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Original Investigation

A Clinical Analysis of Microvascular Decompression Surgery with Sacrification of the Superior Petrosal Venous Complex for Trigeminal Neuralgia: A Single-Surgeon Experience

Efdal AKKAYA[1], Zeki GOKCIL[2], Cem ERBAS[3], Serhat PUSAT[4], Zuleyha KAZAK BENGISUN[5], Ersin ERDOGAN[3]

[1]Ufuk University, School of Medicine, Department of Neurology, Ankara, Turkey
[2]Eastern Mediterranean University, Faculty of Health Sciences, Physiotherapy and Rehabilitation, Department of Neurology, Northern Cyprus
[3]Brain and Spine Surgery Center, Ankara, Turkey
[4]Sultan Abdulhamid Han Education and Research Hospital, Department of Neurosurgery, Istanbul, Turkey
[5]Ufuk University, School of Medicine, Department of Anesthesiology, Ankara, Turkey

Corresponding author: Efdal AKKAYA ✉ efdalakkaya@hotmail.com

ABSTRACT

AIM: To report the surgical outcomes in patients with trigeminal neuralgia (TN) who underwent microvascular decompression (MVD) with superior petrosal vein sacrification.

MATERIAL and METHODS: Data from 63 patients, whose information was obtained from a group of 113 patients who underwent surgery from 2008 to 2018, were reviewed retrospectively by the first author who was not part of the surgical team, and the pain conditions were evaluated objectively.

RESULTS: Following surgery, pain relief occurred in 84% of patients during the early postoperative period and in 69.8% of patients during long-term follow-up. The major offending vessel was the superior cerebellar artery.

CONCLUSION: MVD surgery, in particular for patients with typical pain, is one of the most effective treatment strategies for trigeminal neuralgia. Superior petrosal vein sacrification is a safe method that helps neurosurgeons to visualise the surgical area and perform a better work-up. Neurosurgeons should not be afraid to carry out superior petrosal vein sacrification.

KEYWORDS: Microvascular decompression, Superior petrosal vein, Surgery, Trigeminal neuralgia

INTRODUCTION

Trigeminal neuralgia (TN) was first described in 1934 by Dandy as a disease caused by vascular compression of the trigeminal nerve (2,4), and has been called the 'suicide disease' due to the severity of pain that ruins daily life. There are two types of TN: typical TN, characterised by sharp, stabbing, electrical pain (type 1), and atypical TN (type 2), with which patients complain of less intense, constant, dull or burning pain. In comparison with ablative procedures such as radiofrequency thermocoagulation, percutaneous balloon compression, or stereotactic radiosurgery, microvascular decompression surgery (MVD) is superior in pain relief (7). In this review, we aimed to evaluate our MVD surgery outcomes in light of the literature.

MATERIAL and METHODS

In the present retrospective study, we evaluated data from 63 patients whose information was obtained from a group of 113 patients who underwent MVD surgery from 2008 to 2018. Patients were called by the principal investigating neurologist who was not part of the surgical team, and the pain conditions were evaluated objectively. All patients were diagnosed

Efdal AKKAYA : 0000-0002-6656-0989
Zeki GOKCIL : 0000-0002-0544-524X
Cem ERBAS : 0000-0001-7719-9271
Serhat PUSAT : 0000-0003-2412-2320
Zuleyha KAZAK BENGISUN : 0000-0002-0731-2969
Ersin ERDOGAN : 0000-0003-1308-949X

with trigeminal neuralgia according to criteria of the 2nd and 3rd editions of the International Classification of Headache Disorders (ICHD-2 and -3). Detailed medical history, duration of illness, previously performed treatment techniques, and presence of hypertension were recorded. All patients were refractory to medical therapy. All MVD surgery procedures were performed by one neurosurgeon (EE). Patients were questioned regarding the change in the severity of pain prior to and following surgery, which was classified using the Barrow Neurological Institute (BNI) Pain Intensity Scale Score (Table I) (17).

All patients underwent magnetic resonance imaging (MRI) prior to surgery to determine neurovascular conflict (Figure 1A, B), with 1.5 or 3T contrast-enhanced T1W, FLAIR, T2W, and 3D FIESTA (or 3D CISS) sequences being evaluated. MRI predicted neurovascular conflict in 83% of cases. Vascular compression status was better determined during surgical exploration in all cases. Moreover, all patients underwent computerised tomography (CT) following surgery to control surgical complications and examine the surgical area.

