	Right	127	63.50
Type of conflicting vessels	Artery	179	89.50
	Vein	21	10.50
Compression location of TN	Nerve root	173	86.50
	Others	27	13.50
Compression degree of TN	Mild	60	30.00
	Severe	140	70.00
Pain relief at 3 months	CPR	152	76.00
	Others	48	24.00
Pain relief at 6 months	CPR	142	71.00
	Others	58	29.00
Pain relief at 1 year	CPR	138	69.00
	Others	62	31.00
Pain relief at 2 years	CPR	136	68.00
	Others	64	32.00
Pain relief at 3 years	CPR	135	67.50
	Others	65	32.50
	Total	200	100.00

Abbreviations: PTN, primary trigeminal neuralgia; TN, trigeminal nerve; CPR, complete pain relief.

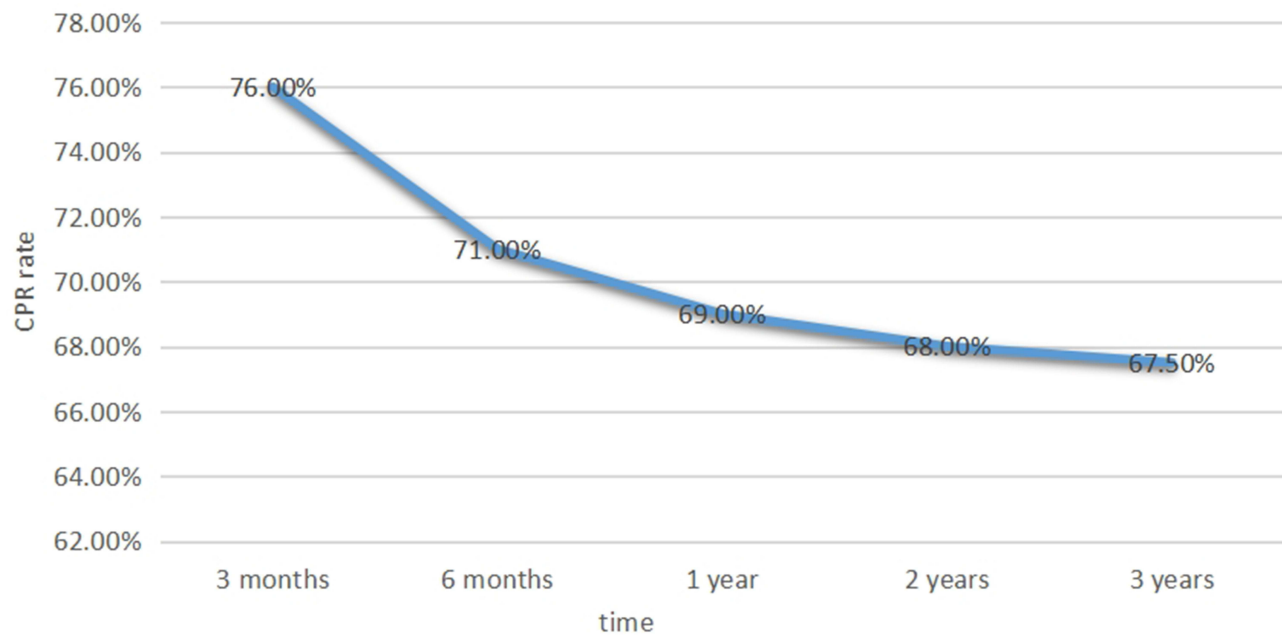


Figure 2 CPR rates of adult patients with PTN at 3 months, 6 months, 1 year, 2 years, and 3 years after sufficient decompression of TN during MVD.

Abbreviations: CPR, complete pain relief; PTN, primary trigeminal neuralgia; TN, trigeminal nerve; MVD, microvascular decompression.

variables in univariate analysis were included in multivariate analysis, and then logistic regression analysis was performed. The receiver operating characteristic (ROC) curve of CPR was analyzed, and then the area under the ROC curve, and the sensitivity and specificity of the ROC curve were calculated, respectively. A p-value <0.05 were considered to indicate statistical significance.

Table 2 Univariate Analysis of CPR of Adult Patients with PTN at 3 Months After MVD

	The CPR Group	The Other Group	χ^2/Z	P
Gender			6.867	0.009
Male	67 (44.08%)	11 (22.92%)		
Female	85 (55.92%)	37 (77.08%)		
Age	62 (55.00, 67.00)	59 (51.25, 68.75)	-1.033	0.301
Affected side			1.465	0.260
Left	59 (38.82%)	14 (29.17%)		
Right	93 (61.18%)	34 (70.83%)		
Duration of PTN before MVD	36 (9.75, 81.00)	36 (9.00, 84.00)	-0.069	0.945
Duration of medications use before MVD	24 (6.00, 40.00)	24 (6.00, 49.25)	-0.211	0.833
Compression degree of TN			106.772	0.000
Mild	17 (11.18%)	43 (89.58%)		
Severe	135 (88.82%)	5 (10.42%)		
Compression location of TN			1.444	0.230
Nerve root	129 (84.87%)	44 (91.67%)		
Others	23 (15.13%)	4 (8.33%)		
Type of conflicting vessels			18.482	0.000
Artery	144 (94.74%)	35 (72.92%)		
Vein	8 (5.26%)	13 (27.08%)		

Abbreviations: CPR, complete pain relief; PTN, primary trigeminal neuralgia; MVD, microvascular decompression; TN, trigeminal nerve.

