УДК 616.833.15-009.7 DOI: 10.18699/SSMJ20240517

Оригинальное исследование / Research article

Predictors of successful microvascular decompression surgery in patients with classical trigeminal neuralgia according to the neuroimaging data

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Abstract

Trigeminal neuralgia presents significant challenges in neurosurgery, with patients responding variably to Microvascular Decompression (MVD). Advanced neuroimaging techniques, specifically MRI using the Constructive Interference in Steady State (CISS) sequence and Diffusion Tensor Imaging (DTI), have emerged as promising tools in predicting the outcomes of MVD. Aim of the study was to determine neuroimaging predictors of successful microvascular decompression surgery in patients with classical trigeminal neuralgia. **Material and methods.** This retrospective study analyzed 58 patients who underwent microvascular decompression for classical trigeminal neuralgia at the Federal Neurosurgical Center in Novosibirsk, Russia, between January 2017 and December 2021. Outcomes were assessed by the Barrow Neurological Institution (BNI) scale. Preoperative neuroimaging with CISS and DTI was used to evaluate neurovascular conflict severity, nerve diffusion and other criteria. **Results.** 79.3 % (BNI I & II) of patients were practically free of pain postoperatively, in which 65.5 % (BNI I) had successfully completely recovered from the procedure with no pain, and 13.8 % (BNI II) had a good outcome. And the study found a significant correlation between favorable MVD outcomes and higher Sindou grades 2 and 3, indicating more severe neurovascular conflict ($p < 0.001$). Also significant differences were observed in outcomes based on fractional anisotropy values on symptomatic nerve ($p = 0.029$). **Discussion**. Anatomical factors which measured by MRI had limited impact on outcomes, while Sindou grading showed a significant correlation with surgical outcomes, and higher fractional anisotropy values were associated with poorer outcomes. **Conclusions.** The investigation of neuroimaging predictors for MVD surgery outcomes in patients with trigeminal neuralgia, received from CISS-sequence imaging and pre-treatment DTI, indicates the importance of estimation of severity of vascular compression in surgical planning and the predictive value of fractional anisotropy values from DTI for preoperative assessments.

Key words: trigeminal neuralgia, microvascular decompression, neuroimaging, Sindou classification, neurovascular conflict.

Conflict of interest. The authors declare no conflict of interest.

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Citation: Alzeeralhouseini A.F., Moisak G.I., Filimonova E.A., Rzaev J.A. Predictors of successful microvascular decompression surgery in patients with classical trigeminal neuralgia according to the neuroimaging data. *Sibirskij nauchnyj medicinskij zhurnal = Siberian Scientific Medical Journal.* 2024;44(5):145–154. [In Russian]. doi: 10.18699/SSMJ20240517

Предикторы успешной операции микроваскулярной декомпрессии у пациентов с классической невралгией тройничного нерва по данным нейровизуализации

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Резюме

Тригеминальная невралгия представляет значительные трудности в нейрохирургии, при этом пациенты поразному реагируют на микроваскулярную декомпрессию (МВД). Современные методы нейровизуализации, в частности МРТ с использованием последовательности constructive interference in steady state (CISS) и diffusion tensor imaging (DTI), стали перспективными инструментами для прогнозирования исходов МВД. Целью исследования было определить нейровизуализационные предикторы успешной МВД у пациентов с классической невралгией тройничного нерва. **Материал и методы.** В данном ретроспективном исследовании проанализировано 58 пациентов, перенесших МВД по поводу классической невралгии тройничного нерва в Федеральном нейрохирургическом центре (Новосибирск, Россия) в период с января 2017 г. по декабрь 2021 г. Исходы оценивались по шкале интенсивности тригеминальной боли Института неврологии Бэрроу (Barrow Neurological Institute (BNI) score for trigeminal neuralgia). Для оценки выраженности нейроваскулярного конфликта, диффузии нервов и других параметров использовалась дооперационная нейровизуализация с CISS и DTI. **Результаты.** 79,3 % (BNI I и II) пациентов практически не испытывали боли после операции, из них 65,5 % (BNI I) успешно полностью восстановились после процедуры без боли, а 13,8 % (BNI II) имели хороший исход. В ходе исследования выявлена значительная корреляция между благоприятными исходами МВД и более высокими оценками 2 и 3 по шкале Sindou, что свидетельствует о более тяжелом нейроваскулярном конфликте ($p < 0,001$). Также значимые различия наблюдались в исходах в зависимости от значений фракционной анизотропии на симптомном нерве ($p = 0,029$). **Обсуждение.** Анатомические факторы, измеренные с помощью МРТ, имели ограниченное влияние на исходы, в то время как градация по шкале Sindou показала значительную корреляцию с хирургическими исходами, а более высокие значения фракционной анизотропии были связаны с худшими исходами. **Заключение.** Изучение нейровизуализационных предикторов исходов операции МВД у пациентов с невралгией тройничного нерва, полученных на основе CISS-последовательности визуализации и DTI до лечения, свидетельствует о важности оценки тяжести сосудистой компрессии при планировании хирургического вмешательства и прогностической ценности значений фракционной анизотропии по данным DTI для предоперационной оценки.

