Efficacy of primary microvascular decompression versus subsequent microvascular decompression for trigeminal neuralgia

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OBJECTIVE Trigeminal neuralgia (TN) is characterized by intermittent, paroxysmal, and lancinating pain along the distribution of the trigeminal nerve. Microvascular decompression (MVD) directly addresses compression of the trigeminal nerve. The purpose of this study was to determine whether patients undergoing MVD as their first surgical intervention experience greater pain control than patients who undergo subsequent MVD.

METHODS A retrospective review of patient records from 1998 to 2015 identified a total of 942 patients with TN and 500 patients who underwent MVD. After excluding several cases, 306 patients underwent MVD as their first surgical intervention and 175 patients underwent subsequent MVD. Demographics and clinicopathological data and outcomes were obtained for analysis.

RESULTS In patients who underwent subsequent MVD, surgical intervention was performed at an older age (55.22 vs 49.98 years old, $p < 0.0001$) and the duration of symptoms was greater (7.22 vs 4.45 years, $p < 0.0001$) than for patients in whom MVD was their first surgical intervention. Patients who underwent initial MVD had improved pain relief and no improvement in pain rates compared with those who had subsequent MVD (95.8% and 4.2% vs 90.3% and 9.7%, respectively, $p = 0.0041$).

Patients who underwent initial MVD had significantly lower rates of facial numbness in the pre- and postoperative periods compared with patients who underwent subsequent MVD ($p < 0.0001$). The number of complications in both groups was similar ($p = 0.4572$).

CONCLUSIONS The results demonstrate that patients who underwent other procedures prior to MVD had less pain relief and a higher incidence of facial numbness despite rates of complications similar to patients who underwent MVD as their first surgical intervention.

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KEY WORDS microvascular decompression; trigeminal neuralgia; pain

TRIGEMINAL neuralgia (TN) is a disorder characterized by intermittent, paroxysmal, lancinating pain along the distribution of the trigeminal nerve. Patients with TN suffer from intractable pain that can become refractory to medical management that prompts evaluation for surgical cure. Compression of the trigeminal nerve is the most

common identifiable cause of TN.^{7,10,11,13,27,36} A variety of surgical options exist, which include minimally invasive procedures such as stereotactic radiosurgery (SRS), percutaneous procedures such as glycerol rhizotomy (GR), radiofrequency-thermocoagulation GR (RFTC-GR), and more invasive procedures such as microvascular decom-

ABBREVIATIONS CISS = constructive interference in steady-state; MVD = microvascular decompression; SRS = stereotactic radiosurgery; TN = trigeminal neuralgia.

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pression (MVD). MVD aims to reverse the presumed etiology of TN via placement of a Teflon pledget between the compressed nerve and, most commonly, an overlying vascular structure. It is considered the gold standard surgical treatment for patients with medically intractable TN and demonstrable compression.^{15,26,31} Although MVD has been shown to exhibit the most durable outcomes, some patients elect to undergo less invasive procedures or are poor surgical candidates.¹⁶ Initial pain relief outcomes for patients undergoing MVD are excellent, ranging from 70% to 100% in multiple studies.^{1,4,8,12,16,18,29,31,32,34,38} TN patients commonly undergo multiple less invasive treatment options prior to MVD, but the effect of these prior surgical treatments on the efficacy of subsequent MVD has not been elucidated. Furthermore, few studies have compared the efficacy of MVD performed as first-line surgical intervention to MVD performed as a subsequent surgical intervention, nor has there been examination of factors associated with multiple interventions prior to MVD that predict outcomes.

We retrospectively analyzed demographic features, initial pain relief outcomes, durability of the results, complications, and vascular compression in patients undergoing an MVD performed as their first surgical intervention versus patients undergoing an MVD performed as a subsequent surgical intervention. We aimed to determine whether patients receiving an MVD as their initial intervention ("initial MVD") have better pain-related outcomes and/or reduced complications compared with patients undergoing an MVD as an intervention following other surgeries ("subsequent MVD").

