



Treatment Outcomes in Trigeminal Neuralgia—A Systematic Review of Domains, Dimensions and Measures

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Key words

- Outcome measures
- Systematic review
- Treatment outcomes
- Trigeminal neuralgia

Abbreviations and Acronyms

BNI: The Barrow Neurology Institute Pain Intensity Scale

BPI: Brief Pain Inventory

COS: Core Outcome Set

MVD: Microvascular decompression

QOL: Quality of life

TN: Trigeminal neuralgia

VAS: Visual analogue scale

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INTRODUCTION

The International Classification of Headache Disorders defines trigeminal neuralgia (TN) as “A disorder characterized by recurrent unilateral brief electric shock-like pain, abrupt in onset and termination, limited to the distribution of one or more divisions of the trigeminal nerve and triggered by innocuous stimuli.”¹ It is a rare condition, and population-based studies estimate a prevalence ranging from 0.03% (95% confidence interval 0.01–0.08) to 0.3% (95% confidence interval 0.16–0.55).² It remains one of the few neuropathic pain conditions for which multiple therapies, including medical and surgical, are available. However, the best treatment option has yet to be identified. The difficulty in defining what the most successful treatment for TN is

■ **BACKGROUND:** Trigeminal neuralgia (TN) is a painful disorder characterized by sudden electric shock–like pain. It is a rare condition for which multiple treatments are available, including medical and surgical. The best treatment option is yet to be defined, and this is related to the lack of definition in the treatment outcomes and outcome measures. The aim of this systematic review was to summarize all the outcomes and outcomes measures that have been published to date and highlight variability in their use.

■ **METHODS:** We have conducted a literature search using a wide range of databases (1946–2019 for medical and 2008–2019 for surgical treatment), for all intervention studies in TN. Four hundred and sixty-seven studies were selected for data extraction on TN classification, data collection method, intervention, and treatment outcomes mapped to the Initiative on Methods, Measurement, and Pain Assessment in Clinical Trials (IMMPACT guidelines).

■ **RESULTS:** Most studies collected data on pain ($n = 459$) and side effects ($n = 386$) domains; however, very few collected data on the impact of treatment on physical ($n = 46$) and emotional functioning ($n = 17$) and on patient satisfaction ($n = 35$). There was high variability on outcome measures used for pain relief ($n = 10$), pain intensity ($n = 9$), and frequency of pain episodes ($n = 3$).

■ **CONCLUSIONS:** A clear definition of what are the important outcomes for patients with TN is essential. The choice of standardized outcome measures allowing for consistent reporting in TN treatment will allow for comparison of studies and facilitate treatment choice for patients and clinicians thus, improving health outcomes and reducing health care cost.

relates to the fact that there are no clearly defined outcomes; therefore, comparison between treatments is challenging. Outcomes are defined as measures or observations, which are used to assess treatment effects.³ For the purpose of this review, outcome refers to clinical outcome, which is the result(s) of the medical or surgical treatment of TN on the patient’s health or well-being. To improve comparison of treatments, clearly defined outcomes (what is assessed) and outcomes measures (how to assess outcome magnitude) should be used. Outcome measures are tools used to assess the impact of treatment interventions.

The variability in instruments used to measure treatment outcomes contributes to the difficulties in appraising research

results.³ These difficulties are a reality for clinicians and patients and result in uncertainty when faced with multiple treatment options.

To minimize the discrepancy between studies and results, groups of researchers and clinicians have developed guidelines for the systematic reporting of outcome measures. One such example is the Initiative on Methods, Measurement, and Pain Assessment in Clinical Trials (IMMPACT), which has developed recommendations for core outcome domains to be reported in clinical trials of pain disorders.⁴

There have been studies reporting on the use of outcome measures in individual TN treatments, but there has not been a comprehensive review looking at all medical and surgical treatments published to

date. The aim of this systematic review was, therefore, to summarize all the treatment outcomes used in the TN literature, to highlight the variability in their reporting, and, additionally, to summarize the instruments used to measure those outcomes.

