Microvascular Decompression Versus Less-Invasive Interventions for Primary Trigeminal Neuralgia : A Systematic Review and Meta-Analysis

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ABSTRACT

Introduction
The widely accepted treatment of primary trigeminal neuralgia (PTN) is microvascular decompression of the trigeminal nerve root, although other less-invasive interventions are available. We aim to comprehensively compare the efficacy of MVD as well as the proportions of procedure failure, reoperation, and complications to less-invasive procedures.

Methods
A literature search was conducted from February to May 2023 in accordance with PRISMA recommendations using PubMed, Medline, and Scopus to identify studies comparing MVD to other interventions for PTN. Interventions included for meta-analysis were percutaneous balloon microcompression (PBC), radiofrequency rhizotomy (RFR), and stereotactic radiosurgery (SRS). All subjects were diagnosed with primary trigeminal neuralgia and were surgically naive. The Barrow Neurological Institute (BNI) Pain Intensity Score was used to determine procedure success or failure. Demographic information, reported complications, and re-operation were also recorded. Outcomes were reported as single means and proportions which were meta-analyzed and compared at a 95% confidence interval.

Results
Seventeen studies were included for analysis with a total of 2756 patients. Pain relief was greatest in MVD and PBC. Procedure failure was lowest in MVD and PBC. The proportion of post-operative complications was greater following MVD compared to both RFR and SRS but less than that of PBC. Although the complications reported after MVD carry the highest morbidity.

Conclusions
The authors conclude that patients undergoing MVD or PBC were more likely to experience a successful outcome than patients undergoing RFR or SRS. Efficacy of MVD supports literature proposing neurovascular compression as etiology of primary trigeminal neuralgia. However, the equally high efficacy of PBC suggests that it should be considered as an initial treatment option for patients with trigeminal neuralgia. PBC has a less severe complication profile while being less expensive and less invasive.

Keywords: Trigeminal Neuralgia, Tic Douloureux, Microvascular Decompression, Stereotactic Radiosurgery, Percutaneous Balloon Microcompression, Radiofrequency Rhizotomy

