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Original Article

Microvascular decompression for primary trigeminal neuralgia with the 3/4 circumferential expanded polytetrafluoroethylene (ePTFE) sleeve technique

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ABSTRACT

Background: Microvascular decompression (MVD) using Teflon or Ivalon is the surgeon's preference for treating trigeminal neuralgia (Tn). Still, sometimes the prosthetic material is unavailable, or there is some recurrence of pain during the follow-up. In this case series, we report the outcome analysis for MVD using the expanded polytetrafluoroethylene (ePTFE) sleeve technique in classic Tn.

Methods: We conducted a retrospective analysis of patients with Tn from January 2017 to March 2022. Classic or primary Tn was considered a direct compression by a cerebrovascular structure in the posterior fossa, detected by magnetic resonance imaging or direct surgical visualization. Pre- and postoperative Barrow Neurological Institute Pain Intensity Scale (BNI-SI) and Barrow Neurological Institute Hypoesthesia Scale (BNI-HS) were used for the clinical results assessment of the ePTFE sleeve circumferential technique.

Results: There were nine patients approached with the 3/4 circumferential ePTFE sleeve technique with BNI-SI IV (n: 11, 58%) and BNI-SI V (n: 8, 42%). In all patients, there was a clinical improvement after the surgical treatment ($P < 0.001$). All patients obtained BNI-SI ≤ IIIa in an average follow-up of 11.89 (±14.137), with a slight improvement in BNI-HS (P: 0.157). In our revision, this technique has not previously been described for Tn.

Conclusion: The circumferential ePTFE sleeve technique is a good option for MVD in Tn. For classic Tn, MVD could remain the first option, and this technique could be applied for multi-vessel compression.

Keywords: Classic trigeminal neuralgia, Expanded polytetrafluoroethylene sleeve technique, Microvascular decompression, (ePTFE)

INTRODUCTION

The International Classification of Headache Disorders defines trigeminal neuralgia (Tn) as severe paroxysmal pain in the territory of the trigeminal nerve triggered by a stimulus,[21] mainly by a mechanical precipitant.[33] In order of frequency, the types of Tn are classic or primary, secondary, and idiopathic. The first one is primarily caused by arterial vascular compression over the nerve at the level of the Root Entry Zone (REZ) or Transition Zone (TZ).[8,11,14,18] Treatment modalities for this pathology vary.[5,14] Since the first descriptions[15-17] added to popularization

with Jannetta,[23] microvascular decompression (MVD) has been the standardized treatment for Tn. Several techniques involve the placement of Ivalon and Teflon prosthetic materials, which are the most commonly used materials for MVD. They are associated with 12% and 19% recurrence rates, respectively,[27] and are associated with some complications.[1,7] Expanded polytetrafluoroethylene (ePTFE) is a graft mainly used by vascular surgeons; its benefits remain inert and biocompatible. Regarding neurosurgical applicability, we analyzed in our institution that it has some benefits for MVD that could be used for hemifacial spasms.[6] For this aim study, we decided to describe the experience during the last years with the ePTFE sleeve technique for Tn since there are no previous descriptions of its clinical reliability for this pathology.

MATERIALS AND METHODS

This is a retrospective study from January 2017 to December 2022 conducted at "Hospital Juárez de México." This study was under the approval of the Research and Ethical Committee. Inclusion criteria were patients with age >18 years and availability, with clinical diagnosis with classic Tn (Direct compression by a vascular structure evidenced by magnetic resonance imaging [MRI]), elective surgical decompression involves patients with 3/4 circumferential ePTFE sleeve technique corroborated with the surgical record. Patients who had undergone previous surgeries or had ePTFE or Teflon combined with other prosthetic materials, incomplete data files, and follow-up of <3 Months were excluded from the study. Our clinical database shows a total of 47 patients that were operated for MVD under the diagnosis of Tn. The postoperative note was reviewed for the main criteria selection: classic Tn (*n*: 19), which involved vascular compression of the trigeminal nerve described in the operative note. Surgical criteria for each patient were applied using the 3/4 circumferential ePTFE sleeve technique and Teflon prosthetic material.