Table 3 Logistic Regression Analysis of CPR of Adult Patients with PTN at 3 Months After MVD

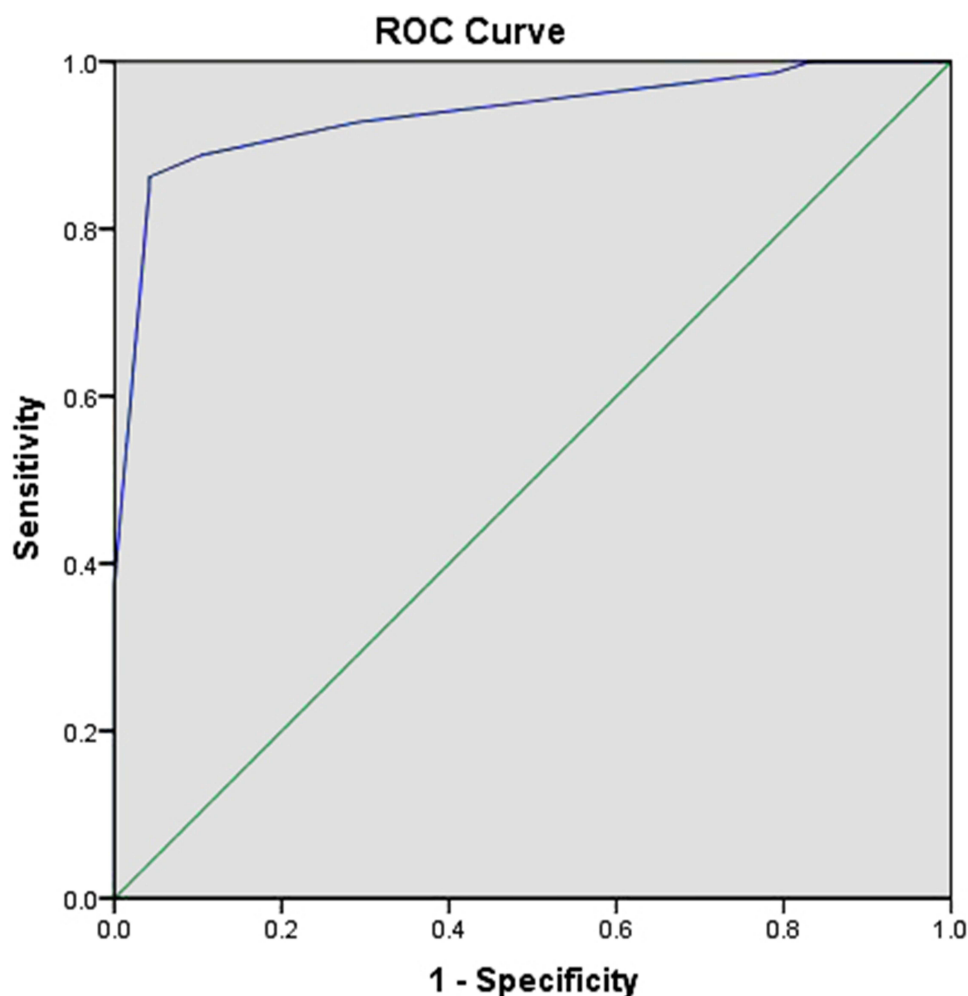
	B	SE	Wald	P-value	OR	95% CI	
						Lower Bound	Upper Bound
Gender	1.327	0.569	5.445	0.020	3.770	1.237	11.491
Type of conflicting vessels	2.120	0.781	7.366	0.007	8.329	1.802	38.491
Compression degree of TN	4.435	0.612	52.581	0.000	84.382	25.445	279.834
Constant	-3.259	0.828	15.489	0.000	0.038		

Abbreviations: CPR, complete pain relief; PTN, primary trigeminal neuralgia; MVD, microvascular decompression; SE, standard error; OR, odds ratio; CI, confidence interval; TN, trigeminal nerve.

Results

Demographic and Clinical Data of Adult Patients with PTN

A total of 200 adult patients with PTN who underwent MVD as their initial neurosurgical procedure in the Department of Neurosurgery at the Second Affiliated Hospital of Harbin Medical University from January 2017 to December 2019 and completed a 3-year post-surgery follow-up were enrolled in this study. Median age, and duration of PTN and medications

**Figure 3** The ROC curve of CPR of adult patients with PTN at 3 months after MVD.

Abbreviations: ROC, receiver operating characteristic; CPR, complete pain relief; PTN, primary trigeminal neuralgia; MVD, microvascular decompression.

use before MVD in this study population were 61 years, 36 months, and 24 months, respectively. Adult patients with PTN usually received oral medications, such as carbamazepine, oxcarbazepine, pregabalin, and gabapentin to alleviate pain and/or relieve symptoms before MVD, and the dosage varied from person to person. The remaining demographic and clinical information were displayed in Table 1. CPR rates of adult patients with PTN at 3 months, 6 months, 1 year, 2 years, and 3 years after sufficient decompression of TN during MVD were 76.0%, 71%, 69%, 68%, and 67.5%, respectively (Figure 2).