INTRODUCTION

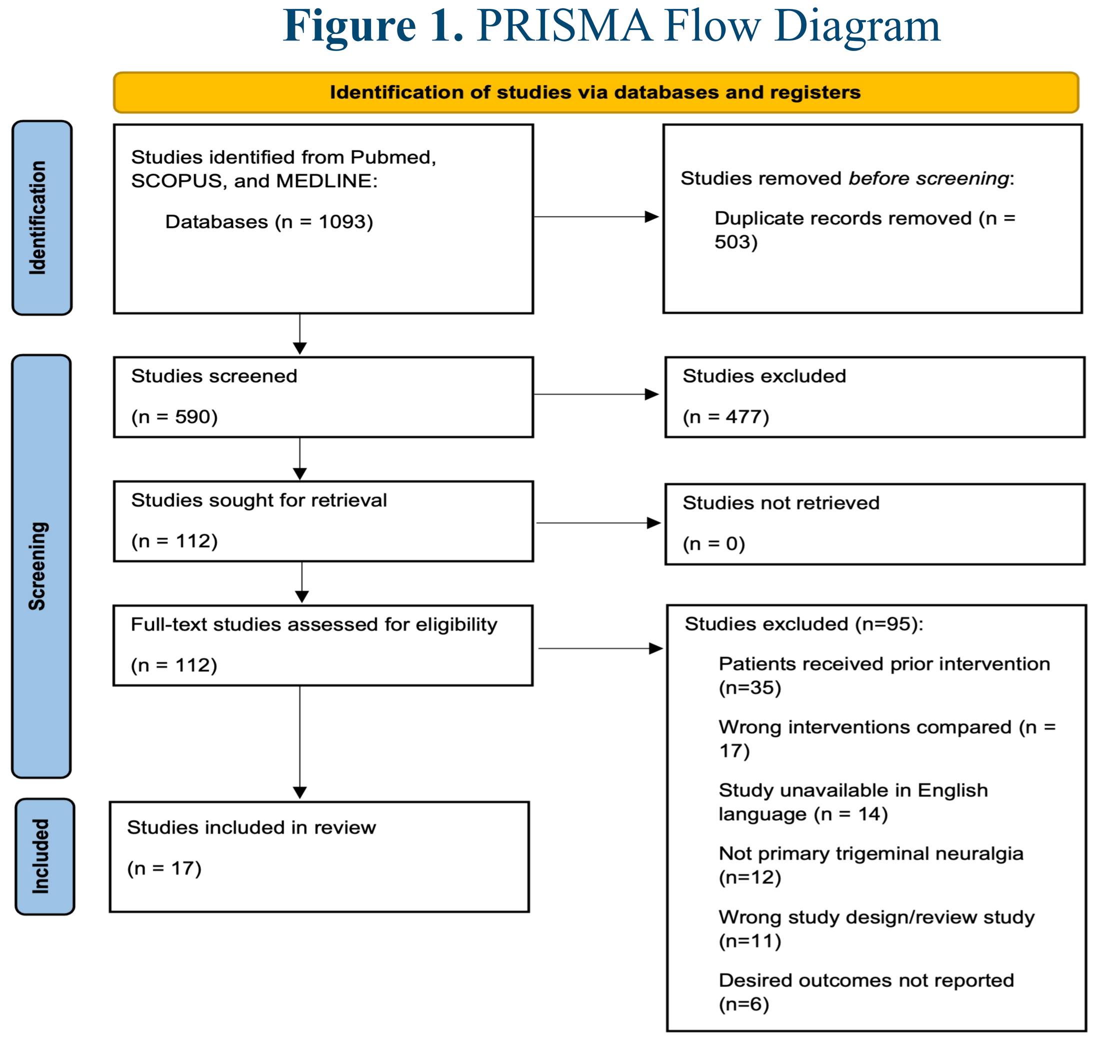
Trigeminal neuralgia (TN), also known as tic douloureux, is characterized by recurrent, short-lasting episodes of extreme pain in the distribution of the fifth cranial nerve.[1] The pain quality is described as sharp, stabbing, shooting, or electric shock-like. Pain is often triggered by activities of daily living such as talking, chewing, and eating or specific movement, most commonly gently touching the face.[1] Poor quality of life and increased incidence of suicide is described in these patients.[2] TN is a rare condition with an overall prevalence of <0.1% of the general population with a significant female predominance.[3] Primary trigeminal neuralgia (PTN) excludes etiologies of multiple sclerosis, brainstem lesions, or mass lesion.

The proposed etiology of PTN is neurovascular compression of the trigeminal nerve root by an aberrant arterial or venous loop.[8] First line medical therapy for TN is carbamazepine and oxcarbazepine - anti-epileptic drugs that block voltage gated sodium channels.[7] There is converging evidence that the pain is caused by demyelination of the trigeminal sensory fibers in the nerve root.[9] In patients that either fail or are intolerant to medical therapy - surgical options are available.

Microvascular decompression, first proposed in 1965 by Dr. Peter Janetta, is the first-line option for medically refractory trigeminal neuralgia in patients that have neurovascular compression confirmed by imaging and can tolerate major surgery.[8] Other, less invasive options are available such as percutaneous ganglion lesions, percutaneous balloon microcompression, or stereotactic radiosurgery. Efficacy of microvascular decompression of the affected trigeminal nerve branch likely confirms an etiology of neurovascular decompression. However, this etiology is debated.