Ключевые слова: тригеминальная невралгия, микроваскулярная декомпрессия, нейровизуализация, шкала Sindou, нейроваскулярный конфликт.

Конфликт интересов. Авторы заявляют об отсутствии конфликта интересов.

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Для цитирования: Алзиралхусейни А.Ф., Мойсак Г.И., Филимонова Е.А., Рзаев Д.А. Предикторы успешной операции микроваскулярной декомпрессии у пациентов с классической невралгией тройничного нерва по данным нейровизуализации. *Сибирский научный медицинский журнал*. 2024;44(5):145–154. doi: doi: 10.18699/SSMJ20240517

Introduction

Decision-making on the type of surgical intervention for trigeminal neuralgia (TN) is currently based not only on clinical data and characteristics of neurological manifestations, but also definitely on neuroimaging data. The classical trigeminal neuralgia is treated by performing Microvascular Decompression (MVD) implying that the cause is compression of the nerve by an adjacent vessel. However, it still remains debatable what factors, features and signs can be predictors of good outcomes in this surgery. The significance of identifying patients likely to benefit from MVD, as emphasized by Y. Zhang et al. [1], is underscored by the need for high-fidelity data from advanced MRI techniques for accurate predictions of nerve-blood vessel conflicts [2]. Prior research demonstrates that sophisticated imaging methods can forecast MVD surgery outcomes, potentially preventing further procedures and enhancing quality of life [3–5]. According to L. Amaya Pascasio et al. [6] the variability in patient`s responses to MVD highlights the complexity of TN treatment, pointing to a possible gap in understanding the neuroanatomical aspects of the trigeminal nerve.

The aim of this study is to seek out the predictors of successful microvascular decompression surgery in patients with classical trigeminal neuralgia using the preoperative neuroimaging pictures, addressing the knowledge gap in the neuroanatomical relationship of the trigeminal nerve.

Material and methods

At the Federal Neurosurgical Center in Novosibirsk, Russia, a retrospective study was conducted on a group of 208 patients who underwent MVD for TN between January 2017 and December 2021. This study included a diverse mix of 121 arterial compression cases, 26 cases of pure venous compression and 61 cases of mixed compression cases. Of these, a specific subset of 58 TN patients (27.8 % of the total) who had the results of both MRI sequences, the diffusion tensor imaging (DTI) and the constructive interference in steady state (CISS) sequence and undergone MVD surgery was closely examined.

Inclusion criteria: all ages; all genders; presence of clear neurovascular compression as shown by MRI; diagnosis of classical TN due to arterial, pure venous, or mixed compression; the first-time MVD; history of TN, paroxysmal and constant pain. Exclusion criteria: previous MVD surgery; secondary TN, attributed to tumors, multiple sclerosis, or vascular malformations; no evidence of vascular compression.