Medical records include evaluations of facial pain using the modified Barrow Neurological Institute Pain Intensity Scale (BNI-SI). This last scale was divided with Barrow Neurological Institute (BNI) III, in IIIa and IIIb. Improvement was considered at the postoperative evaluation with BNI ≤IIIb. Each obtained score was compared between two groups (ePTFE and Teflon). Evaluation of hypoesthesia was assessed concerning Barrow Neurological Institute for Hypesthesia Assessment (BNI-HS); in cases there was any severity of the hypesthesia referred from the patient related to each group (ePTFE sleeve and Teflon). These patients' follow-ups were at least 3 months from surgery.

Data analysis was performed using the Statistical Package for the Social Sciences Statistics 27.0 (IBM) for MacOS. The analytic statistic was conducted using non-parametric and parametric tests for the association depending on the variable. Significance was considered <0.005. Both groups were compared with the surgery after the placement of each prosthetic material (3/4 circumferential ePTFE sleeve and Teflon technique).

Barrow Neurological Institute Pain Intensity Scale (BNI-SI)

It was created to assess clinical results for stereotactic functional radiosurgery for this pathology.[28] It has been standardized for assessment of the severity in clinical pathology related to the trigeminal nerve and for MVD.[22,29,31] The modified BNI pain intensity scale, grade III, is divided into IIIa; without pain with medication, and IIIb; the presence of pain controlled with medication[31,39] [Table 1]. The improvement was determined if point out the score ≤IIIb for both groups. Each group (Teflon and ePTFE) was compared to the score obtained with BNI-SI.

Barrow Neurological Scale for hypoesthesia (BNI-SH)

It implemented by the same institution for the treatment of Tn, defined as a result of new sensory deficits (numbness, burning sensations, and dysesthesias) after radiosurgery.[19,39] The evaluation was performed using BNI-SH in that surgical manipulation during surgery could compromise the trigeminal nerve[31] [Table 2]. Each group (ePTFE sleeve and Teflon) was compared to the preoperative and postoperative scores.

Surgical technique with ePTFE sleeve technique

Patients were positioned in Park Bench with the previous placement of a Mayfield head holder and assisted with neuromonitoring. Curvilinear incision, retrosigmoid craniotomy, and aperture dura mater were performed in a usual fashion. After completion,

Table 1: Barrow Neurological Institute pain intensity scale.

Score	Definition
I	No facial pain, no medication
II	Occasional facial pain, no medication
III	No facial pain; continued medication
IIIa	Facial pain is adequately controlled with medication
IIIb	Facial pain is not adequately controlled with medication.
IV	Facial pain is not adequately controlled with medication.
V	Severe facial pain without relief

Table 2: Barrow Neurological Institute Hypesthesia Scale.

Score	Definition
I	No facial numbness
II	Mild facial numbness that is not bothersome
III	Somewhat bothersome facial numbness
IV	Very bothersome facial numbness

the arachnoid membrane was dissected, and the trigeminal nerve was visualized. Here, decompression was performed depending on the site of compression, from REZ, TZ, or cisternal portion. The superior petrosal vein (SPV) was preserved to reduce related complications.[26] ePTFE, IMPRA®, Tempe, Arizona, US placement was cut out depending on decompressing the trigeminal nerve surface. The disposal was suitable for decompression, as we previously described in a patient with hemifacial spasm[6], as a sleeve overlying the nerve with a circumferential 3/4 ePTFE and folded ePTFE sleeve, isolating it from the vascular structures [Figures 1 and 2].