Given that microvascular decompression is invasive and requires craniotomy, we aim to analyze the efficacy and complications of MVD as compared to less-invasive procedures for the treatment of PTN. Many surgeons recommend less-invasive procedures for older patients or patients that would be less tolerable to general anesthesia or craniotomy.[10]

Figure 1. PRISMA Flow Diagram



METHODS

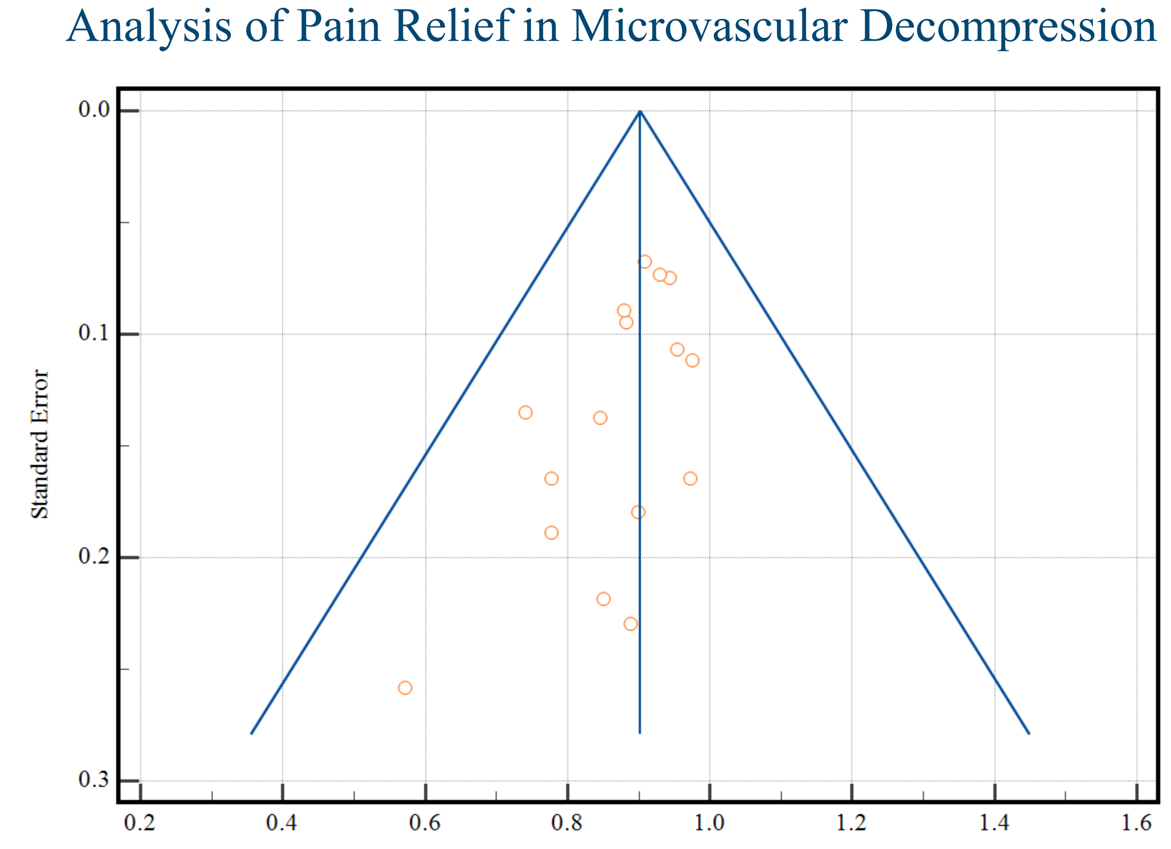
Search Criteria: This study was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses ('PRISMA') guidelines. We completed our search using PubMed, subsequently Medline, and Scopus to identify prospective studies, retrospective studies, and randomized controlled clinical trials that compared microvascular decompression to another, less-invasive surgical intervention for PTN. A combination of subject headings (e.g., Medical Subject Headings [MeSH] in PubMed) and the following keywords were used in the search: 'Trigeminal Neuralgia', 'Microvascular Decompression', 'Percutaneous Balloon Microcompression', 'Stereotactic Radiosurgery','Radiofrequency Rhizotomy', etc.. Databases were searched from the date of inception through March 9, 2023, with a filter to exclude publications written in a language other than English. The review management software, Covidence (Veritas Health Innovation Ltd, Melbourne, Australia), was utilized for study screening and selection. Titles and abstracts were screened for relevance and study design, then full texts were reviewed to determine inclusion. References of all included articles and similar systematic reviews were examined for additional citations.