METHODS

A protocol for the systematic review was published in the International Prospective Registry of Systematic Reviews (PROSPERO) (Registration CRD42018118675, December 2018) and followed recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses group.⁵

Search Strategy

A literature search was conducted to include all TN studies in which there was a medical and/or a surgical intervention with a view to capturing all treatment outcomes and the outcome measures used. The searches were performed electronically, with the help of a librarian, and by hand. We searched MEDLINE (Ovid) (1946 to October 2019 for medical treatment and 2008 to October 2019 for surgical treatment), EMBASE (1947 to October 2019 for medical treatment and 2008 to October 2019 for surgical treatment), Cochrane Oral Health Group's Trials Register, CINAHL Plus with Full Text, and PsycINFO. The search of surgical papers was restricted to studies published from 2008 onwards, given that 2 systematic reviews had been published on surgical management of TN.^{6,7} Furthermore, international guidelines on the surgical management of TN⁸ and a review of quality of reporting of surgical studies, which reviewed the literature up to 2008,⁹ also had been published. The search strategy for MEDLINE AND EMBASE can be found in [Appendix A](#).

Eligibility Criteria

The inclusion criteria were as follows: 1) intervention studies with a cohort of patients diagnosed with TN; 2) medical and/or surgical intervention; 3) TN cohort ≥ 10 patients; 4) subjects aged 18 years and older; 5) English language; and 6) full text available.

No discrimination was made concerning the study design, as the aim was to

capture all the treatment outcomes and outcomes measures published to date. Studies in which there were 2 or more cohorts (TN and hemifacial spasm, for example) were included but only data relevant to the TN cohort was evaluated.

Screening

The references were organized in EndNote X9 and duplicates removed. Initially, 25 study titles were piloted between 2 reviewers (C.V.N. and R.N.R.). The interrater agreement was 0.60. Following discussion and modification of the piloting sheet to include abstracts, the process was repeated with 50 further studies. The final Kappa coefficient was 0.80.

The body of references was then screened on title and abstract; if no consensus was reached, a third reviewer (J.M.Z.) made the final decision. Three reviewers (C.V.N., R.N.R., and J.M.Z.) subsequently screened full texts, if available, against eligibility criteria.

Data Collection and Synthesis

We have used EPPi-Reviewer 4 software¹⁰ to extract data from the final selected references. Data were extracted by 3 reviewers (C.V.N., R.N.R., and J.M.Z.) on TN classification (classical, idiopathic, and secondary to neurologic disease, Burchiel classification, and unspecified), cohort type (prospective, retrospective, and unspecified), intervention (medical and/or surgical), and treatment outcomes (domain, dimension, and instruments).

Data on outcome domains were captured according to the IMMPACT recommendations.⁴ This review includes studies that precede those recommendations, as well as study designs other than clinical trials, but it was decided to use their guidance for a clear and standardized organization of the results. Treatment outcome measures were identified, and where available, data were collected on outcome measure instruments. The complete data extraction code can be found in [Appendix B](#).

Statistical Analysis

Descriptive statistical analysis was performed to summarize the number of times outcomes and outcome measures were reported in the TN literature.

RESULTS

Four hundred sixty-seven ($n = 467$) papers were included in the final review and grouped according to TN classification, method of data collection, treatment intervention, and treatment outcomes (domain, dimension, and instruments/measures). [Figure 1](#) illustrates the flow chart of references.¹¹

TN Classification

Just less than one half of the papers (47%) described their TN cohort as classic, idiopathic, secondary to neurologic disease or used the Burchiel classification.¹² One hundred twenty ($n = 120$) studies did not specify the type of TN in their cohort and 47 others used a nomenclature that was not clearly defined, e.g., refractory TN, medically unresponsive TN, and recurrent TN after microvascular decompression (MVD).