RESULTS

Demographic data

In total, 19 patients were surgically intervened for classic Tn MVD. Of the 19 patients, ten were operated using Teflon, and nine were managed with ePTFE for vascular decompression. MRI detected the vascular compression and was corroborated by the revision of the operative note. The patients (*n*: 19) were women (73.7%, *n*: 14) and men (26.3%, *n*: 5), with an average age of 54.74 years old. The predominance side was on the right side (68.4%), with high blood pressure in 36.8% of the population from several years before Tn clinical manifestations. Of all patients were operated on under BNI-SI IV (58%, *n* = 11) and BNI-SI V (42%, *n* = 8), with BNI-SH I (31.6%, *n*: 6), BNI-SH II (47.4%, *n*: 9), and BNI-SH III (21.1%, *n*: 4). The majority conflict vessels encountered was superior cerebellar artery (52.6%), anteroinferior cerebellar artery (15.8%), and SPV (15.8%) [Table 3].

Barrow Neurological Institute-scale for pain intensity (BNI-SI)

The overall postoperative outcomes for the ePTFE group (*n*: 9) were BNI-SI I (44.4%, *n*: 4) and BNI-SI IIIa (55.6%, *n*: 5), obtaining all patients with BNI-SI ≤IIIa. In the Teflon group, 30% obtained BNI-SI I, 10% BNI-SI II, BNI-SI IIIa (30%), BNI-SI IIIb (20%), and one patient improved until recurred at 4 months with BNI-SI V [Figure 3].

The mean follow-up for ePTFE patients was 11.89 months (±14.137), and the Teflon group was 17.7 (±17.205) months, without difference in each group ($P = 0.129$). In both groups, surgical treatment was effective ($P < 0.001$), and no differences between postoperative groups (*P*: 0.316) with respect to BNI-SI were found [Table 3 and Figure 4]. Re-intervention was applied to one patient in the Teflon group, operated on with bad pain control years before, establishing BNI in the same pain intensity.

Barrow Neurological Institute for hyposthesia scale (BNI-HS)

For hypoesthesia, after the surgical procedure, the ePTFE group 56% (*n*: 5) maintained BNI-HS I with slight improvement