Statistical Methods: Meta-analysis of single means were performed by Comprehensive Meta-Analysis version 3 (Biostat Inc., Englewood, NJ, USA). Meta-analysis of proportions and single means was performed using MedCalc 20.218 (MedCalc Software Ltd., Ostend, Belgium). Each measure was weighted according to the number of patients affected. The weighted-summary proportion was calculated by the Freeman–Tukey transformation. Heterogeneity among studies was assessed using χ^2 and I^2 statistics. $I^2 < 50\%$ indicated acceptable heterogeneity, and, therefore, the fixed-effects model was used. Otherwise, the random-effects model was performed. A p-value of <0.05 was considered to indicate a statistically significant difference for comparisons of proportions and single means.

Table 1. General Study Characteristics

Study	Country	Oxford Level of Evidence	Total Number of Patients (n)	Percent Male (%)	Mean Age (years)	Mean Pre-Op Disease Course (months)	Surgical Interventions Compared
Chaves 2021	Brazil	4	37	32.432	-	-	MVD, PBC
Dai 2016	China	3	202	44.554	58.0	-	MVD, SRS
Gao 2017	China	2	117	41.880	48.37	75.84	MVD, PSR
Hitchon 2016	United States	3	195	37.436	57.0	-	MVD, RFR, SRS
Holland 2015	United States	4	89	-	53.9	-	MVD, RFR, SRS
Ichida 2015	Brazil	3	48	-	49.17	72	MVD, PBC
Inoue 2017	Japan	3	231	35.498	62.0	-	MVD, SRS
Laghmari 2007	Morocco	4	165	50.909	50.0	-	MVD, PBC, RFR
Li 2020	United States	4	214	-	60.0	-	MVD, SRS
Linskey 2008	United States	3	80	41.250	53.8	83.64	MVD, SRS
Nanda 2015	United States	4	69	33.333	-	-	MVD, SRS
Ni 2020	China	4	60	41.667	62.52	-	MVD, PBC
Noorani 2021	United Kingdom	3	314	43.949	58.5	-	MVD, PBC, CR, RFR
Raygor 2020	United States	3	193	34.715	72.2	98.8	MVD, MVD + PSR, SRS
Ritter 2009	United States	4	108	42.593	58.0	-	MVD, RFR
Yu 2019	China	4	193	47.150	-	-	MVD, MVD + PSR, SRS
Zeng 2018	China	2	441	42.404	56.0	-	MVD, SRS
Total	-	-	2756	41.590	62.537	67.043	-

Figure 2. Funnel Plot of Studies Included for Analysis of Pain Relief in Microvascular Decompression



RESULTS

Table 2. Results of Meta-Analysis of Single Means and Proportions

Measured Item	MVD	PBC	RFR	SRS
Mean Age (Years)	57.298	65.454	70.523	70.676
Mean Pre-Op Disease Course (Months)	58.543	61.987	60.000	83.615
Mean Follow-Up (Months)	35.321	72.000	81.496	32.780
Percent Male (%)	42.072	25.073	36.628	41.370
Side of Pain (% Right Side)	58.007	56.548	52.446	57.132
Pain Relief (%)	88.370	87.256	57.352	73.746
Post-Op BNI I/II/III (%)	90.668	93.271	-	78.588
Procedure Failure (%)	12.138	14.408	36.583	24.664
Post-Op BNI IV/V (%)	9.332	6.729	-	21.412
Complication Rate (%)	13.497	25.219	8.389	2.340
Post-Op Numbness (%)	8.331	75.153	58.466	21.779
Required Reoperation (%)	9.565	-	54.033	18.106
Mean Pre-Op VAS	7.44	-	-	7.03
Mean Post-Op VAS	1.14	-	-	1.57