Methods

Patient Selection

We retrospectively reviewed medical records of patients treated from 1998 to 2015 and identified a total of 942 patients with a diagnosis of TN, 500 of whom underwent MVD at our institution. Outcomes were available for 489 MVDs (98%), and 5 MVDs (1%) were excluded due to lack of follow-up. Of note, a subset of patients included in the analysis in this manuscript was reported on in a previous paper;⁹ however, we were addressing a different question. The diagnostic criterion for TN was pain in the distribution of the trigeminal nerve; pain that was intermittent, paroxysmal, shocklike, and lancinating in character; triggered by light touch; and responsive to TN medications. Idiopathic pain was described in 485 patients (97%), and 4 (1%) patients who experienced a component of constant, atypical pain were excluded. We also identified and excluded 1 patient with an epidermoid tumor causing compression (0.5%), leaving 481 patients (98%) for subsequent analysis. Of the 481 patients, 306 patients underwent MVD as their first surgical intervention and 175 patients underwent MVD as a subsequent surgical intervention. All patients who underwent subsequent MVD were included for analysis, regardless of the type of surgical intervention they first received. We defined prior interventions as GR, RFTC-GR, and SRS. Inclusion criteria are documented in Table 1. Our institutional review board approved this study.

TABLE 1. Inclusion criteria

Condition	No.	%
Patients who underwent MVD	500	
Patients w/ follow-up	489	97.8
Patients w/ idiopathic TN	485	97.0
Patients w/ idiopathic TN (MS & cancer excluded)	481	96.2
MVD as 1st intervention	306	61.2
MVD as subsequent intervention	175	35.0

MS = multiple sclerosis.

Operative Technique

Patients were positioned either in park-bench position or supine with a shoulder bump under the ipsilateral shoulder and the patient's head pinned in a Mayfield clamp, rotated 60° toward the contralateral shoulder. Neuronavigation was used to identify the junction between the sigmoid sinus and transverse sinus over which a 5-cm curvilinear skin incision was made. The Anspach drill was used to make a 3 × 2-cm retrosigmoid craniectomy. A cruciate dural opening was made and the arachnoid was incised to release CSF from the cisterna magna. The Leyla bar and Yaşargil retractor were positioned to gently retract the cerebellum medially. The microscope was brought in and the trigeminal nerve was visualized. The nerve was explored circumferentially to identify all possible arterial and venous sources of compression. Teflon pledgets were fluffed and positioned between the nerve and sources of compression to decompress the trigeminal nerve.

Follow-Up and Data Collection

Follow-up information was collected from outpatient records and surveys that were mailed to patients' homes to determine pain outcomes from surgical intervention, any pain recurrences, and any subsequent operations in both treatment groups. Follow-up surveys were used to gather information on postoperative outcomes and recurrence. The retrospective review of medical records included demographic information, medical history, TN symptomatology and medications, and the outcomes of prior surgical interventions.

Initial pain relief and hypesthesia for all patients was assessed at the first follow-up appointment, generally 2 weeks postoperatively. Pain relief outcomes were classified as follows: complete pain relief without TN medications, complete pain relief with TN medications, partial pain relief with or without medications, and no pain relief.

Postoperative numbness was assessed using the Barrow Neurological Institute Facial Hypesthesia Scale and Scoring System. According to this scale, a score of I indicates no facial numbness, II indicates mild facial numbness that is not bothersome, III indicates somewhat bothersome facial numbness, and IV indicates very bothersome facial numbness. The presence or absence of 13 relevant complications was recorded systematically.

Statistical Analysis

Statistical analysis was performed using Prism (GraphPad Software). Continuous variables are presented as

means, standard deviations, or percentages and were analyzed using a one-tailed Student t-test. Categorical or binomial values were analyzed by Fisher exact chi-square test, with p values less than 0.05 being considered statistically significant.