CPR of Adult Patients with PTN at 3 Months After MVD

In univariate analysis, gender, compression degree of TN, and type of conflicting vessels showed significant differences between the two groups ($p = 0.009$, $p = 0.000$, $p = 0.000$, respectively) (Table 2). In logistic regression analysis, the related factors to CPR included gender, compression degree of TN, and type of conflicting vessels. CPR rates of male, arterial and severe compression were 3.77, 8.329 and 84.382 times as much as those of female, venous and mild compression, respectively, indicating that compression degree of TN had the greatest impact (Table 3). The area under the ROC curve and the sensitivity and specificity of the ROC curve were 0.937, 86.2%, and 4.2%, respectively (Figure 3 and Table 4).

CPR of Adult Patients with PTN at 6 Months After MVD

In univariate analysis, compression degree of TN and type of conflicting vessels showed significant differences between the two groups ($p = 0.000$, $p = 0.000$, respectively) (Table 5). In logistic regression analysis, the related factors to CPR

Table 4 Area Under the ROC Curve at 3 Months After MVD

Area	SE	Asymptotic P-value	Asymptotic 95% CI	
			Lower Bound	Upper Bound
0.937	0.018	0.000	0.902	0.972

Abbreviations: ROC, receiver operating characteristic; MVD, microvascular decompression; SE, standard error; CI, confidence interval.

Table 5 Univariate Analysis of CPR of Adult Patients with PTN at 6 Months After MVD

	The CPR Group	The Other Group	χ^2/Z	P
Gender			3.224	0.073
Male	61 (42.96%)	17 (29.31%)		
Female	81 (57.04%)	41 (70.69%)		
Age	61.5 (55.00, 68.00)	59 (54.75, 66.00)	-0.551	0.582
Affected side			2.800	0.094
Left	57 (40.14%)	16 (27.59%)		
Right	85 (59.86%)	42 (72.41%)		
Duration of PTN before MVD	36 (8.75, 72.00)	42 (11.00, 96.00)	-0.718	0.473
Duration of medications use before MVD	24 (6.00, 40.00)	24 (6.00, 51.50)	-0.753	0.542
Compression degree of TN			88.087	0.000
Mild	15 (10.56%)	45 (77.59%)		
Severe	127 (89.44%)	13 (22.41%)		
Compression location of TN			3.050	0.081
Nerve root	119 (83.80%)	54 (93.10%)		
Others	23 (16.20%)	4 (6.90%)		
Type of conflicting vessels			20.514	0.000
Artery	136 (95.77%)	43 (74.14%)		
Vein	6 (4.23%)	15 (25.86%)		

Abbreviations: CPR, complete pain relief; PTN, primary trigeminal neuralgia; MVD, microvascular decompression; TN, trigeminal nerve.

Table 6 Logistic Regression Analysis of CPR of Adult Patients with PTN at 6 Months After MVD

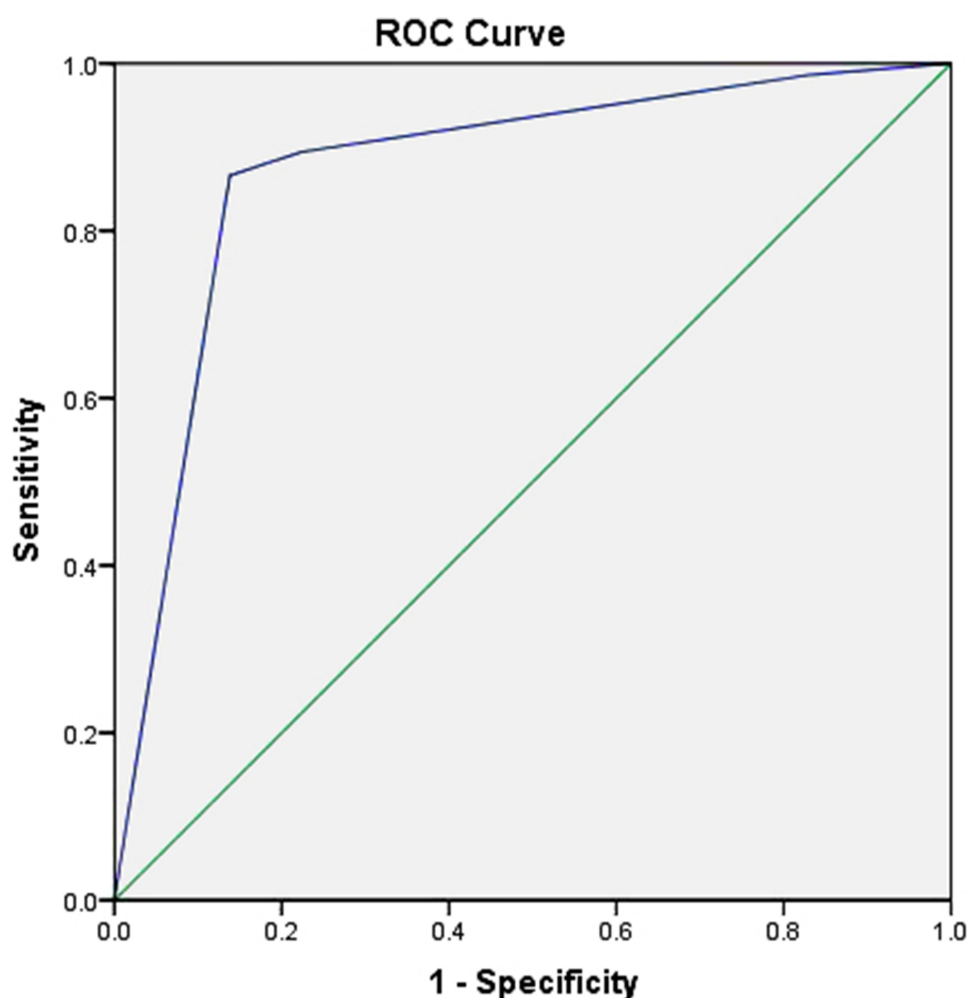
	B	SE	Wald	P-value	OR	95% CI	
						Lower Bound	Upper Bound
Type of conflicting vessels	2.141	0.667	10.314	0.001	8.509	2.303	31.431
Compression degree of TN	3.402	0.442	59.295	0.000	30.035	12.633	71.404
Constant	-2.986	0.703	18.058	0.000	0.050		