Parameters of MRI sequences: MRI sequences, leveraging both 1.5 T and 3 T MRI units, encompass a variety of sequences such as 3D turbo field echo (TFE), 3D turbo spin echo (TSE), 2D TSE, 3D SE, CISS, and 3D echo planar imaging (EPI) tailored for T1-weighted imaging (T1WI), T2-weighted imaging (T2WI), fluid-attenuated inversion recovery (FLAIR), 3D time of flight (TOF), and DTI. These sequences are carefully chosen to maximize the efficiency of neurovascular conflicts and trigeminal nerve morphology recognition, important for the preoperative assessment in the treatment of TN (tab. 1).

In this study, two primary neuroimaging techniques were employed for a detailed evaluation of 58 cases of TN, focusing on the symptomatic trigeminal nerve prior to surgery:

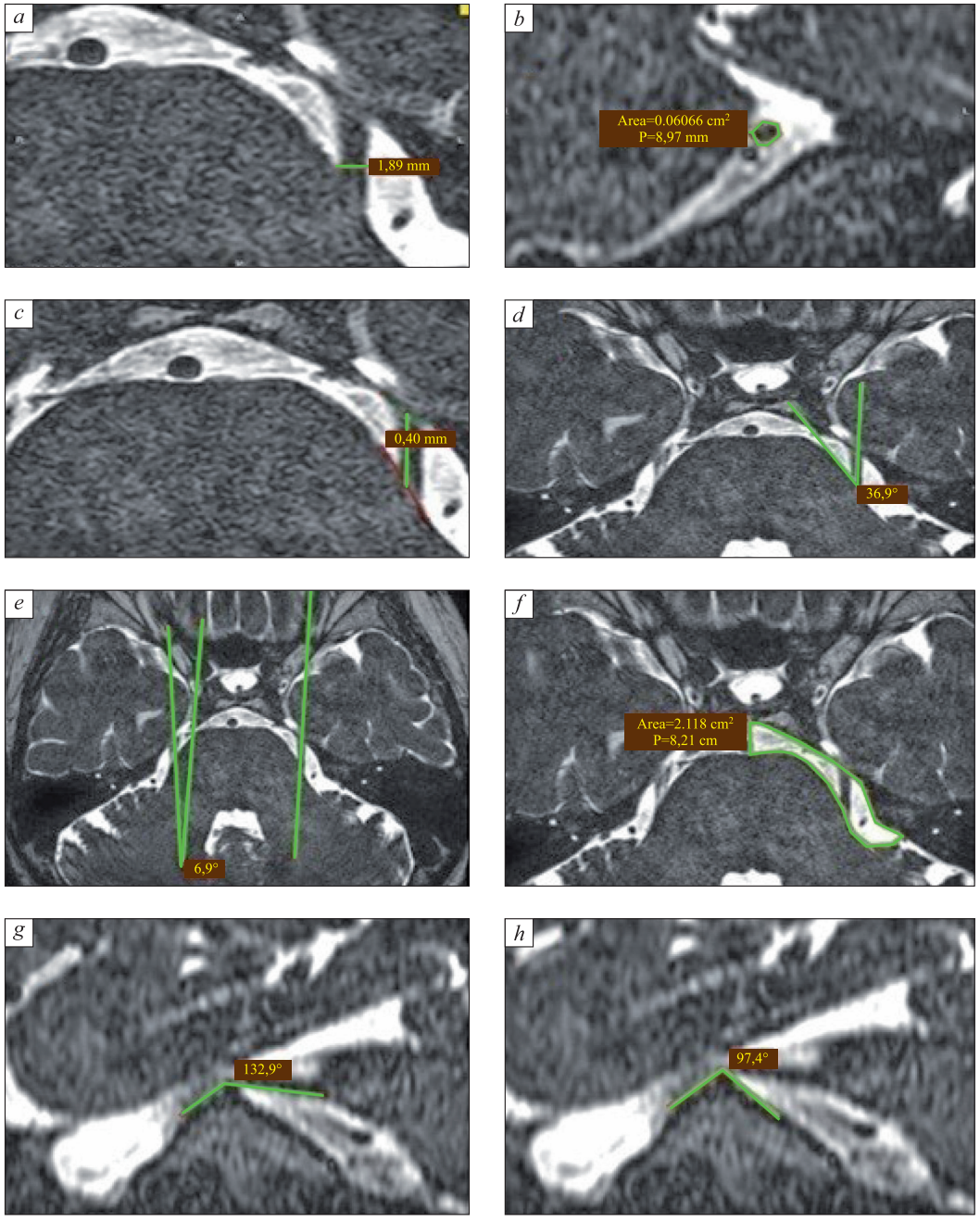
1. MRI with the CISS sequence (the initial method applied) – the technique is particularly effective for obtaining detailed images of cerebrospinal fluid and surrounding tissues. It played a crucial role in identifying issues with the trigeminal nerve and distinguishing between arterial and venous compressions. Possible predictors such as the (root diameter, root area, root length, trigeminal pontine angle, inter-trigeminal angle, prepontine cistern area, sagittal angle, and petrous ridge angle) were assessed and measured in accordance with the MRI CISS sequence in axial, sagittal, and coronal view [7–14] (figure).