Results

Patient Demographics

Patient demographics are listed in Table 2. There were 216 female patients (71%) who underwent MVD as their first surgical intervention versus 119 female patients (68%) who underwent subsequent MVD. The mean age at intervention was 49.98 years for patients who underwent initial MVD and 55.22 years for patients who underwent subsequent MVD ($p < 0.0001$). The mean TN symptom duration average was 4.44 years versus 7.22 years for patients who underwent initial MVD versus subsequent MVD, respectively ($p < 0.0001$). The ratio of left-sided symptoms to right-sided symptoms was 0.42:0.58 versus 0.42:0.58 for patients who underwent initial MVD versus patients who underwent subsequent MVD, respectively. There were 21 (7%) patients in the initial MVD group who experienced bilateral symptoms compared with 13 (7%) in the subsequent MVD group. The distribution of symptoms involved 1 nerve (V1, V2, or V3) alone in 96 patients (31%) who underwent initial MVD versus in 60 patients (34%) who underwent subsequent MVD. The distribution of symptoms involved any combination of 2 nerves (V1 and V2, V1 and V3, or V2 and V3) in 135 patients (44%) who underwent initial MVD versus 69 (39%) in patients who underwent subsequent MVD. Lastly, the distribution of symptoms involved all nerve divisions (V1–V3) in 75 patients (16%) who underwent initial MVD versus 46 patients (23%) who underwent subsequent MVD. Of note, the number of female patients, side of TN pain, unilateral and bilateral TN symptom percentage, and distribution of TN pain were well matched between the 2 groups. As previously stated, there were significant differences in mean age at surgery ($p < 0.0001$) and TN symptom duration ($p < 0.001$) between the groups.

Pain Relief

Pain relief outcomes are documented in Table 3. A total of 224 cases (73%) in which MVD was the first surgical intervention and 120 (69%) in which it was a subsequent surgical intervention resulted in pain-free status without medications. In 29 (10%) initial MVD interventions and 15 (9%) subsequent MVD interventions, patients reported being pain free but still on medications. In 40 (13%) cases in which MVD was the first surgical intervention and in 23 (13%) cases in which it was a subsequent procedure, patients reported an improvement in TN pain. Finally, in 13 (4%) cases in which MVD was the first surgical intervention and 17 (10%) cases in which it was a subsequent surgical procedure, patients reported no improvement in TN pain. Among patients who underwent MVD as their first surgical intervention, 95.8% of patients experienced some pain relief whereas among those who underwent MVD as a subsequent intervention, 90.3% reported some pain relief ($p = 0.0041$).

TABLE 2. Patient demographics*

Variable	1st Surgical Intervention	Subsequent Surgical Intervention	Total	p Value
Patients	306	175	482	
No. of female patients	216	119	336	
Mean age (yrs)	49.98 ± 12.17	55.22 ± 13.36		<0.0001
Mean TN symptom duration (yrs)	4.448 ± 4.303	7.224 ± 5.491		<0.0001
Side (lt/rt ratio)	0.42:0.58	0.42:0.58		
Unilat TN symptoms	285	162		
Distribution				
V1	12	10	22	
V2	34	18	52	
V3	50	32	82	
V1 & V2	45	31	86	
V1 & V3	5	5	10	
V2 & V3	85	33	118	
V1–V3	75	46	121	
Any V1	62	46		
Any V2	164	82		
Any V3	210	111		

* Mean values are presented ± SD.

Sensory Changes

Preoperative and postoperative sensory changes are documented in Table 4. Patients who underwent initial MVD experienced negligible sensory changes, but patients who underwent subsequent MVD experienced an increase in sensory loss postoperatively. For procedures in which MVD was the first surgical intervention, 93% of patients before and 85% of patients after surgery experienced intact facial sensation with no facial numbness. For procedures in which MVD was a subsequent surgical intervention, 77% of patients before and 65% of patients after surgery experienced no facial numbness. A higher number of patients reported no facial numbness before their operation if MVD was their first surgical intervention ($p < 0.0001$). Similarly, patients in whom MVD was the initial surgical intervention were found to have a higher rate of preserved facial sensation postoperatively compared with those in whom MVD was a subsequent surgical intervention ($p < 0.0001$).