Abbreviations: CPR, complete pain relief; PTN, primary trigeminal neuralgia; MVD, microvascular decompression; SE, standard error; OR, odds ratio; CI, confidence interval; TN, trigeminal nerve.

included compression degree of TN and type of conflicting vessels. CPR rates of arterial and severe compression were 8.509 and 30.035 times greater than those of venous and mild compression, indicating that compression degree of TN had the largest effect (Table 6). The area under the ROC curve and the sensitivity and specificity of the ROC curve were 0.874, 86.6%, and 13.8%, respectively (Figure 4 and Table 7).

CPR of Adult Patients with PTN at 1 Year After MVD

In univariate analysis, compression degree of TN and type of conflicting vessels showed significant differences between the two groups ($p = 0.000$, $p = 0.000$, respectively) (Table 8). In logistic regression analysis, the related factors to CPR

**Figure 4** The ROC curve of CPR of adult patients with PTN at 6 months after MVD.

Abbreviations: ROC, receiver operating characteristic; CPR, complete pain relief; PTN, primary trigeminal neuralgia; MVD, microvascular decompression.

Table 7 Area Under the ROC Curve at 6 Months After MVD

Area	SE	Asymptotic P-value	Asymptotic 95% CI	
			Lower Bound	Upper Bound
0.874	0.030	0.000	0.815	0.934

Abbreviations: ROC, receiver operating characteristic; MVD, microvascular decompression; SE, standard error; CI, confidence interval.

Table 8 Univariate Analysis of CPR of Adult Patients with PTN at 1 Year After MVD

	The CPR Group	The Other Group	χ^2/Z	P
Gender			3.753	0.053
Male	60 (43.48%)	18 (29.03%)		
Female	78 (56.52%)	44 (70.97%)		
Age	61 (55.00, 68.00)	60 (54.75, 66.00)	-0.541	0.589
Affected side			0.698	0.404
Left	53 (38.41%)	20 (32.26%)		
Right	85 (61.59%)	42 (67.74%)		
Duration of PTN before MVD	36 (7.75, 72.00)	36 (12.00, 87.00)	-0.737	0.461
Duration of medications use before MVD	24 (5.75, 40.00)	24 (6.75, 50.00)	-0.761	0.447
Compression degree of TN			89.779	0.000
Mild	13 (9.42%)	47 (75.81%)		
Severe	125 (90.58%)	15 (24.19%)		
Compression location of TN			2.273	0.132
Nerve root	116 (84.06%)	57 (91.94%)		
Others	22 (15.94%)	5 (8.06%)		
Type of conflicting vessels			27.371	0.000
Artery	134 (97.10%)	45 (72.58%)		
Vein	4 (2.90%)	17 (27.42%)		

Abbreviations: CPR, complete pain relief; PTN, primary trigeminal neuralgia; MVD, microvascular decompression; TN, trigeminal nerve.

included compression degree of TN and type of conflicting vessels. CPR rates of arterial and severe compression were 17.361 and 34.344 times greater than those of venous and mild compression, indicating that compression degree of TN had the largest effect (Table 9). The area under the ROC curve and the sensitivity and specificity of the ROC curve were 0.879, 88.4%, and 14.5%, respectively (Figure 5 and Table 10).

CPR of Adult Patients with PTN at 2 Years After MVD

In univariate analysis, compression degree of TN and type of conflicting vessels showed significant differences between the two groups ($p = 0.000$, $p = 0.000$, respectively) (Table 11). In logistic regression analysis, the related factors to CPR included compression degree of TN and type of conflicting vessels. CPR rates of arterial and severe compression were

Table 9 Logistic Regression Analysis of CPR of Adult Patients with PTN at 1 Year After MVD

	B	SE	Wald	P-value	OR	95% CI	
						Lower Bound	Upper Bound
Type of conflicting vessels	2.854	0.708	16.256	0.000	17.361	4.335	69.528
Compression degree of TN	3.536	0.456	60.197	0.000	34.344	14.056	83.915
Constant	-3.871	0.762	25.808	0.000	0.021		

Abbreviations: CPR, complete pain relief; PTN, primary trigeminal neuralgia; MVD, microvascular decompression; SE, standard error; OR, odds ratio; CI, confidence interval; TN, trigeminal nerve.