2. Diffusion tensor imaging (DTI) was used for examination of TN microstructure. DTI is a type of MRI-based technique that maps and characterizes the three-dimensional diffusion of water as a function of

Table 1. *MRI data from the 1.5 T (Avanto, Siemens, FRG) and 3.0 T system (Ingenia, Philips, Netherlands)*

Таблица 1. *Данные МРТ, полученные с помощью систем 1,5 Т (Avanto, Siemens, ФРГ) и 3,0 Т (Ingenia, Philips, Нидерланды)*

	T1WI	T2WI	FLAIR	3D TOF	CISS	DTI
1.5 T system						
Sequence type	3D TFE	3D TSE	2D TSE	3D SE	3D TSE	3D EPI
TR, ms	1650	5000	7500	25	1200	2700
TE, ms	3	91	92	7	263	94
Flip angle	15	150	150	25	150	90
Matrix	256×192	384×261	256×224	256×241	320×324	128×128
FOV, mm	187×250	208×229	201×230	180×180	200×200	1150×1150
Slice thickness, mm	1	5	5	0.93	0.6	2
Number of slices	176	25	25	146	72	260
3.0 T system						
Sequence type	3D TFE	3D TSE	2D TSE	3D SE	3D TSE	3D EPI
TR, ms	6.6	3000	11000	23	1500	8513
TE, ms	3	80	125	3.5	180	89.4
Flip angle	8	90	90	18	90	90
Matrix	240×240	420×344	352×211	500×333	352×350	112×109
FOV, mm	240	230	230	200	170	224
Slice thickness, mm	1	4	4	1.2	0.8	2
Number of slices	192	28	28	140	55	9158



Measurement of the TN root diameter (axial view) (a), of the TN root area (sagittal view) (b), of the TN root length the pons until the entrance of the Meckel cave (axial view) (c), of the trigeminal pontine angle between the TN root and anterior surface of the pons (axial view) (d), of the inter-trigeminal angle (axial view) (e), of the cross-sectional area of cerebellopontine angle cistern (axial view) (f), of the sagittal angle of the trigeminal nerve at the porus trigeminus (sagittal view) (g), of the angle of the petrous ridge (sagittal view) (h)

Измерение диаметра корешка ТН (аксиальный вид) (a), площади корешка ТН (сагиттальный вид) (b), длины корешка ТН от Варолиева моста до входа в пещеру Меккеля (аксиальный вид) (c), угла между корешком ТН и передней поверхностью Варолиева моста (аксиальный вид) (d), межтригеминального угла (аксиальный вид) (e), площади поперечного сечения цистерны мостомозжечкового угла (аксиальный вид) (f), сагиттального угла тройничного нерва у porus trigeminus (сагиттальный вид) (g), угла каменистого гребеня (сагиттальный вид) (h)

spatial location. It is particularly useful in assessing the integrity of white matter tracts in the brain.

Neurovascular conflict (NVC) severity in TN was graded in accordance with the Sindou grading system, as previously described (P.R. Leal et al.) [15]: grade 1, simple contact; grade 2, a displaced or distorted nerve; and grade 3, marked indentation of the nerve root. The Sindou grade represents an

objective measure of NVC severity, which is essential for an analysis of the potential correlation between NVC grade and surgical outcomes.