Method of Outcome Data Collection

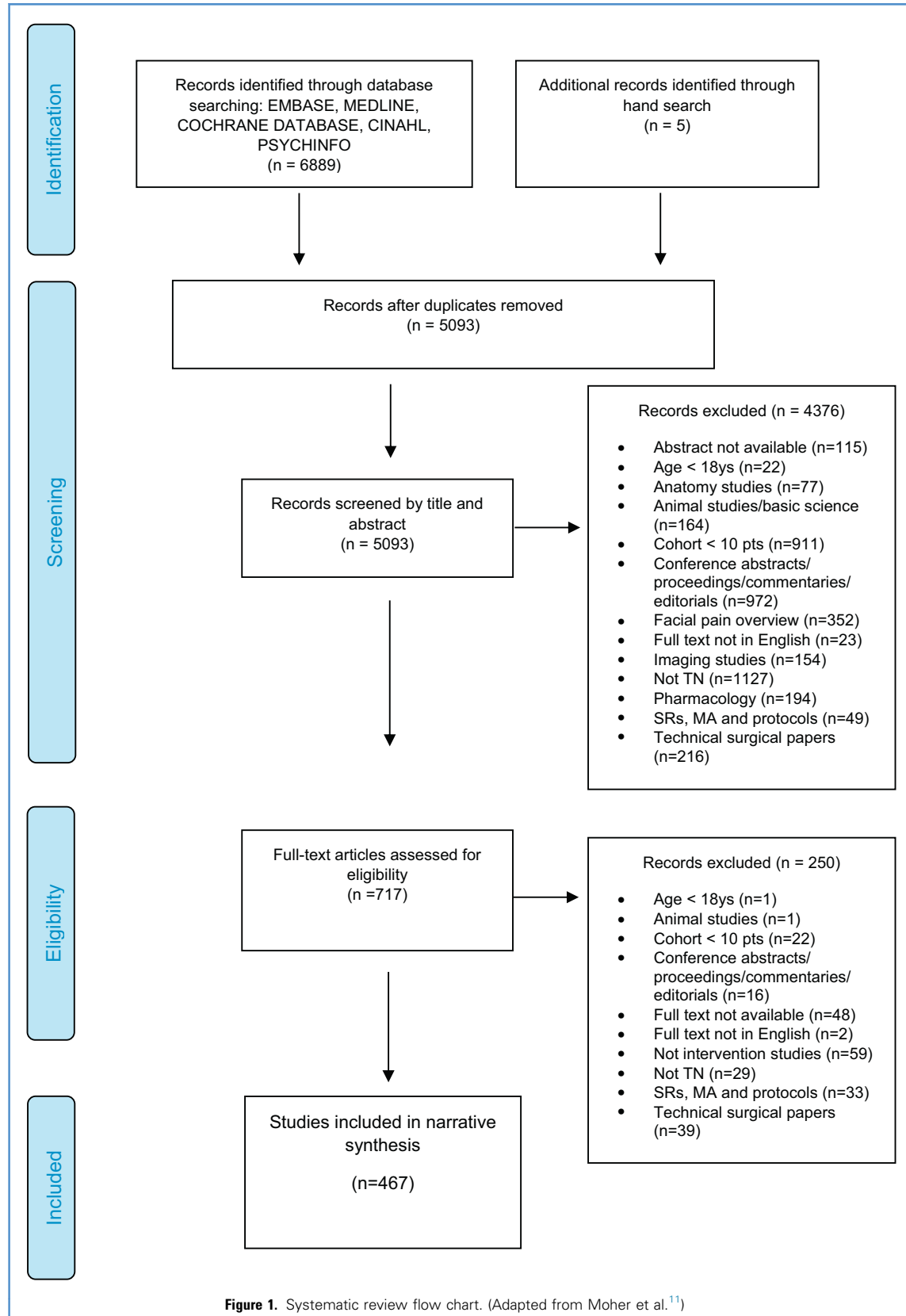
More than one half of the studies reviewed ($n = 254$) collected their data retrospectively. Data were collected prospectively in 131 studies and 81 did not specify how their data were collected.