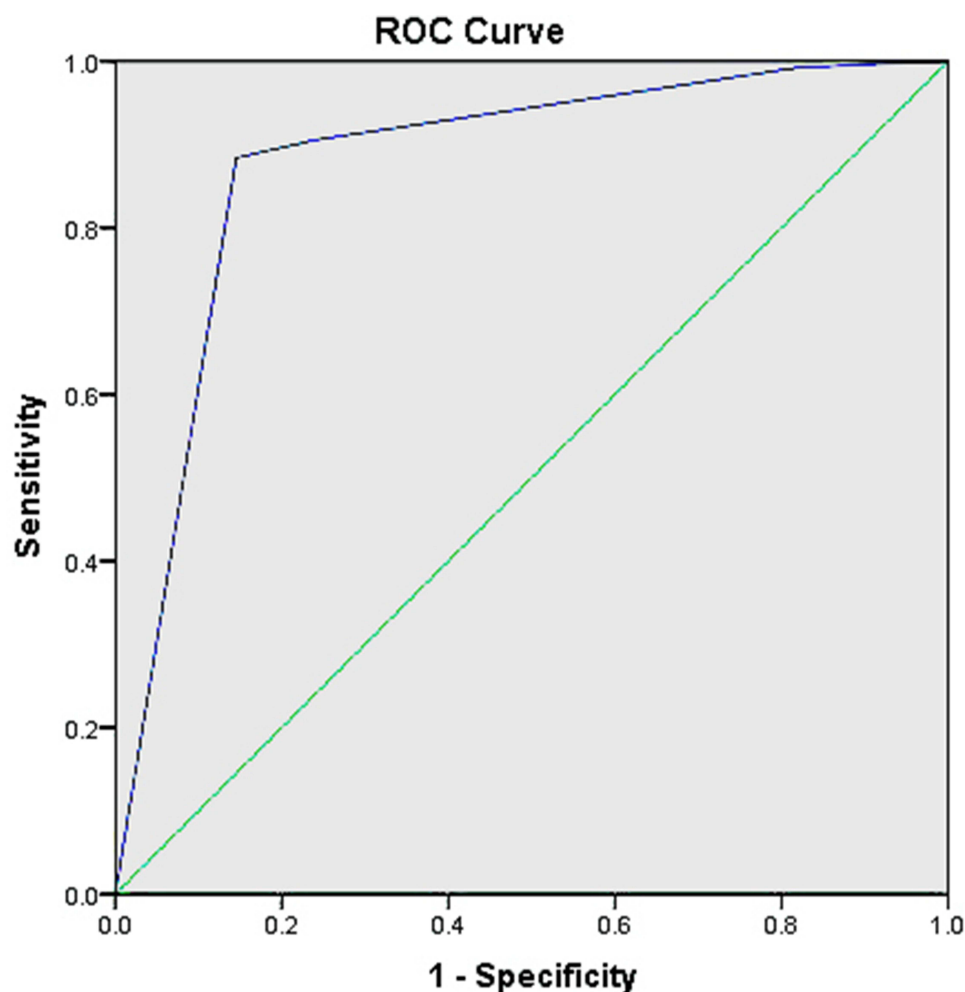


Figure 5 The ROC curve of CPR of adult patients with PTN at 1 year after MVD.

Abbreviations: ROC, receiver operating characteristic; CPR, complete pain relief; PTN, primary trigeminal neuralgia; MVD, microvascular decompression.

14.528 and 28.286 times higher than those of venous and mild compression, indicating that compression degree of TN had the largest effect (Table 12). The area under the ROC curve and the sensitivity and specificity of the ROC curve were 0.864, 88.2%, and 17.2%, respectively (Figure 6 and Table 13).

CPR of Adult Patients with PTN at 3 Years After MVD

In univariate analysis, compression degree of TN and type of conflicting vessels showed significant differences between the two groups ($p = 0.000$, $p = 0.000$, respectively) (Table 14). In logistic regression analysis, the related factors to CPR included compression degree of TN and type of conflicting vessels. CPR rates of arterial and severe compression were 14.327 and 31.408 times greater than those of venous and mild compression, indicating that compression degree of TN showed the greatest effect (Table 15). The area under the ROC curve and the sensitivity and specificity of the ROC curve were 0.869, 88.9%, and 16.9%, respectively (Figure 7 and Table 16).

Table 10 Area Under the ROC Curve at 1 Year After MVD

Area	SE	Asymptotic P-value	Asymptotic 95% CI	
			Lower Bound	Upper Bound
0.879	0.030	0.000	0.821	0.937

Abbreviations: ROC, receiver operating characteristic; MVD, microvascular decompression; SE, standard error; CI, confidence interval.

Table 11 Univariate Analysis of CPR of Adult Patients with PTN at 2 Years After MVD

	The CPR Group	The Other Group	χ^2/Z	P
Gender			2.376	0.123
Male	58 (42.65%)	20 (31.25%)		
Female	78 (57.35%)	44 (68.75%)		
Age	61.5 (55.00, 68.00)	59 (54.00, 66.00)	-0.924	0.356
Affected side			0.119	0.290
Left	53 (38.97%)	20 (31.25%)		
Right	83 (61.03%)	44 (68.75%)		
Duration of PTN before MVD	36 (8.25, 72.00)	36 (12.00, 84.00)	-0.422	0.673
Duration of medications use before MVD	24 (6.00, 40.00)	24 (6.25, 49.25)	-0.518	0.604
Compression degree of TN			84.563	0.000
Mild	13 (9.56%)	47 (73.44%)		
Severe	123 (90.44%)	17 (26.56%)		
Compression location of TN			2.607	0.106
Nerve root	114 (83.82%)	59 (92.19%)		
Others	22 (16.18%)	5 (7.81%)		
Type of conflicting vessels			25.840	0.000
Artery	132 (97.06%)	47 (73.44%)		
Vein	4 (2.94%)	17 (26.56%)		

Abbreviations: CPR, complete pain relief; PTN, primary trigeminal neuralgia; MVD, microvascular decompression; TN, trigeminal nerve.