DTI data processing was performed using the FMRIB Software Library (FSL) (https://fsl.fmrib.ox.ac.uk/fsl/fslwiki/) after converting DICOM files to the NIfTI format. First, artifact correction (motion and eddy current) was performed. The individual mean fractional anisotropy (FA), axial diffusivity (AD), radial diffusivity (RD), and mean diffusivity (MD) maps for each patient was calculated with DTIFIT (https://fsl.fmrib.ox.ac.uk/fsl/fslwiki/FDT/UserGuide). After that, the diffusivity measurements were performed manually in ImageJ software (https://imagej.net/ij/) by placing small size round-shaped Region of Interest (ROI) at the site of trigeminal nerve root.

Subjective clinical outcomes were analyzed using the Barrow Neurological Institution (BNI) Pain Intensity Scale [16] in two categories: a favorable outcome of BNI I and II represented successful treatment of TN symptoms following MVD surgery; an unfavorable outcome was represented by BNI III, IV, and V, representing the failure of the surgical treatment.

The statistical analysis for this study was meticulously designed to assess the relationship between various factors and the outcomes of MVD surgery. Fisher's exact test was used to examine the relationship between the Sindou grading of trigeminal neuralgia and the outcomes of MVD surgery; continuous variables were examined in detail for variances in the distribution using the non-parametric test called Mann-Whitney U Test. This approach was employed to evaluate the distribution of various parameters, including FA of symptomatic (lesioned), age, gender, side of the face affected, type of trigeminal neuralgia, duration of pain, and several anatomical factors delineated by the CISS MRI sequence: root diameter, root length, trigeminal pontine angle, inter-trigeminal angle, sagittal angle, petrous ridge angle, prepontine cistern area, and the root area, across two independent groups. Logistic regression analysis was done to estimate the contribution of demographic, clinical and neuroimaging variables to the prediction of BNI outcomes. Chi-squared test was used to determine the statistical significance of individual predictors.

Results

This study analyzed demographic profiles of 58 patients undergoing MVD for TN, focusing on age, gender, affected side, pain type, neurovascular compression, affected branch, and symptom duration. The cohort predominantly consisted of females (65.5 %), with ages ranging from 36 to 82 years (average 59.34 years). Most patients (81 %) experienced paroxysmal pain, with 60.3 % suffering from right-sided TN, particularly affecting the V2-V3 nerve divisions (25.6 %). Symptoms lasted between 1 to 44 years, averaging at 9.73 years. Despite the comprehensive demographic analysis, no significant correlation was found between these variables and the success of MVD surgery, as indicated by p-values over 0.05, suggesting these factors do not predict surgical outcomes (tab. 2).

During the 1 to 5-year follow-up, the 58 patients studied showed promising pain management post-MVD for trigeminal neuralgia, with an average follow-up duration of 3.55 years. A significant 46 (79.3 %) of patients achieved pain relief, with 65.5 % experiencing complete pain relief (BNI I) and 13.8 % reporting mild pain without the need for medication (BNI II). However, 12 (20.7 %) did not see satisfactory results (BNI III – 7 cases, BNI IV – 3 cases, BNI V – 2 cases).

The NVC severity in TN was rated using the Sindou grading system which defined the degree of conflict in 58 patients as follows: 25 instances in Grade One, 15 in Grade Two, and 18 in Grade Three. A critical analysis of our findings reveals a statistically significant correlation between the Sindou grade and MVD outcomes. Patients classified under Sindou grades 2 and 3 experienced markedly more favorable outcome, with a higher incidence of BNI I and II results (n = 32), compared to those classified under Sindou grade 1 (n = 14) (unfavorable outcome, BNI III, IV,V – 1 and 11 cases, respectively). This distinction underscores the effectiveness of MVD in patients with more severe NVC, as indicated by

Table 2. *Demographic information about the patients (n = 58)*

Таблица 2. *Демографическая информация о пациентах (n = 58)*

Age at MVD	36 to 82 years (mean: 59.34 years)
Gender	38 women, 20 men
Affected side	Right – 35, left – 23
Paroxysmal and continuous pain of TN	Paroxysmal – 47, continuous – 11
Affected branch	V2 – 14, V3 – 8, V2-V3 – 15, V1-V2 – 8, V1-V3 – 11
Pain duration	1 to 44 years (mean: 9.73 years)