During surgery, the trigeminal rhizotomy technique was performed in 4 cases with no neurovascular conflict. PTFE polymer Teflon™ pledgets were used as Teflon™ felt. In all patients with arterial compression and one patient with venous compression, Teflon™ felt was implanted between the offending vessel and the trigeminal nerve (Figure 2). With the exception of one, the superior petrosal vein was sacrificed in all patients.

Table I: Barrow Neurological Institute (BNI) Pain Intensity Scale Score (4)

Score	Description
I	No 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

Surgical Technique

Following the induction of anesthesia and intubation, a three-point head-fixation device was applied and the patient was placed in the lateral decubitus position with appropriate pressure points and an axillary silicone roll. The neck was flexed slightly, with the chin approximately two finger-breadths from the sternum. The head was rotated 10 degrees away from the affected side. The vertex was kept parallel to the floor to keep the 7th and 8th cranial nerve complex at a more inferior position in relation to the trigeminal nerve. The retrosigmoid approach was performed as described previously by our own experience (6). An incision of 5−7 cm in length was made along the hairline in the postauricular region. The occipital artery and the other superficial vessels were retracted to reach the calvarium. Subsequently, retrosigmoidal keyhole craniectomy was performed. The dura mater was opened to reach the pontocerebellar region. With the exception of one patient, the superior petrosal vein was sacrificed in all patients. Following visualisation of the trigeminal nerve, Teflon was implanted between it and the offending vessel, tissue glue was used, and the dura was sutured. Polymethyl methacrylate (PMMA), which was prepared and modelled manually as a bone graft, was a useful, cheap, natural, and easy technique to repair the calvarium following MVD surgery. We described the in situ cranioplasty technique in 2016 (5).

■ RESULTS

Of the 63 patients, 38 were female and 25 were male. The mean age was 48.6 years old (ranging from 23 to 81) in females and 50.8 years old in males (ranging from 26 to 85) (Table II). A total of 58 patients with sharp, stabbing, electrical pain were considered as having typical trigeminal neuralgia (TN), while 5

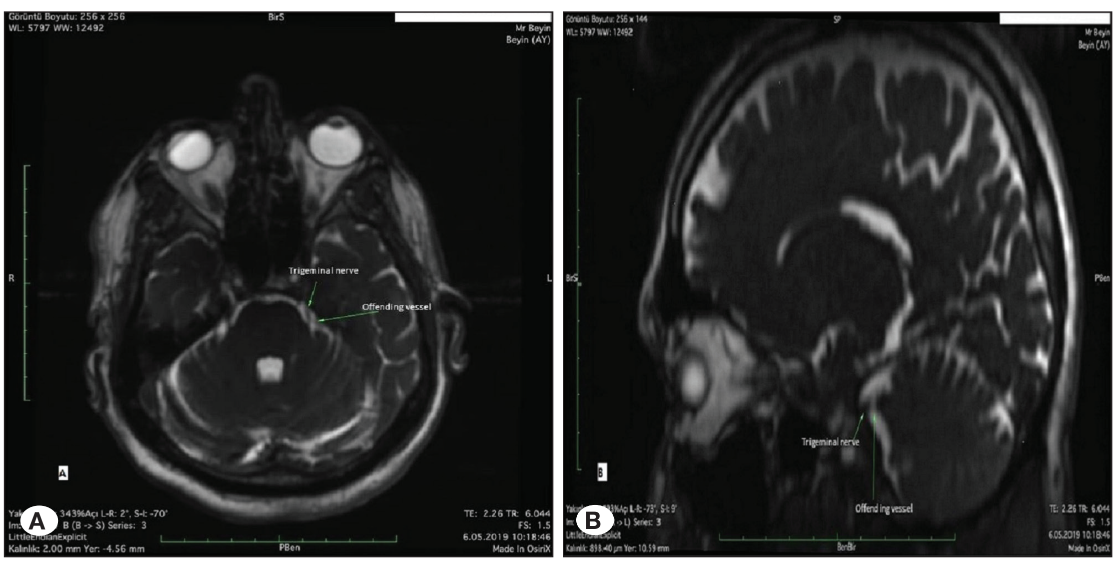

Figure 1: T2W MRI in axial **(A)** and sagittal **(B)** plane shows neurovascular conflict on left side (short arrow: trigeminal nerve, long arrow: offending vessel).

patients with less intense, constant, dull or burning pain were considered as having atypical TN. Pain was felt on the right side in 36 patients (57%) and on the left side in 27 patients (43%). The patients' preoperative painful periods ranged from 1 to 30 years, with an average of 6 years. Pain was in V1 in one patient, V2 in one patient, V1-2 in one patient, V3 in 5 patients, V2-3 in 50 patients, and in the V1-2-3 branches of the trigeminal nerve in 5 patients.