Table 12 Logistic Regression Analysis of CPR of Adult Patients with PTN at 2 Years After MVD

	B	SE	Wald	P-value	OR	95% CI	
						Lower Bound	Upper Bound
Type of conflicting vessels	2.676	0.692	14.934	0.000	14.528	3.739	56.448
Compression degree of TN	3.342	0.437	58.436	0.000	28.286	12.006	66.643
Constant	-3.697	0.745	24.604	0.000	0.025		

Abbreviations: CPR, complete pain relief; PTN, primary trigeminal neuralgia; MVD, microvascular decompression; SE, standard error; OR, odds ratio; CI, confidence interval; TN, trigeminal nerve.

Discussion

PTN is a common and severe intermittently recurring orofacial lancinating pain syndrome confined to the somatosensory distribution of TN that can cause significant chronic debilitating neuropathic pain and great discomfort to the patient, with clear-cut pain-free intervals and a tendency to occur in the elderly.¹⁹ The clinical practice needs to be urgently improved through prompt recognition of the clinical picture, accurate evaluation of the neurosensory system, and appropriate adherence to the specific guidelines despite the common clinical features and available international diagnostic criteria of PTN. Misdiagnosis, delayed diagnosis, and even mistreatment are still not negligible in clinical practice.^{20,21} Vascular compression-induced NVC in TN root entry zone (REZ), whether arterial or venous compression, can cause demyelination of trigeminal sensory fibers and atrophic changes of TN, which is the primary hypothesis for the underlying neural mechanism and thus plays an important causative role in PTN.^{14,22} NVC may be more likely to develop and progress if the posterior cranial fossa (PCF) is crowded or a sharp trigeminal-pontine angle is present, both of which are risk factors for PTN.^{23,24} Current gold standard of conventional pharmacotherapy for PTN is sodium channel blockers, including carbamazepine and oxcarbazepine, with the need for titration and poor tolerability, such as the occurrence of drowsiness, diplopia and ataxia, although they are effective in pain control.²⁵ If adult patients with PTN are unable to respond to conventional pharmacotherapy or have a low tolerance for it, neurosurgical interventions should be considered.²⁶

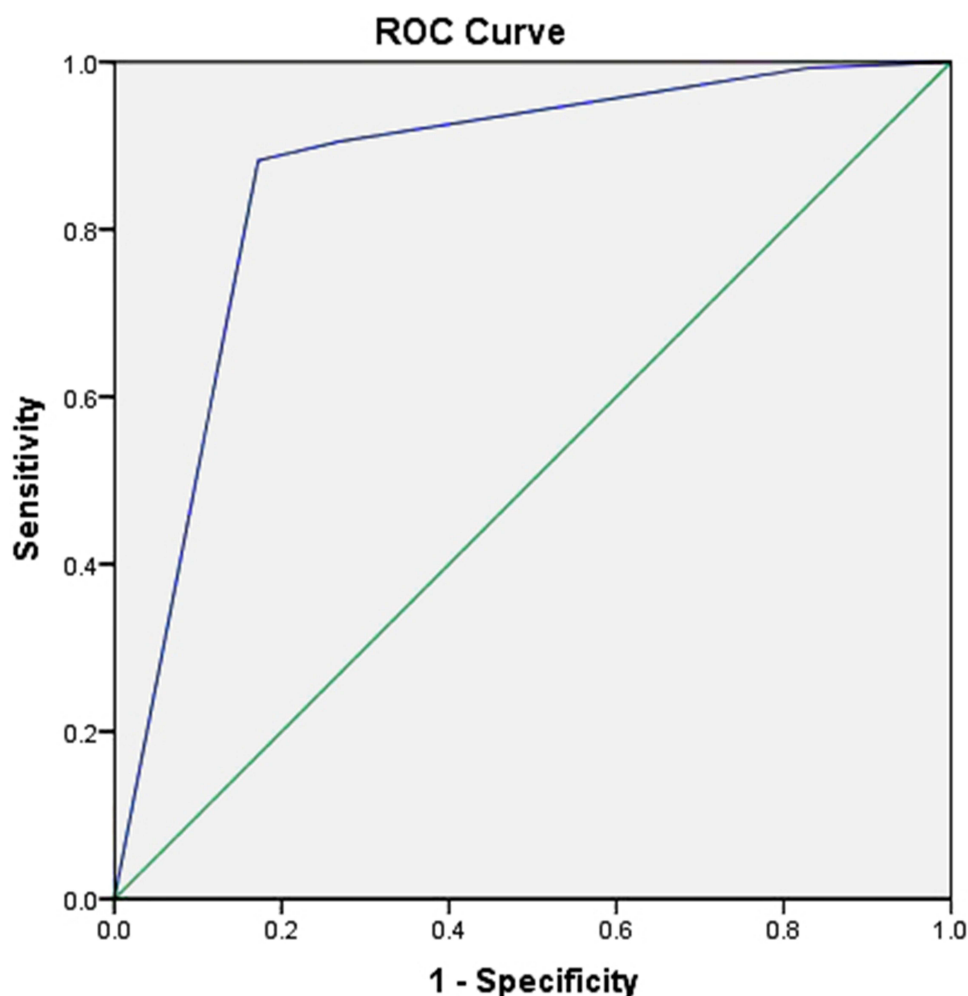


Figure 6 The ROC curve of CPR of adult patients with PTN at 2 years after MVD.