Note: V1 – the first division of TN, V2 – the second division of the trigeminal nerve, V3 – the third division of the trigeminal nerve

higher Sindou grades, highlighting the grade's utility as a prognostic indicator for surgical success. The statistical significance of this correlation, supported by a p value of less than 0.001 obtained through Fisher's exact test, reinforces the predictive value of the Sindou grading system in surgical planning and patient counseling.

This comprehensive analysis underscores the Sindou grade as a crucial predictor of MVD surgery success, delineating its significance in preoperative evaluations and suggesting that the severity of NVC plays a critical role in determining postoperative outcomes. Furthermore, our study delved into the relationship between FA values in the symptomatic nerve and the outcomes of MVD surgery. We discovered that higher median FA values are associated with poorer MVD outcomes, specifically categorized as BNI III, IV, and V (0.308) compared to favorable outcome (BNI I, II) (0.227) ($p = 0.029$).

The investigation into various anatomical factors measured by the CISS MRI sequence such as root diameter, root length, trigeminal pontine angle, inter-trigeminal angle, sagittal angle, petrous ridge angle, prepontine cistern area, and the root area did not find any statistically significant differences in influencing microvascular decompression (MVD) outcomes. This analysis was conducted to discern the significance of these factors between the outcomes categorized as BNI I and II versus BNI III, IV, and V. However, these elements exhibited p values more than 0.05, indicating their limited predictive value regarding surgical success. Thus, while extensive, the investigation across both symptomatic nerves, as well as the range of anatomical measurements provided by the CISS MRI sequence, underscores that these factors do not significantly affect the efficacy of MVD in treating trigeminal neuralgia, guiding future research to focus on more indicative predictors of surgical outcome. These data underscore the pivotal role of preoperative imaging in optimizing the management and surgical outcomes for patients with TN. Specifically the study illuminates the impact of NVC severity, classified by the Sindou grade, and FA values on the efficacy of MVD surgery based on imaging findings.

Logistic regression and the chi-square test highlighted the Sindou grading system as a crucial predictor. A higher Sindou score correlated with more successful outcomes ($p = 0.035$), emphasizing its importance in surgical planning and predicting MVD success.

Discussion

Analysis of neuroimaging anatomical predictors for MVD outcomes in classical trigeminal neuralgia: This study examined Sindou grading, FA values, and other factors to predict MVD surgery outcomes in TN. In our study using the CISS MRI sequence, we examined various anatomical factors including root dimensions and angles. These parameters have been extensively documented in previous academic literature, according to H. Pang et al., a sharper trigeminal-pontine angle may worsen nerve degeneration in trigeminal neuralgia [7]. M. Parise et al. noted that smaller cerebellopontine angle cistern area and short trigeminal nerve length affect neurovascular conflict in trigeminal neuralgia and could impact treatment outcomes [8]. P.P. Suthar et al. found a correlation between the trigeminal nerve's sagittal angle and neurovascular conflict grade, potentially influencing treatment outcomes [12]. Finally, A. Brinzeu et al. discussed how the acute angle of the petrous ridge and the trigeminal nerve's angulation contribute to trigeminal neuralgia pathogenesis and treatment success [14]. Our study did not reveal significant variations in these anatomical variables' impact on microvascular decompression results for trigeminal neuralgia patients.