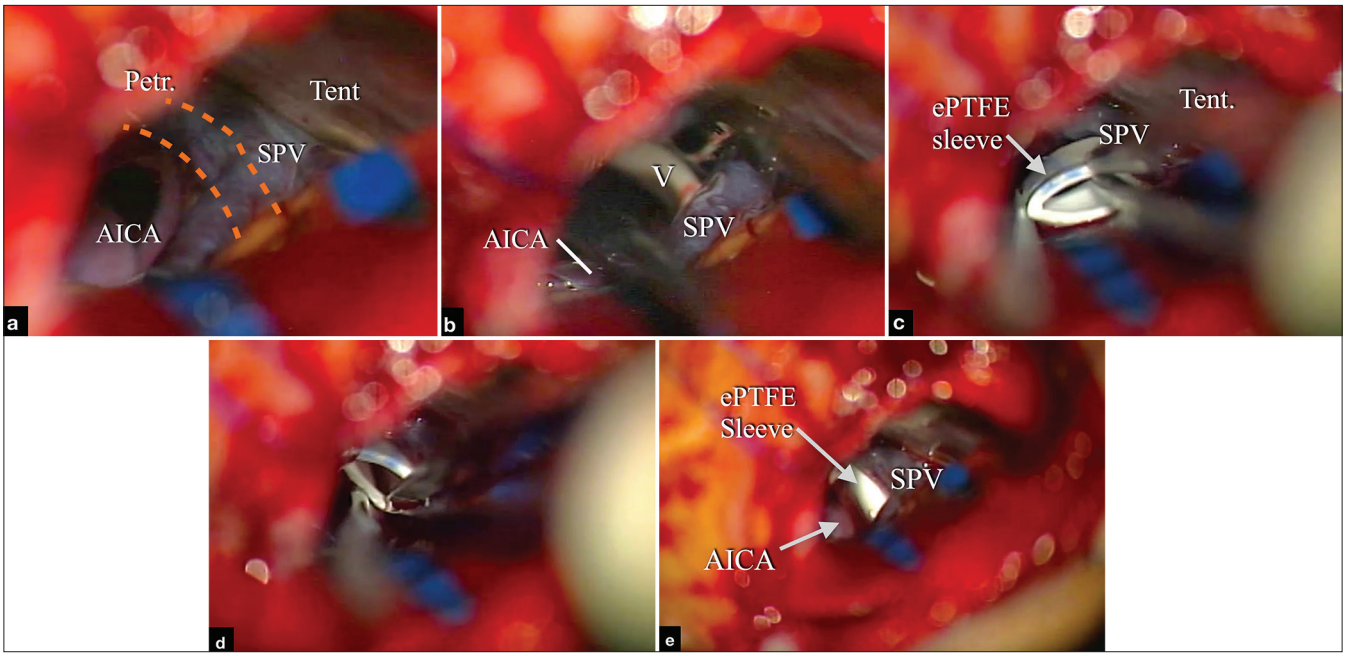

Figure 1: After performing the left retro sigmoid approach, (a) the AICA and SPV rostral branch was compressing the trigeminal nerve (orange dotted lines mark trigeminal nerve course). (b) Arachnoid dissection around the nerve was mandatory for prosthetic material placement. (c) Introduction in a folded manner, (d) starting from the inferior portion between AICA-Nerve, and (e) followed by SPV-Nerve until completed the placement of it. (AICA: Anteroinferior cerebellar artery, SPV: Superior petrosal vein). ePTFE : Expanded polytetrafluoroethylene.

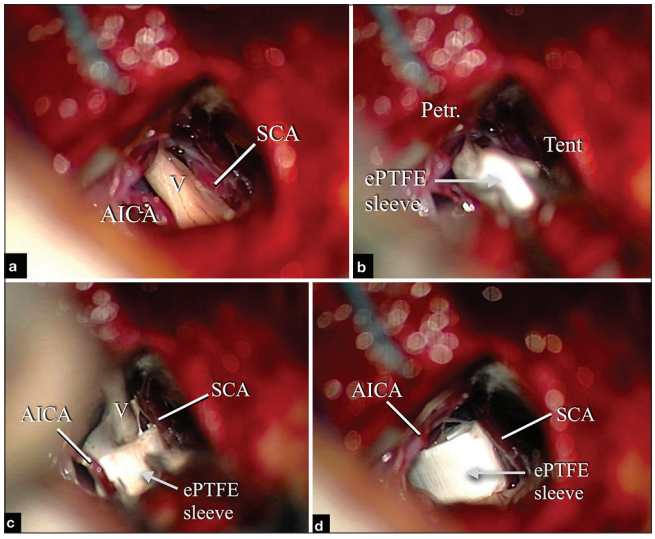

Figure 2: In this figure, (a) after completing the left retro sigmoid approach with a slight release of arachnoid adhesions, we found double compression by SCA and AICA. (b) Introduction in a folded way to place the prosthetic material, (c) followed by surrounding the trigeminal nerve, keeping a side AICA, and (d) followed by SCA for completion of the sleeve. In this case, the source of compression was SCA and AICA. An expanded polytetrafluoroethylene sleeve was placed between the arteries. SCA: Superior cerebellar artery, AICA: Anteroinferior cerebellar artery. ePTFE : Expanded polytetrafluoroethylene.

obtained in BNI-HS. Concerning the Teflon group, an increased majority stayed BNI grade I (60%) and BNI grade II (30%) [Figure 5]. In both groups (ePTFE and Teflon), proportions between pre and post were similar. Notwithstanding the group treated with ePTFE, there was a significant difference (*P*: 0.034) between pre- and post-surgical treatment than the Teflon group (*P*: 0.157) [Table 3 and Figure 6].