Abbreviations: ROC, receiver operating characteristic; CPR, complete pain relief; PTN, primary trigeminal neuralgia; MVD, microvascular decompression.

Compared with other neurosurgical interventions, standard MVD has the highest pain relief, success rate and patient satisfaction as well as the lowest incidence of complications and recurrence rate, and therefore is generally well-accepted as the preferred choice for adult patients with PTN in clinical practice.^{27–30} Sufficient decompression of TN and thorough exploration of both sensory and motor roots during MVD is a prerequisite to obtaining optimal pain relief in adult patients with PTN.³¹ The main purpose of this study is derived from this clinical fact that it is still unclear why a sizable portion of adult PTN patients with explicit NVC are unable to obtain satisfactory short- and long-term CPR even after sufficient decompression of TN during MVD. According to reports, MVD has a recurrence rate of about 10%, which is significantly lower than that of traditional pharmacotherapy and other neurosurgical interventions, with non-arterial compression being one of the contributing factors.³² Improvements in

Table 13 Area Under the ROC Curve at 2 Years After MVD

Area	SE	Asymptotic P-value	Asymptotic 95% CI	
			Lower Bound	Upper Bound
0.864	0.031	0.000	0.803	0.925

Abbreviations: ROC, receiver operating characteristic; MVD, microvascular decompression; SE, standard error; CI, confidence interval.

Table 14 Univariate Analysis of CPR of Adult Patients with PTN at 3 Years After MVD

	The CPR Group	The Other Group	χ^2/Z	P
Gender			1.813	0.178
Male	57 (42.22%)	21 (32.31%)		
Female	78 (57.78%)	44 (67.69%)		
Age	62 (55.00, 68.00)	59 (54.00, 66.00)	-1.070	0.285
Affected side			0.730	0.393
Left	52 (38.52%)	21 (32.31%)		
Right	83 (61.48%)	44 (67.69%)		
Duration of PTN before MVD	36 (8.00, 72.00)	36 (12.00, 84.00)	-0.372	0.710
Duration of medications use before MVD	24 (6.00, 40.00)	24 (6.50, 48.50)	-0.460	0.645
Compression degree of TN			88.156	0.000
Mild	12 (8.89%)	48 (73.85%)		
Severe	123 (91.11%)	17 (26.15%)		
Compression location of TN			2.781	0.095
Nerve root	113 (83.70%)	60 (92.31%)		
Others	22 (16.30%)	5 (7.69%)		
Type of conflicting vessels			25.110	0.000
Artery	131 (97.04%)	48 (73.85%)		
Vein	4 (2.96%)	17 (26.15%)		

Abbreviations: CPR, complete pain relief; PTN, primary trigeminal neuralgia; MVD, microvascular decompression; TN, trigeminal nerve.

Table 15 Logistic Regression Analysis of CPR of Adult Patients with PTN at 3 Years After MVD

	B	SE	Wald	P-value	OR	95% CI	
						Lower Bound	Upper Bound
Type of conflicting vessels	2.662	0.696	14.640	0.000	14.327	3.664	56.024
Compression degree of TN	3.447	0.444	60.325	0.000	31.408	13.160	74.957
Constant	-3.790	0.753	25.359	0.000	0.023		

Abbreviations: CPR, complete pain relief; PTN, primary trigeminal neuralgia; MVD, microvascular decompression; SE, standard error; OR, odds ratio; CI, confidence interval; TN, trigeminal nerve.

the advanced imaging technologies and neurosurgical techniques of MVD or combination with other neurosurgical interventions, such as partial sensory rhizotomy (PSR), may be fruitful in attempting to lower the recurrence rate.³² Even for persistent or recurrent PTN, repeated MVD (Re-MVD) and PCF exploration remain feasible and reliable options for salvage therapy.^{33–36}

This study population was characterized by a predominance of females and a preference for right-sided, arterial, and nerve root compression. CPR rate in adult patients with PTN gradually decreased from 76% at 3 months to 67.5% at 3 years after sufficient decompression of TN during MVD, which was consistently within the clinically acceptable range. In general, our results are consistent with the fact that MVD is an effective therapeutic option independent of patient's age.³⁷ In addition, our results showed that compression degree of TN constantly had the greatest impact on CPR in adult patients with PTN at different time points after sufficient decompression of TN during MVD, which was under previous results.^{38–40} From our results, although the specificity and negative predictive value of the ROC curve at various time points after MVD were constrained in this case series, adult PTN patients with severe and arterial compression on TN had better short- and long-term CPR after sufficient decompression of TN during MVD as their initial neurosurgical procedure. Therefore, preoperative neuroimaging as a prognostic marker of optimal management strategy, especially 3D-TOF-MRA with distinct signal, contributes to determining the optimal candidates suitable for MVD, guiding the appropriate treatment plan, and thus obtaining the best curative effect by demonstrating explicit NVC with nearby specific offending vessels and its severity.