Value of pre-surgical CISS sequence imaging for assessing TN compression

The relationship between Sindou grades, indicating the severity of NVC, and the outcomes of MVD surgery in patients with TN is a pivotal aspect of contemporary neurosurgical research. Our study's findings, which suggest that higher Sindou grades are associated with better outcomes of MVD in TN, offer a nuanced perspective that both aligns and contrasts with existing literature on the subject. This discussion seeks to compare our results with those of previous studies. M. Sindou et al. established a foundational understanding of the impact of compression severity and the presence of focal arachnoiditis on MVD success rates. Their findings underscore the significance of anatomical considerations, showing that higher severity of compression correlates with better treatment outcomes [23]. This aligns with our observations, reinforcing the notion that the degree of NVC plays a crucial role in predicting MVD efficacy. M. Sindou et al. study also noted the negative impact of focal arachnoiditis, a factor not directly addressed in our study but important for a comprehensive understanding of surgical outcomes [23]. The findings of R. Loayza et al. further support our results, indicating that patients with severe NVC (grade 2–3) experience better surgical outcomes [21]. This direct correlation between NVC severity and post-MVD improvement is a key component of our study's conclusions, offering additional evidence that more pronounced neurovascular conflict facilitates a

more definitive surgical intervention and subsequent relief.

Conversely, P.R. Leal et al. present an intriguing counterpoint to our findings. They reported that higher grades of NVC severity, especially Grade III with clear-cut and marked indentation on the root, could lead to worse outcomes. This discrepancy raises important considerations about the potential for certain types of severe compression to pose challenges to successful decompression, possibly due to more complex surgical requirements or the extent of nerve damage [15]. Our study, focusing on the general trend of higher Sindou grades leading to better outcomes, may need to further delineate the nuances of NVC characteristics that influence surgical success.

M.A. Hughes et al. and F.A. Hardaway et al. both highlighted the predictive value of severe NVC for excellent surgical outcomes, echoing the general sentiment of our findings. M.A. Hughes et al. revealed that severe NVC greatly increases the likelihood of being pain-free post-MVD. F.A. Hardaway et al. associated higher scores in a prognostic scoring system, indicative of severe NVC, with better pain relief outcomes [24, 25]. These studies collectively underscore the utility of preoperative NVC assessment in forecasting MVD success, aligning closely with our observation that higher Sindou grades, which denote more severe compression, are predictive of favorable surgical outcomes.

The study by A.S.S. Andersen et al. adds another layer of complexity by emphasizing the role of NVC with morphological changes in predicting better surgical outcomes [22]. While this study does not directly contradict our findings, it suggests that the specific nature of NVC, beyond its severity, plays a critical role in determining the effectiveness of MVD. This points need for further research to understand how different characteristics of NVC, including but not limited to its severity as classified by Sindou grades, influence MVD outcomes.

Our study's assertion that higher Sindou grades lead to better MVD outcomes in TN patients finds substantial support in the broader body of literature, particularly in studies emphasizing the importance of NVC severity. However, the nuanced discrepancies and additional factors highlighted by other research underscore the complexity of predicting MVD success and the multifaceted nature of TN pathology. These findings collectively advocate for a more detailed preoperative evaluation of NVC characteristics, including Sindou grades, to refine surgical strategies and optimize patient outcomes in the treatment of trigeminal neuralgia.

Predictive accuracy of preoperative DTI imaging metrics for classical TN treatment outcomes

The exploration of the relationship between FA values and outcomes following MVD surgery for TN presents a compelling avenue for understanding the nuances of neurosurgical prognosis and patient management. Our investigation into the significance of higher FA values correlating with poorer outcomes, juxtaposed against the non-significant results associated with lower FA values for better outcomes, adds a nuanced layer to the current understanding of MVD efficacy.

This finding, supported by a p value of 0.029, introduces FA as a significant predictor of surgical outcomes. It suggests that elevated FA values are potentially indicating the preservation of the microstructural changes of the nerve. We suppose that it can be in situation when the development of TN is not associated with the influence of vascular compression, and it can be related to other reasons of pain. This assumption also took into consideration that low efficiency of the surgery was observed with a mild degree of nerve compression when nerve structure probably was not damaged. The preservation of the microstructure of the nerve may be associated with a lower likelihood of achieving favorable outcomes post-MVD because vascular compression can be not relevant to the pathogenesis of TN development in this group of patients. In the same key, the high effectiveness of surgery after elimination of the severe degree of compression with low FA values probably confirms the vascular compression as a main factor in pathogenesis of the development of TN in this cohort of patients.