DISCUSSION

This study describes the clinical results with pre-established scales in patients with classic Tn using the 3/4 circumferential ePTFE sleeve technique for MVD, which was not previously described in the literature. Patients were separated into two groups, in which ePTFE or Teflon prosthetic materials were used; clinical outcomes were assessed concerning BNI-SI and BNI-HS.

Classic Tn is a pathology caused secondary to an irritation of the V cranial nerve by a vascular structure. The first descriptions were by Gardner and Dandy;[15-17] with the improvement of Jannetta,[23] MVD has been the indicative treatment for this pathology.

Tn tends to affect the population from around the 4th to 5th decade of life, with predominance on the right side,[35,36] consistent with our findings. Common pattern distribution

Table 3: Characteristics of patients with the use of ePTFE sleeve and teflon techniques.

	ePTFE sleeve MVD (*n*: 9)	Teflon MVD (*n*: 10)	Total (*n*: 19) (%)	*P*-value
SCA	4	6	10 (52.6)	*P*: 3.462
AICA	1	2	3 (15.8)	
SPV	2	1	3 (15.8)	
AICA+SPV	1	0	1 (5.26)	
SCA+SPV	0	1	1 (5.26)	
SCA+AICA	1	0	1 (5.26)	
Follow-up (months)	11.89 (±14.137)	17.7 (±17.205)	14.95 (±15.675)	
BNI-SI Postop				
I	4	3	7 (36.8)	*P*: 6.141
II	0	1	1 (5.3)	
IIIa	5	3	8 (42.1)	
IIIb	0	2	2 (10.5)	
V	0	1	1 (5.3)	
BNI-SI Preop				
IV	5	6	11 (57.9)	*P*: 0.038
V	4	4	8 (42.1)	
BNI-SH Preop				
I	2	4	6 (31.6)	*P*: 1.785
II	4	5	9 (47.4)	
III	3	1	4 (21.1)	
BNI-SH Postop				
I	5	6	11 (57.9)	*P*: 1.568
II	4	3	7 (36.8)	
III	0	1	1 (5.3)	

ePTFE: Expanded polytetrafluoroethylene, MVD: Microvascular decompression, SCA: Superior cerebellar artery, AICA: Anteroinferior cerebellar artery, SPV: Superior petrosal vein, BNI-SH: Barrow neurological scale for hypoesthesia

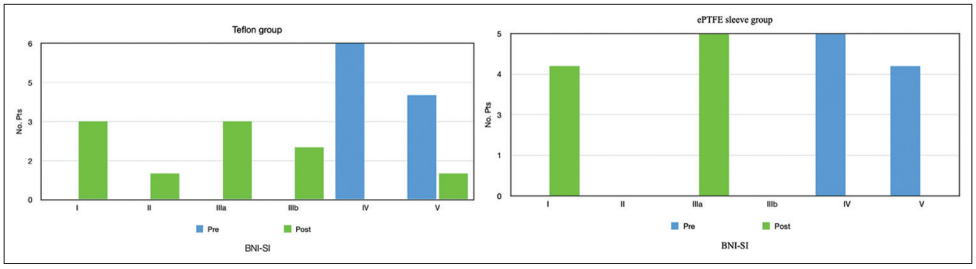

Figure 3: Distribution of patients preoperative and postoperative for Teflon and Expanded polytetrafluoroethylene sleeve in relation to Barrow Neurological Institute Pain Intensity Scale (BNI-SI).