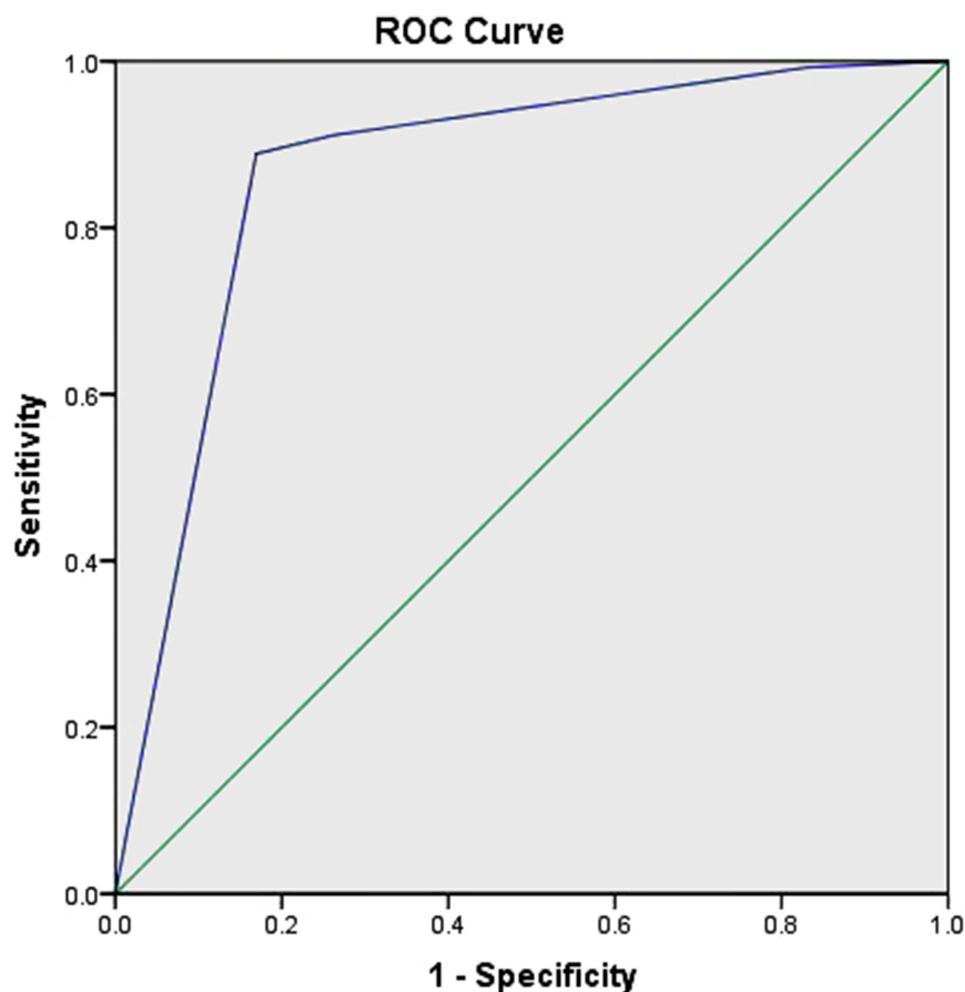


Figure 7 The ROC curve of CPR of adult patients with PTN at 3 years after MVD.

Abbreviations: ROC, receiver operating characteristic; CPR, complete pain relief; PTN, primary trigeminal neuralgia; MVD, microvascular decompression.

Limitations

There are several limitations in the present study. First of all, the nature of a single-center small-sample retrospective study constrained the reliability and generalizability of our conclusion. Second, the conclusion of our study could not be directly generalized to other patient populations because it was only applicable to adult PTN patients with explicit NVC prior to surgery who underwent MVD as their initial neurosurgical procedure. Third, the comparable demographic and clinical data were limited in this study. Finally, the post-surgery follow-up was discontinued at 3 years without further follow-up information available.

Table 16 Area Under the ROC Curve at 3 Years After MVD

Area	SE	Asymptotic P-value	Asymptotic 95% CI	
			Lower Bound	Upper Bound
0.869	0.031	0.000	0.809	0.929

Abbreviations: ROC, receiver operating characteristic; MVD, microvascular decompression; SE, standard error; CI, confidence interval.

Conclusion

In conclusion, compression degree of TN and type of conflicting vessels can determine short- and long-term CPR in adult patients with PTN after sufficient decompression of TN during MVD, which will contribute to better characterizing potential candidates suitable for MVD and thus optimizing the planning and implementation of MVD. Future multi-center prospective clinical trials with a sizable sample size are required to further validate our findings.

Data Sharing Statement

The data are available from the corresponding author on reasonable request.

Ethics statement

The requirement for written informed consent was waived according to the retrospective nature of the study, institutional requirements and national law. All operative procedure had undergone rigorous ethical review for keeping the safety of medical care and individual privacy. All patients' data were reserved confidentially under the inspection of the ethical committee of the Second Affiliated Hospital of Harbin Medical University even if without written informed consent. We will always comply with relevant laws, regulations, and international ethical guidelines, particularly the "Declaration of Helsinki".

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

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