Complications

Complications are documented in Table 5. In procedures in which MVD was the first surgical intervention, complications included dysesthesia (1 case [1%]), paresthesia (1 case [0.3%]), meningitis (3 cases [1.0%]), hemifacial spasm (1 case [0.3%]), hearing loss (5 cases [1.6%]), facial palsy (3 cases [1.0%]), and CSF leak (4 cases [1.3%]). In procedures in which MVD was a subsequent surgical intervention, complications included paresthesia (3 cases [2%]), herpes simplex virus reaction (1 case [1%]), corneal anesthesia (2 cases [1%]), hearing loss (2 cases [1%]), cra-

TABLE 3. Initial pain relief outcomes

Outcome	1st Surgical Intervention	%	Subsequent Surgical Intervention	%	Total	Overall %	p Value
No pain, no meds	224	73.2	120	68.6	344	71.52	0.0041
No pain w/ meds	29	9.5	15	8.6	44	9.15	
Pain improved	40	13.1	23	13.1	63	13.09	
Pain unchanged	13	4.2	17	9.7	30	6.24	
Total	306	100	175	100	481	100	

Med = medication.

nial nerve VI palsy (1 case [1%]), and facial palsy (2 cases [1%]). There was no difference in complication rates between groups ($p = 0.4572$). The mortality rate during the immediate postoperative period was 0% for both groups.

Discussion

MVD has been shown to be the only surgical treatment that directly treats the proposed etiology of TN. It is relatively safe, and the number of procedures performed in the United States rose by 194% between 1988 and 2008.^{3,28,37} Additionally, MVD has been shown to have higher rates of TN pain relief in the elderly.^{6,21,33} However, it is an invasive procedure and not without certain risks, although these risks have been shown to be independent of age.²³ We retrospectively analyzed the clinical outcomes of 481 patients, in whom MVD was either the first or a subsequent surgical intervention after less invasive procedures. In patients who underwent a subsequent MVD, we documented a lower rate of pain relief compared with patients who underwent an initial MVD. Additionally, patients who underwent MVD as their first surgical intervention experienced lower rates of facial numbness in the preoperative and postoperative period. The rates of complications in both groups were similar, and there were no deaths in our series.

Sindou et al. documented complete pain relief in 77% of patients over a follow-up period that ranged from 3 to 20 years.³⁰ As mentioned, the rate of initial pain relief after MVD has been shown to vary from 70% to 100%

in patients treated for TN.^{1,4,8,12,16,18,29,31,32,34,38} In the largest series, Barker et al. reported the results of 1204 MVDs with immediate, 1-year, and 10-year complete pain relief achieved in 82%, 80%, and 70% of procedures, respectively.⁴ Sindou et al. reported that 73.3% of patients were free of pain at 15 years.³¹ Furthermore, Bederson and Wilson reported a recurrence rate of 2% per year, while Barker et al. reported annual recurrence rates of < 2% and < 1% at 5 and 10 years, respectively.^{4,5} Similar to these studies, we observed the rates of complete pain relief and any pain relief of 73.2% and 95.8%, respectively, in the initial MVD group and 68.6% and 90.3%, respectively, in the subsequent MVD group.

MVD has the potential to alter facial sensations in a variety of ways, and, interestingly, at baseline, somatosensory perception may be altered in patients with TN. Miles et al. demonstrated decreased tactile sensation in asymptomatic nerve distributions on patients' symptomatic side preoperatively ($p = 0.006$). Using the contralateral division as a control, they reported that by 6 months after surgery, patients had no difference in perception of touch, as well as coolness, the latter being less significant. They also demonstrated a significant difference between pinprick sensation on the symptomatic side and the asymptomatic side that resolved at the 12-month postoperative time point. Last, among patients whose TN affected the maxillary division, the skin temperature on the symptomatic side was 0.6°C lower than that on the asymptomatic

TABLE 4. Preoperative and postoperative hypesthesia measured using the Barrow Neurological Institute Facial Hypesthesia Scale and Scoring System

BNI Score	1st Surgical Intervention	%	Subsequent Surgical Intervention	%	Total	Overall %	p Value
Preop							
1	283	92.5	135	77.1	418	86.9	<0.0001
2	22	7.2	35	20.0	57	11.9	
3	1	0.3	2	1.2	3	0.6	
4	0	0	3	1.7	3	0.6	
Total	306	100	175	100	481	100	
Postop							
1	259	84.7	113	64.6	372	77.3	<0.0001
2	45	14.7	55	31.4	100	20.8	
3	1	0.3	5	2.9	6	1.3	
4	1	0.3	2	1.1	3	0.6	
Total	306	100	175	100	481	100	

BNI = Barrow Neurological Institute.