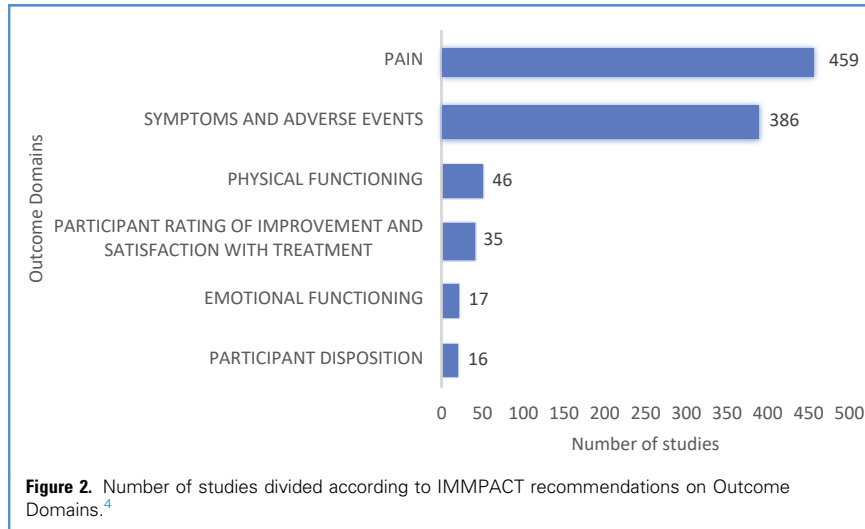
Intervention

Treatment interventions were divided into medical and surgical; however, data were not collected on the specific medical and surgical treatment modalities. The use of systemic and topical medicines and botulin toxin were included in medical management and all the ablative techniques,⁷ neurosurgical procedures (MVD), and laser treatment in surgical management. The majority of studies reviewed were surgical papers ($n = 398$) and a minority combined medical and surgical treatment ($n = 10$).

Outcome Domains, Dimensions, and Measures

For systematization and clarity, outcome data were organized and mapped to the IMMPACT outcome domain recommendations for clinical trials in chronic pain ([Figure 2](#)).⁴ Only 42 of the 467 reviewed studies were published during or before 2003, predating the IMMPACT publication. The IMMPACT Outcome Domains are as follows: 1) Pain; 2) Physical functioning; 3) Emotional





functioning; 4) Participant ratings of global improvement/satisfaction; 5) Symptoms and adverse events; and 6) Participant disposition.

With the exception of 8 papers, all studies used pain as an outcome domain (Figure 2 and Table 1).¹³⁻⁴⁵⁹ Symptoms and adverse events also were described in a high number of papers ($n = 386$); however, the impact of treatment on physical and emotional functioning was significantly less evaluated, in 46 and 17 studies, respectively (Tables 2 and 3).⁴⁶⁰⁻⁴⁶⁴ Of the 334 surgical studies that described adverse events, only 62 mentioned mortality rates. Participant disposition was described in 16 studies (3%).

Pain

Pain Relief. Pain relief was used as an outcome dimension in the majority of studies ($n = 314$). Ten different outcome measures were used for pain relief and 78 of 314 (25%) studies did not use an outcome measure. The Barrow Neurology Institute Pain Intensity Scale (BNI) was the most used pain relief measure in 131 of studies (42%), followed by a Likert scale in 76 (24%) and the visual analogue scale (VAS) in 18 (6%).

Pain Intensity. Pain intensity was used as a treatment outcome dimension in 193 of the 459 studies describing pain as an outcome domain. There were 9 different measures used for pain intensity and 8 studies did not use any. The VAS was the

most commonly used measure in 85 studies followed by the BNI ($n = 45$) and the use of qualitative pain descriptors ($n = 32$).

Pain Frequency. Only 27 of 459 studies (6%) used pain frequency as a treatment outcome dimension. The majority did not use an outcome measure ($n = 15$) and 10 indicated the use of a pain diary. One study used a pain vector diagram and another study used The Constant Face Pain Questionnaire.

Physical Functioning

Forty-six studies included at least 1 measure for evaluating physical functioning dimensions, such as quality of life (QOL; $n = 34$), daily activities ($n = 9$), pain interference ($n = 4$), ability to work ($n = 2$), and disability ($n = 1$). These are summarized in Table 2 with the references.