Table 3. Comparison of Single Means and Proportions: MVD versus PBC

*Significance Level: p-Value <0.05

	MVD	PBC	Δ	Confidence Interval (95%)	p-Value
Mean Age (Years)	57.298	65.454	8.156	6.6894 to 9.6225	<0.0001*
Mean Pre-Op Disease Course (Months)	58.543	61.987	3.444	-9.4572 to 16.3452	0.6004
Mean Follow-Up (Months)	35.321	72.000	36.69	30.605 to 42.775	<0.0001*
Percent Male (%)	42.072	25.073	16.9990	10.7878 to 22.6131	<0.0001*
Side of Pain (% Right)	58.007	56.548	1.4590	-8.5781 to 11.9414	0.7835
Pain Relief (%)	88.370	87.256	1.1140	-4.6384 to 9.8251	0.7533
Post-Op BNI I/II/III (%)	90.668	93.271	2.6030	-7.2334 to 7.1609	0.5114
Procedure Failure (%)	12.138	14.408	2.2700	-2.8236 to 8.988	0.4242
Post-Op BNI IV/V (%)	9.332	6.729	2.6030	-7.2334 to 7.1609	0.5114
Required Reoperation (%)	9.565	-	-	-	-
Complication Rate (%)	13.497	25.219	11.7220	3.8868 to 21.3549	0.0015*
Post-Op Numbness Rate (%)	8.331	75.153	66.8220	57.2016 to 74.5038	<0.0001*

Table 4. Comparison of Single Means and Proportions: MVD versus RFR

*Significance Level: p-Value <0.05

	MVD	RFR	Δ	Confidence Interval (95%)	p-Value
Mean Age (Years)	57.298	70.523	13.225	12.0146 to 14.4354	<0.0001*
Mean Pre-Op Disease Course (Months)	58.543	60.000	1.457	-11.3708 to 14.2848	0.8236
Mean Follow-Up (Months)	35.321	81.496	46.175	42.0501 to 50.2991	<0.0001*
Percent Male (%)	42.072	36.628	5.4440	-0.1969 to 10.8877	0.0584
Side of Pain (% Right)	58.007	52.446	5.5610	-2.3731 to 13.5545	0.1724
Pain Relief (%)	88.370	57.352	31.0180	23.3379 to 38.986	<0.0001*
Post-Op BNI I/II/III (%)	90.668	-	-	-	-
Procedure Failure (%)	12.138	36.583	24.4450	18.3207 to 30.9102	<0.0001*
Post-Op BNI IV/V (%)	9.332	-	-	-	-
Required Reoperation (%)	9.565	54.033	44.46830	35.37011 to 53.10441	<0.0001*
Complication Rate (%)	13.497	8.389	5.1080	0.5702 – 8.5959	0.0288*
Post-Op Numbness Rate (%)	8.331	58.466	50.1350	42.6287 to 57.2297	<0.0001*

Table 5. Comparison of Single Means and Proportions: MVD versus SRS

*Significance Level: p-Value <0.05

	MVD	SRS	Δ	Confidence Interval (95%)	p-Value
Mean Age (Years)	57.298	70.676	13.378	12.6071 to 14.1488	<0.0001*
Mean Pre-Op Disease Course (Months)	58.543	83.615	25.072	19.2407 to 30.9033	<0.0001*
Mean Follow-Up (Months)	35.321	32.780	2.541	-4.6822 to 3.3998	0.0201*
Percent Male (%)	42.072	41.370	0.7020	-3.7045 to 5.0812	0.0976
Side of Pain (% Right)	58.007	57.132	0.8750	-4.2079 to 5.9688	0.7368
Pain Relief (%)	88.370	73.746	14.6240	11.2455 to 18.0608	<0.0001*
Post-Op BNI I/II/III (%)	90.668	78.588	12.0800	8.6501 to 15.634	<0.0001*
Procedure Failure (%)	12.138	24.664	12.5260	9.1334 to 16.0042	<0.0001*
Post-Op BNI IV/V (%)	9.332	21.412	12.0800	8.6501 to 15.634	<0.0001*
Required Reoperation (%)	9.565	18.106	8.5410	3.7298 to 13.4085	0.0005*
Complication Rate (%)	13.497	2.340	11.1570	8.9915 to 13.2926	<0.0001*
Post-Op Numbness Rate (%)	8.331	21.779	13.4480	10.041 to 16.9753	<0.0001*