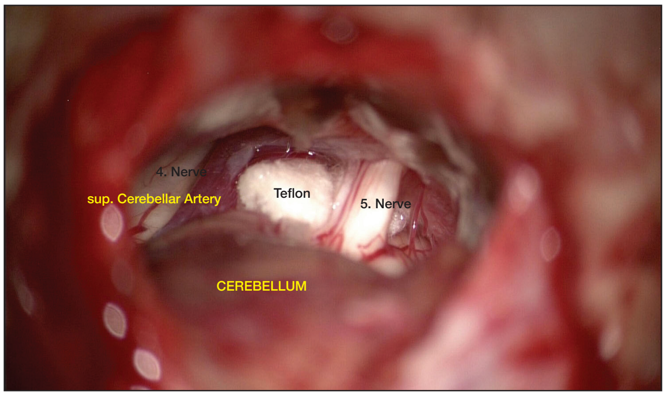

Figure 2: Intraoperative photograph shows trigeminal nerve (5. nerve), superior cerebellar artery as the offending vessel and the teflon felt between them.

Table II: Demographic Characteristics of Patients

Gender	Number of patients	Age
Female	38	48.6 (range 23-81)
Male	25	50.8 (range 26-85)
Total	63	50.1 (range 23-85)

Table III: Pain Properties

Trigeminal neuralgia	Number of patients
Typical	58 (92.1%)
Atypical	5 (7.9%)
Side of pain	**Number of patients**
Right	36 (57%)
Left	27 (43%)

Number of patients according to the affected branch of trigeminal nerve

V1	V2	V3	V1-2	V2-3	V1-2-3
1	1	5	1	50	5

Number of patients according to the offending vessel

SCA	AICA	BA	VA	AICA, SCA	VA, SCA, SPV	SCA, SPV	venous structure alone
32	1	1	1	2	1	7	14
Artery					Artery and Vein Combination		
37					8		

During surgery, neurovascular conflict was observed as arterial alone in 37 patients, venous structure alone in 14 patients, and both the artery and vein in 8 patients. In 4 cases, there was no neurovascular conflict. Vascular compression on the trigeminal nerve was: the anterior inferior cerebellar artery (AICA) in one patient, basilar artery (BA) in one patient, AICA and superior cerebellar artery (SCA) in two patients, SCA alone in 32 patients, vertebral artery (VA) in one patient, and a combination of SCA and venous structure in 7 cases (Table III). In one patient who had pain in all branches of the trigeminal nerve (V1-2-3), there was fusiform aneurysmatic dilatation, which causes compression on 7^{th} and 8^{th} cranial nerve and SCA compression on the trigeminal nerve. The most common cause of neurovascular conflict was the SCA, and the most common painful region was the V2-3 branches of the trigeminal nerve.

All patients suffered from severe pain despite medical treatment prior to surgery. Despite using at least two combined medications at a maximum dosage for an optimum period, almost all patients had ongoing pain. Surgical or ablation techniques had been previously applied in 18 (28.5%) patients. One patient had multiple sclerosis and 19 (30.1%) patients had hypertension.

Patients were questioned regarding the severity of their pain during the first month of the postoperative period, which is accepted as the early period, and after the first month, which is accepted as the long-term follow-up.

During the early postoperative period, the pain severity in 8 patients partially decreased but there were no changes in 2 patients. A total of 53 patients said their pain completely ended, but all of these patients were still receiving at least a single medication.

During the long-term follow-up, 9 patients who had no pain during the early postoperative period said that their pain started again but more mildly as compared with the status prior to surgery. In this group, one patient with atypical pain had been completely pain-free following the surgery, while the other patient with atypical pain did not benefit from the operation. The other three patients mentioned that they rarely felt short-term blunt pain only in the surgical area. During the long-term follow-up, the onset of pain ranged from 1 to 14 months. In one patient, the pain began 5 years after the operation.