Quality of Life. The most used instrument for assessing impact on QOL was the 36-Item Short form Survey Instrument ($n = 14$), followed by the EQ-5D (5-Question Quality Of Life Instrument) ($n = 4$), Sickness Impact Profile ($n = 2$), and Brief Pain Inventory (BPI) ($n = 2$). The World Health Organization Quality of Life and 12-Item Short Form Health Survey were used in 1 study each. Of note, the BPI facial was used only once.

Two studies did not use an outcome measure and 8 used a different measure (Quality of Life Impact Scale, 0–100 scale (2 studies used this measure), Trigeminal

Neuralgia Quality of Life Assessment Scale, Epilepsy Surgery Inventory-55, 10-point Quality of Life Scale, Wong Baker FACES scale, and a 5-Point Scale).

Daily Activities. Activities of daily living was the most commonly used instrument ($n = 4$) followed by the Penn Facial Pain scale ($n = 1$). One study did not use an outcome measure and 4 studies used different measures (Brief Fatigue Inventory, Karnofsky Performance Status Scale, Category Point Scale, yes/no questionnaire).

Pain Interference. The only instrument used to evaluate pain interference was the BPI facial ($n = 4$), which is the only instrument specific for facial pain.

Ability to Work. Only 2 measures were used to evaluate ability to work; one study used a Likert scale and a second study used the Self Perceived Productivity Scale.

Disability. The Pain Disability Index was used in 1 study only.

Emotional Functioning

Three dimensions were assessed in this domain: depression ($n = 5$), anxiety ($n = 3$), and catastrophizing ($n = 1$). Some studies combined anxiety and depression ($n = 12$). Please refer to Table 3 for references.

Anxiety and Depression. The combination of anxiety and depression was evaluated by the use of Hospital Anxiety and Depression Scale in 9 studies, and 1 study did not use an outcome measure. One other measure was found in 2 studies—the Research Diagnostic Criteria.

Depression. To evaluate depression alone, the Beck Depression Inventory was used in 3 studies followed by the Hamilton Depression Scale ($n = 1$) and the Patient Health Questionnaire-9 ($n = 1$).

Anxiety. To evaluate anxiety, only 2 instruments were used, the Beck Anxiety Inventory ($n = 2$) and the Hamilton Anxiety Scale ($n = 1$).

Catastrophizing. Only one study evaluated catastrophizing, with the aid of the Pain Catastrophizing Scale.

Table 1. Pain Dimensions and Outcome Measures Identified in the Systematic Review

Outcome Dimension	Outcome Measure	Reference Numbers
Pain relief (314)	Barrow Neurology Institute Pain Intensity Scale (BNI)	13-143
	No outcome measure	144-221
	Likert scale	66,219,222-295
	Visual analogue scale (VAS)	13,294,296-311
	Numeric Rating Scale (NRS)	296,312-316
	Modified BNI	317,318
	Marseille scale	41,63,319
	MVD evaluation score	320,321
	Regis classification	112,322
	Burchiel classification	323
Other	324	
Pain intensity (193)	VAS	32,42,96,123,124,145,164,168-170,195,219,220,241,248,295,298,299,301,302,304-307,309,310,325-383
	BNI	15,22,39,44,46,49,55,56,62,68,74,82,127,128,195,202,210,339,355,360-362,384-406
	Qualitative pain descriptors	150,184,186,188,191,192,218,295,366,385,407-428
	NRS	31,35,71,145,235,266,278,298,304,314-316,413,429-440
	Brief Pain Inventory (BPI)	34,48,127,311,438,441-447
	McGill Pain Questionnaire	22,214,241,278,344,356,357,446-448
	No outcome measure	116,117,225,292,449-452
	Verbal Pain Scale (VPS)	214,295,363,367,409,453,454
	Verbal Numeric Pain Scale (VNPS)	49,188,455
Other	324	
Pain frequency (27)	No outcome measure	159,160,207,208,349,350,354,373,432,433,444,452,456-458
	Pain diary	188,278,292,295,309,330,376,380,438,459
	Pain vector diagram	453
	The Constant Face Pain Questionnaire	241

MVD, microvascular decompression.