Incorporating FA measurements into diagnostic protocols can enhance predictive accuracy of surgical outcomes and help clinicians develop more tailored treatment strategies. Future research should further explore the mechanisms underlying these correlations and investigate additional imaging and anatomical factors that could refine surgical candidacy and outcome predictions. This discussion aims to contextualize our findings within the broader spectrum of existing literature, especially focusing on the studies [17–20], to elucidate the complexities and potential prognostic implications of FA values in TN patients undergoing MVD. F. Chen et al. highlight the predictive value of declining FA proportions in determining the success of MVD in patients with type 2 trigeminal neuralgia, suggesting that a significant reduction in FA is indicative of favorable surgical outcomes [17]. This assertion is supported by W. Chai et al., who observed that lower pre-surgical FA values were associated with better post-surgical outcomes, as evidenced by

improved FA ratios on follow-up MRI scans [18]. Similarly, Y. Wang et al. found decreased FA values in the affected side of trigeminal neuralgia patients, indicating microstructural changes that could reflect axonal demyelination or neuro-inflammation, with a postoperative recovery in FA values associating with a potential improvement in surgical outcomes [19].

Our study's observation of higher FA values correlating with worse outcomes introduces an interest in the interpretation of FA as a prognostic marker and emphasized of the complexity of trigeminal neuralgia pathology and the multifactorial nature of MVD outcomes. M.S. Willsey et al. contribute to this discussion by noting that lower FA values in the trigeminal nerve root in TN1 patients might be indicative of a better prognosis post-surgery, emphasizing the variability in FA's prognostic value depending on the TN subtype [20].

The potential association between lower FA values and higher grades of neurovascular compression, as posited in some literature, could serve as a bridge between our findings and those of previous studies. If lower FA is indeed linked with more severe neurovascular conflict, this could explain the improved outcomes following MVD, as more severe cases of compression are likely to have a more pronounced surgical relief post-decompression. This theory aligns with the findings of R. Loayza et al. and A.S.S. Andersen et al., who both emphasize the importance of neurovascular conflict severity in predicting MVD success [21, 22].

Our findings push us to take into account broader consideration of patient-specific factors, including the extent and nature of neurovascular compression, the presence of demyelination, and the surgical technique employed. It underscores the importance of a tailored approach to MVD, where preoperative FA values, alongside comprehensive neuroimaging and clinical assessment, guide surgical planning and prognostication. This fact underscores the need for further research to explore the intricacies of FA as a prognostic tool in MVD in conjunction with other clinical, anatomical and pathophysiological factors. Such investigations should aim to elucidate the underlying mechanisms that govern the relationship between FA values and surgical outcomes, potentially paving the way for more nuanced and patient-specific approaches to the management of trigeminal neuralgia.

It's obvious that the differences between 1.5 T and 3 T MRI scanners play a crucial role in obtaining detailed high-resolution images for diagnosing neurovascular issues in trigeminal neuralgia patients. The use of 3D sequences in various modalities enhances anatomical imaging, aiding in the detection of vessel abnormalities and nerve problems. Including DTI evaluations at both field strengths is essential for assessing nerve integrity before surgery. These careful imaging choices aim to maximize the diagnostic potential of MRI for predicting surgical outcomes with microvascular decompression.

Conclusions

This study examines the predictors of successful microvascular decompression surgery in patients with classical trigeminal neuralgia using the preoperative neuroimaging pictures, in particular the predictive capabilities of pre-treatment diffusivity patterns and CISS-sequence imaging for MVD surgery outcomes in patients with TN. The significance of Sindou grading in surgical planning and the predictive value of FA values derived from DTI in enhancing preoperative evaluations were emphasized. Sindou grading assesses NVC severity, while FA values provide insights into the trigeminal nerve's microstructural integrity can indicate surgical outcomes. Considering these two criteria improves surgical decision-making and opens avenues for future research to refine diagnostic criteria and treatment planning for TN. The study underscores the potential of advanced neuroimaging techniques in improving patient care and quality of life.

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Поступила в редакцию 29.04.2024
После доработки 23.07.2024
Принята к публикации 27.08.2024

Received 29.04.2024
Revision received 23.07.2024
Accepted 27.08.2024