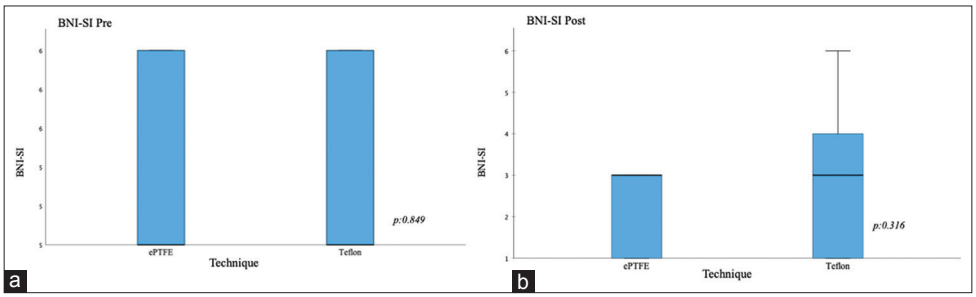

Figure 4: Graphic representation. Barrow Neurological Institute Pain Intensity Scale (BNI-SI) (a) Preoperative and (b) postoperative distribution of patients using expanded polytetrafluoroethylene and Teflon with no significant differences.

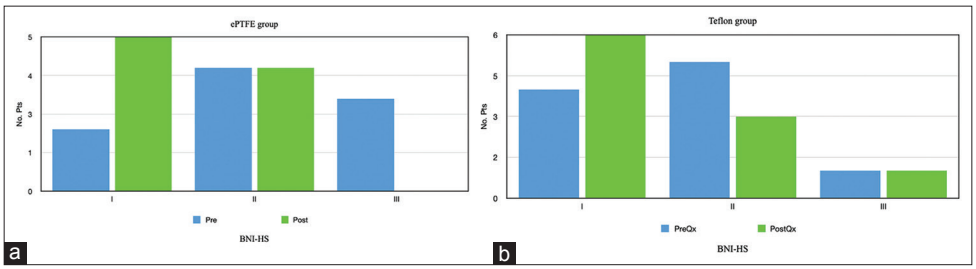

Figure 5: Barrow Neurological Institute for hyposthesia scale (BNI-HS) graphic representation of the distribution of patients (a) preoperative and (b) postoperative with the use of expanded polytetrafluoroethylene sleeve and Teflon.

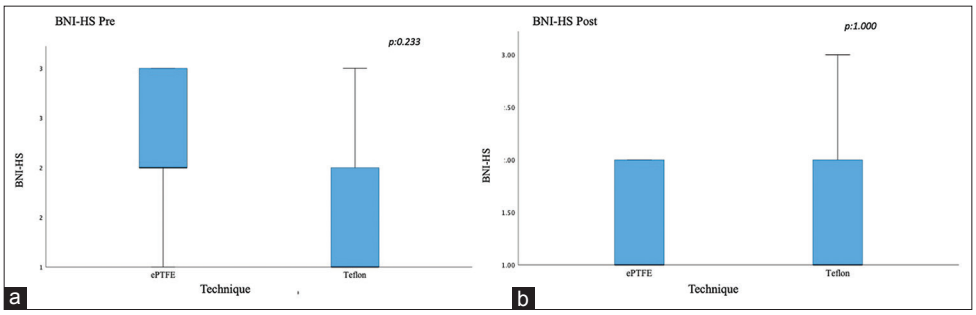

Figure 6: Graphic representation, Barrow Neurological Institute for hyposthesia scale (BNI-HS) pre- and postoperative after (a) Teflon and (b) expanded polytetrafluoroethylene group.

for this pathology involves V2–V3 (42%) and V2 (20%). In our series, V1–V2–V3 was the most common pain distribution up to 47.4%, which, in other series, was only 5%.[5,14]