TABLE 5. Summary of complications

Complication	1st Surgical Intervention	%	Subsequent Surgical Intervention	%	Total	Overall %
Dysesthesia	3	1.0	0	0	3	0.6
Paresthesia	1	0.3	3	1.7	4	0.8
HSV reaction	0	0	1	0.6	1	0.2
Corneal anesthesia	0	0	2	1.1	2	0.4
Anesthesia dolorosa	0	0	0	0	0	0
Masseter weakness	0	0	0	0	0	0
TMJ dysfunction	0	0	0	0	0	0
Hematoma	0	0	0	0	0	0
Meningitis	3	1.0	0	0	3	0.6
Hemifacial spasm	1	0.3	0	0	1	0.4
Hearing loss	5	1.6	2	1.1	6	1.2
VI nerve palsy	0	0	1	0.6	1	0.2
Facial palsy	3	1.0	2	1.1	5	1.0
CSF leak	4	1.3	0	0	4	0.8

HSV = herpes simplex virus; TMJ = temporomandibular joint.

side preoperatively.²² Hypesthesia can affect up to 37% of cases, while facial numbness may occur in 1.6%–17.3% of patients.^{3,4,15} Of note, postoperative facial numbness has been shown to predict facial burning and aching and be a predictor of worse outcomes ($p = 0.03$).³ Our study demonstrated a slight increase in reported facial numbness in both cohorts of patients after MVD. Furthermore, the number of patients with no facial numbness versus any numbness before and after MVD among patients who underwent an initial vs a subsequent MVD was significant ($p < 0.0001$).

CSF leak occurs in 0.8%–3.2% of patients.^{4,15,19} Rates of hearing loss are reported to range between 0.97% and 3.0%.^{24,28} In one of the largest MVD series for TN to date, McLaughlin et al. demonstrated the risk of cerebellar injury to be 0.68%.²⁰ Dysesthesia has been reported as a complication and may occur in as few as 0.3% of patients. In our study, we found that patients who underwent MVD as a subsequent intervention had rates of complications similar to those who underwent MVD as their first surgical intervention. However, it should be noted that the total number of complications was higher in patients who underwent MVD as a primary, rather than subsequent, surgical intervention. It is important to realize that although this potential difference may not be statistically significant, patients who undergo MVD as an initial surgical intervention may indeed experience higher rates of complications.

Various attempts have been made to identify the patient population most likely to benefit from MVD for the treatment of TN. Key patient and disease characteristics have been shown to predict better outcomes and a lower likelihood of recurrence. Jo et al. performed a retrospec-

tive study to establish such characteristics and were able to identify patient age < 70 years, high severity of contact/compression, and single-vessel compression as being correlated with better outcomes. Additionally, their group found a positive correlation between preoperative neuroimaging features and neurovascular compression, specifically the presence of the “CSF rim” sign, defined as a narrow CSF signal between the nerve and the vessel on axial constructive interference in steady-state (CISS) imaging, as well as the “deviation” sign, which was defined as deviation on horizontal compression also identified on axial CISS.¹⁴ Zhang et al. also attempted to identify prognostic factors for patients undergoing MVD for the treatment of TN. Their group identified typical symptoms, preoperative MRI findings, and intraoperative findings of vessel compression as prognostic factors suggestive of an excellent outcome.³⁸ Finally, Barker et al. identified 4 factors predicting long-term relief: immediate postoperative pain relief, male sex, absence of venous compression, and preoperative symptom duration greater than 8 years.⁴