Thus, 84% of patients were completely pain-free during the early postoperative period, while 16% still have ongoing pain with reduced severity. In 2 patients (3.1%), there was no change in the severity of pain. During the long-term follow-up, the pain-free status rate was 69.8% (Tables IV, V).

Three patients had cerebrospinal fluid (CSF) leakage. In two patients, surgery was not needed, while CSF fistula was repaired in one patient. One patient was re-operated on due to flap disposition. Wound infection, facial paralysis/ paraesthesia, hearing loss, seizure, delirium, transient ischaemic attack, epidural/subdural/intracranial haemorrhage, encephalomalacia, cortex damage, cardiac or respiratory problems, or death did not occur in any patient (Table VI).

The 2 patients who did not benefit from the operation during the early postoperative period were both female. The patients' painful zone was the V2-3 branch of the trigeminal nerve and neither had any complications. One had right-sided typical pain and SCA compression on the trigeminal nerve near the pons, and the other had left-sided atypical pain and vein compression was present.

During the early postoperative period, 3 of the 8 patients who partially benefited from surgery without a completely pain-free condition were those whom had complications (37.5%). One patient was re-operated on due to CSF leakage and the other due to flap disposition. In the third case of CSF leakage in the patient with multiple sclerosis, the leakage disappeared without surgery. Neurovascular conflict was seen in 7 of these: 3 had venous compression, the other 3 had SCA compression, and one had SCA and SPV compression on the trigeminal nerve.

In 9 patients who had been pain-free during the early postoperative period but had pain again during the long-term follow-up, there were no complications except for one (11.1%) who had CSF leakage. Five of the 9 patients had SCA compression, one had venous compression, and two had SCA and venous compression on the trigeminal nerve. There was no compressive anatomical structure in the remaining patient but there was a history of surgery due to a parotid tumour. The average duration of illness was 7 years (ranging from 1 to 15 years), and the average age was 63.8 years old, which was above the overall average. Four patients had hypertension, one had atypical pain, and one had had a previous Gamma Knife procedure (Table VII).

Table IV: Post-Operative Pain Condition

Early period		Long term follow-up	
Pain free	**Not pain free**	**Pain free**	**Not pain free**
53 (84%)	10 (16%)	44 (69.8%)	19 (30.2%)

Table V: In Long Term Fallow-Up, Barrow Neurological Institute (BNI) Pain Intensity Scale Score

BNI Score	Number of patients
I	44 (69.8%)
II	8 (12.6%)
III	5 (7.9%)
IV	4 (6.3%)
V	2 (3.1%)

Table VI: Surgical Complications

BOS leakage	**3 (4.7%)**
Flap disposition	1 (1.6%)
Wound Infection	None
Facial Paralysis/Paresthesia	None
Hearing Loss	None
Seizure, Delirium	None
Transient ischemic attack /stroke	None
Death	None

DISCUSSION

TN is a chronic syndrome characterised by intense intermittent facial pain that ruins daily life. Washing the face, shaving, chewing, or any other tactile stimulation, even talking in some patients, can trigger pain attacks. Although the primary treatment for TN is medication therapy, most patients become refractory, at which point, MVD is the most effective treatment. Pain relief following surgery depends on many factors such as age, accompanying diseases, and neurovascular conflict, but mostly on surgical technique. Primarily, eligible patients should be chosen for MVD; those with neurovascular conflict and typical pain are more suitable for surgery. MRI is helpful for determining neurovascular conflict, with a positive predicting value of 95%. In some cases, MRI shows bilateral conflict: on the symptomatic side 89% and on the asymptomatic side 78%, but the most important is the painful side of the patient (8,12). In a large study reported by Tyler–Kabara et al., the rate of complete pain relief following MVD in typical TN was

Table VII: Comparison of the Patients with Pain Recurrence Who was Pain-Free in Early Postoperative Period (A) with the General Patient Group (G)

	Mean age (years)	Duration of illness (mean year)	Hypertension (%)	Early procedures (%)	SCA compression (%)
A	63.8	7	44.4	11.1	55.5
G	50.1	6	30.1	28.5	50.8

84.1% and pain control after surgery was 98.2%. These rates were recorded as 46.9% and 86.6%, respectively, in atypical TN. Surgical outcomes suggest that patients with typical TN benefit from MVD surgery more than those with atypical TN (10,15,16,19).