We generally start with medical management, but in some cases, radiofrequency or Gamma Knife therapy may be necessary.[14] Notwithstanding, the control rate is poor, and

medical treatment over time tends to be related to a less successful control rate of pain over time.[25] Therefore, for classic Tn, MVD could be considered the first choice when there is evidence of direct vascular compression over the nerve.[4] This could be related to the patient's preference for a permanent cure for this pathology.[9] Around 91.8% of patients after immediate postoperative have partial or complete relief (BNI I-III).[38] The overall control rate of pain after MVD depends on the long-term evolution,[2] in which many cases relapse <2 years,[38] and is merely dependent on the time.[20] Descriptions mention that free pain follow-up at 1 year was 78.95% with BNI I and BNI score II with 93.75%.[40] The follow-up patients were at least 3 months, with an average of 11.89 months for ePTFE and 17.7 months for the Teflon group, obtaining only one patient with recurrence in this last group. It could be related to the severity of vascular compression and the direct evidence of vascular conflict, which could directly influence the overall clinical outcomes regarding a good response. Associative factors have been described for high recurrence as atypical neuralgia, non-arterial compression, female sex, and symptoms >8 years.[10] For this study, it was only considered a direct vascular compression, given that the benefit of MVD will be better. Occasionally, venous compression is influenced as a factor for recurrence;[3,34] in our series, we did not find any recurrence with the ePTFE sleeve technique, as another series commented that recurrence in the venous group is lower than in the arterial group.[32]

Several prosthetic materials were previously described in the literature as Ivalon, cotton, and muscle. Regarding availability, Teflon for MVD has been seen as the common prosthesis material in neurosurgical centers.[7] This material is ideal due to its low complication potential [10,13], with a success rate from 57% to 100% for Tn.[27] Inconvenient that there may be a recurrence with this material, and re-exploration of this patient may be associated with some complications.[24] Sometimes mixed vascular compression creates issues in separating and placing prosthetic material,[10] which could challenge it. The advantage of the ePTFE sleeve is that during 3/4 wrapping of the nerve isolates it from the adjacent vascular structures, reducing the sticking point from the vessels. The properties of the ePFTE sleeve in a circumferential manner could create enough decompression without damaging the nerve. This tenet has been described and sustained in a previous research article for hemifacial spasm.[6]

For the assessment of manipulation of the trigeminal nerve,[31] in terms of placement of prosthetic material, BNI-HS was added for a better understanding of the prosthesis material disposal. No sensitivity compromise was encountered after MVD in both groups; hence, the ePTFE sleeve technique has no compromise with the trigeminal nerve regarding the sensitive affection.

Properties with the use of ePTFE are the semi-elasticity and semi-rigidity that we found, and that causes a little radial force around the verve surrounding it from the adjacent vascular structures.[6] Clinical results were satisfactory for both Tn groups (Teflon and ePTFE). Patients were operated on with BNI IV and V with ePTFE, obtaining BNI grade I in 44.4% and BNI IIIa in 55.6%. Comparison between each group at the postoperative, there were no differences between each group. Tn has some clinical manifestations that can affect the patient's quality of life if it is not treated promptly.[5] With the previously described, the ePFTE sleeve technique could be used safely for MVD with good clinical outcomes. For this technique, a gentle microsurgical manipulation is mandatory for the placement of the prosthetic material in a circumferential manner.

Longer follow-up of the patients with the 3/4 circumferential ePTFE sleeve technique is required, and a prospective study is needed to validate the feasibility of this technique in comparison to the use of Teflon. In the ePTFE sleeve group, there were no surgical complications. However, there may be some risks associated such as fibrosis, granuloma formation, or hardening of the prosthetic material, as reported for Teflon prosthetic material.[12,30,37]

This study broadens the outlook for managing neurovascular pathology compression with the ePTFE sleeve technique as a useful prosthetic material for classic Tn and hemifacial spasm.[6]

CONCLUSION

Clinical results based on BNI-SI after trigeminal microvascular compression surgery using ePTFE were adequate and optimal, with similar postoperative clinical results as the Teflon group for classic Tn. The ePTFE sleeve technique is a reliable technique that could be applied to classic Tn, and it is equitable with the Teflon conventional technique.

Ethical approval

The Institutional Review Board has approved this study. The register and approval number is HJM 034/22R. The date of approval is June, 10, 2023.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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