Multiple risk factors for TN recurrence in patients undergoing MVD exist. Some studies have shown female sex as a risk factor for recurrent TN, while others have shown evidence to the contrary.^{12,17,21,35} Greater time from symptom onset to treatment has also been identified as a risk factor for recurrence after MVD.^{2,5} The nature of the pain has also shown to be a poor prognostic factor after surgery. Szapiro et al. reported a 95% cure rate in patients with paroxysmal pain versus a 58% cure rate in patients with paroxysmal and permanent pain, which was statistically significant ($p < 0.001$). Furthermore, among patients with permanent pain, those with pain involving 2 or more divisions fared worse after MVD than patients whose pain involved only 1 division.³⁴ Finally, the presence of compression has been shown to be associated with lower rates of recurrence compared with the absence of compression.^{6,21,25} Interestingly, Barba and Alksne reported that prior destructive surgery was a prognostic factor for poor outcome in patients undergoing MVD ($p < 0.005$).² Barker et al. reported 4 factors that predicted higher rates of recurrence, which were female sex, preoperative symptom duration > 8 years, venous compression, and lack of immediate postoperative pain relief.⁴

Inherent to our study are several limitations. Although multiple studies have revealed that duration of symptoms is a reliable predictor of outcome, numerous variables may also influence outcomes. Data pertaining to these variables—for example, vascular compression, sex, and TN pain—were collected in our series and may also independently influence surgical outcomes.^{2,5} Multiple surgeons performed the MVD procedure, and, as a result, there is likely a small difference in interoperator variability. However, this potential operator variability difference did not manifest in complication rates, as the rates of complications were similar in both groups. This may have manifested as some surgeons offering MVD to different-age patient populations, as well as with different pain outcomes. Furthermore, the patient population at our tertiary-care center is unique and represents patients who may have self-selected for MVD. Another limitation lies in the retrospective nature of the study and the descriptive

nature of facial numbness. No objective definition/measures aside from patient self-reports exist with regard to numbness, and this represents an inherent limitation to the BNI hypesthesia scale. Last, pain outcomes were not classified objectively but rather based on patient self-reports with results interpreted through the context of a standardized pain outcome scoring system.

Our findings suggest that patients with typical TN pain who undergo MVD as their first surgical intervention may experience better pain outcomes than patients who undergo MVD that has been preceded by other surgical interventions. Although MVD results in excellent pain relief outcomes, some patients' pain recurs, and it is important to inform patients that lower success rates are associated with subsequent surgical interventions. Future studies must delineate the role of specific prior surgical interventions, such as prior MVD, SRS, GR, or RFTC-GR, as well as sources of compression, on pain outcome. Additionally, future studies should investigate whether the number of prior interventions influences the clinical outcomes associated with future operations.

Conclusions

MVD is the only surgical treatment aimed at a definitive cause for TN. This study reports patient demographics, pain outcomes, complication rates, facial sensation changes, and time to recurrence for patients undergoing MVD as their first surgical intervention versus MVD as a subsequent surgical intervention; we found a rather robust response to MVD whether it is the first surgical intervention to treat TN or whether it is a subsequent operation. Additionally, our low complication rates and 0% mortality rate suggest that MVD is a safe and effective procedure for patients suffering from TN.

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Disclosures

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Conception and design: Lim, Theodros, Blitz. Acquisition of data: Theodros, Bender, Zhou, Abu-Bonsrah. Analysis and interpretation of data: Lim, Theodros, Carson, Bettgowda. Drafting the article: Theodros. Critically revising the article: Lim, Theodros, Goodwin, Garzon-Muvdi, Mathios, Blitz, Olivi, Carson, Bettgowda. Reviewed submitted version of manuscript: Theodros, Goodwin, Bender, Zhou, Abu-Bonsrah, Mathios, Blitz, Carson, Bettgowda. Statistical analysis: Goodwin, Garzon-Muvdi, De la Garza Ramos. Administrative/technical/material support: Carson, Bettgowda.

Supplemental Information

Previous Presentations

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