Besides MRI, exploration during surgery is valuable in determining the conflicting structure. While the common cause of neurovascular conflict is SCA, there are also accompanying venous structures in most cases. In an anatomical-surgical study by Dumot and Sindou in 326 patients who underwent MVD, 124 patients (38%) had venous conflict; alone in 29 (8.9%) and in conjunction with an artery in 95 (29.1%). Offending venous structures were divided into two groups: superficial and deep superior petrosal venous systems (sSPVS and dSPVS). It was reported that arterial compression is well established, but the role of the veins remains under discussion. Coagulation-division was performed on offending venous structures in 36.8%, and cleavage was carried out in the remaining patients. Sacrification was only performed for one of the affluent SPVs, and the trunk was preserved. Overall in their series, one or more veins were sacrificed in 56 patients (45.2%). Venous neurovascular conflict rates vary from 11.8% to 91.7% in the literature. Anatomical variation of veins is more common, such that it is easy to miss an offending vein and trigeminal root next to the porus if not examined carefully during surgery. Authors recommend avoiding sacrification of an affluent SPV, but it is complicated to identify the branches of SPVs during surgery in a limited time period. Moreover, not recognising a venous conflict ends with an inadequate decompression and recurrence, and once a conflicting venous structure is caught, a neurosurgeon should search the area carefully for more (3).

In some series, especially in the case of venous compression, the recurrence of pain seems to be more frequent due to disregard of the offending venous vessel, which ends up with inadequate decompression (9,11,13). In our series, during the early period, 5 of 10 patients who did not fully recover from pain, and 3 of 9 patients whose pain recurred during the late period, had accompanying venous compression. However, it was reported in a series by Zhong et al., that if the cause of the compression is a large vein and it is the only vein that drains into the petrous sinus, it should be preserved, otherwise it can cause death (21). According to Dumot et al., sSPVS should be preserved to avoid cerebellar swelling and infarction, with exploration of the trigeminal root being recommended by passing through the SPV, limiting sacrification to one affluent SPV (3).

When patients were questioned regarding their recurrent pain type, they described a neuralgiform pain like the TN pain they used to have, not a new kind such as benign intracranial hypertension or other pain types.

In addition to vascular compression, in diseases such as multiple sclerosis (MS), demyelination of the trigeminal nerve can result in TN. In patients with MS, the TN incidence rate is 2–4% and the disease can be partially refractory to all procedures (18). We also describe a case of MS with partially decreased postoperative pain that increased again during the late period. In a review by Ariai et al., it was reported that success of MVD surgery in TN patients with MS is lower than that in the idiopathic group. Patients who recovered from pain during the early period following surgery developed pain again during the late period (1). Although the surgical success rates vary according to the center, Nunta–Aree et al., reported that during the early postoperative period, the pain-free rate was 67.3%, while during the following two years, it became 61.5%. According to our results, the pain-free rate was 84% during the early period and 69.8% during the late period. It has been noted that pain in atypical TN cases is partly more robust. Complications of MVD surgery are hearing loss, facial hypoesthesia, facial paralysis, temporary ataxia, central nervous system infections, wound infections, cerebral haemorrhage, CSF leakage, or death. The most common complications are temporary facial hypoesthesia, CSF leakage, and wound infections (14,20). The complication rate in our series was 6.3%, and the most common complication was CSF leakage, which recovered without surgery in 2 of 3 cases. The success rate that we achieved correlates with other reports in the literature, and no serious complications or death were seen.

In our series, with the exception of one case, the SPV was sacrificed and no complications were seen as a result. With a limited time period during surgery, it is important to achieve a full decompression. Venous structures mostly go unnoticed, since the SPV trigeminal region cannot be scanned well; thus, we generally sacrifice SPV in all patients as our special technique. However, more experience is needed for better results.

■ CONCLUSION

MVD is the most effective method in appropriate cases for the treatment of TN. Besides careful preoperative evaluation, the most important issue that decides surgical achievement is the surgical technique and the experience of the neurosurgical team. In the present review, we claim that SPV sacrification can be performed in most cases and is not related to gross complications; therefore, venous sacrification is not associated with pain recurrence. Further studies are needed to better assess surgical approaches in TN.

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