Figure 3. Risk of Bias of Included Non-Randomized Studies:
Review of authors' judgement about each risk of bias item (presented as percentages) across included non-randomized studies (n=15)

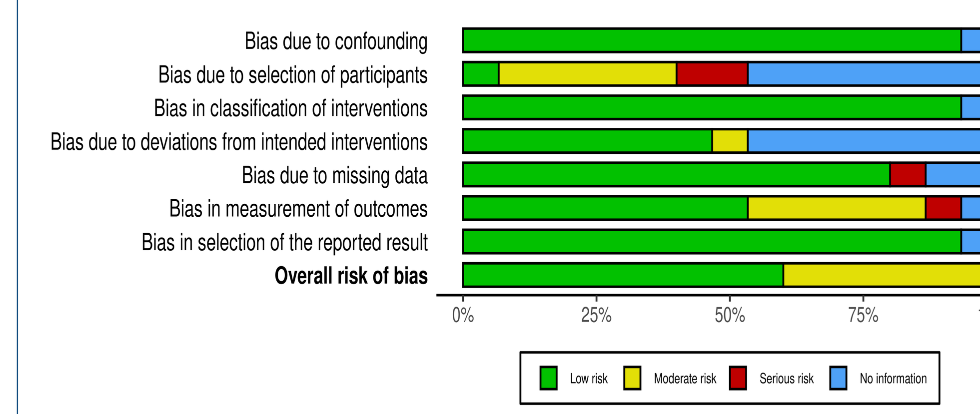
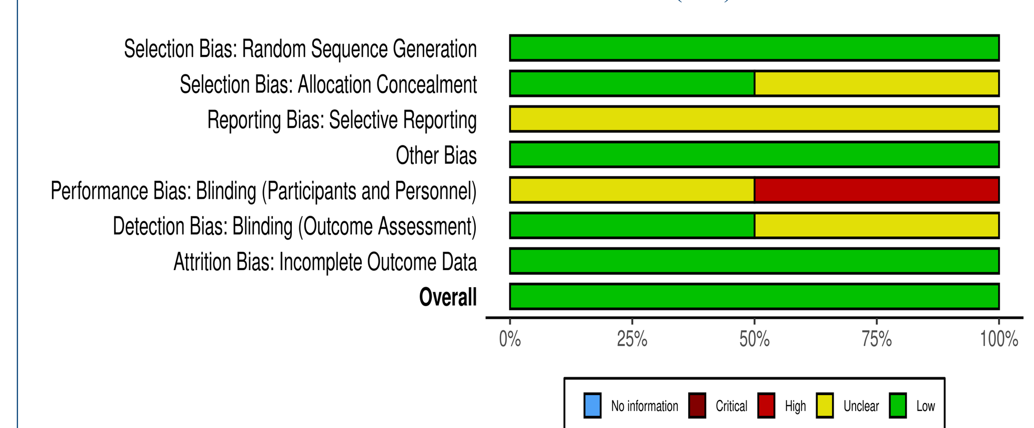


Figure 4. Risk of Bias of Included Randomized Studies:
Review of authors' judgement about each risk of bias item (presented as percentages) across included randomized studies (n=2)



CONCLUSION

To our knowledge, this is the first comprehensive meta-analysis to date of the published literature comparing microvascular decompression to all other commonly performed surgical procedures as a treatment for primary trigeminal neuralgia. We analyzed the post-operative pain relief, procedure failure rates, as well as complication and numbness rates of MVD and three other, less-invasive surgical procedures. We conclude that post-operative pain relief was highest in MVD and PBC while procedure failure rates were lowest in these procedures. MVD and PBC also had the highest rates of complications. Complications of MVD have a higher morbidity than those of PBC. We conclude that PBC is equally as efficacious and safe although it may result in more minor complications than MVD. Given the lower cost, time of operation, and time of recovery of PBC it should be considered in the initial surgical intervention for patients with trigeminal neuralgia.

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