Satisfaction with Treatment

Only 35 studies (7%) reported on patient ratings of improvement and satisfaction with treatment. The majority of studies ($n = 17$) used a Likert Scale to rate their patient satisfaction with treatment, whereas 2 studies used a Patient Satisfaction Scale and one other a VAS scale. Nine studies used the Patient Global Impression of Change to rate change with treatment. Three studies did not use an outcome measure and 4 studies used 4 other outcome measures (QUASU - Satisfaction with Treatment and Medical Team; Satisfaction Survey; The Patient Global Rating of Efficacy and Safety; and The Wong Baker FACES scale).

Adverse Events

Data on adverse events and side effects were collected in 83% of the studies. Of the 59 medical studies, 85% described side effects. Outcome measures were used in only 3 studies—The Liverpool Adverse Event Profile ($n = 2$) and the A-B Neuropsychological Assessment Schedule ($n = 1$).

On the surgical studies group, side effects and adverse events were collected in 334 (84%). The most reported side effect was numbness ($n = 220$) and the Barrow Neurology Institute Numbness Scale was administered in 62 studies. A Likert scale was used once to assess degree of numbness. One other surgical study used the Landriel Ibanez classification, but the

majority of studies limited their reporting to the passive description of the cohort side effects opposed to using an instrument to collect the data.

Patient Disposition

Patient disposition is not considered a treatment outcome. This domain refers to the patient navigating through a study and often presented in a flow diagram.

Guidance on reporting for the different types of studies has been published by the EQUATOR Network (Enhancing the QUALity and Transparency Of health Research) (<https://www.equator-network.org/>) and endorsed by medical and surgical journals.⁹ It has been accepted that the

Table 2. Physical Functioning Domain and Outcome Measures Identified in the Systematic Review

Outcome Dimension	Outcome Measure	Reference Number
Quality of life (34)	36-Item Short form Survey Instrument (SF-36)	41,122,124,344,354,355,360,361,382,425,444,446,460,461
	5-Question Quality of Life Instrument (EQ-5D)	67,266,356,391
	Sickness Impact Profile	349,432
	Brief Pain Inventory	73,344
	World Health Organization Quality of Life (WHOQOL-100)	35
	Brief Pain Inventory Facial	462
	12-Item Short Form Health Survey (SF-12)	463
	Quality of Life Impact Scale	332
	0–100 Scale	71,170
	Wong Baker FACES scale	324
	Trigeminal Neuralgia Quality of Life Assessment Scale	261
	Epilepsy Surgery Inventory-55	362
	5-Point Scale	214
	10-Point Quality of Life Scale	364
Daily activities (9)	Activities of Daily Living	41,278,357,413
	Penn Facial Pain Scale	464
	Karnofsky Performance Status Scale	41
	Brief Fatigue Inventory	443
	Category Point Scale (CPS)	367
	Yes/no questionnaire	292
Pain interference (4)	Brief Pain Inventory—Facial (BPI-Facial)	64,72,442,445
Ability to work (2)	Likert scale	391
	Self-Perceived Productivity Scale	357
Disability (1)	Pain Disability Index	356

reporting of the patient progression in clinical trials should be illustrated by a CONSORT diagram (Consolidated Standards of Reporting Trials)⁴⁶⁵ and, in the case of observational trials, the STROBE statement (Strengthening the Reporting of Observational studies in Epidemiology) should be followed.⁴⁶⁶

In this review, we have identified 16 studies in which there was information about patient progression—CONSORT diagram ($n = 4$), STROBE reporting ($n = 5$) and 7 illustrated their information with a diagram but did not follow any specific guidance.

DISCUSSION

This systematic review provides a summary of the outcomes and outcome

measures that have been used in the medical and surgical treatment of TN to date, performed by clinicians from varied backgrounds, and it highlights the variability in the methodology of studies and choice of outcome measures employed.

Pain: Outcome Dimensions and Outcome Measures

The degree of pain relief as well as the level of pain intensity have been the most commonly used dimensions in chronic pain studies.^{467,468} Similar to what others have found in the TN surgical literature,^{6,7,9} the most common pain dimension reported was pain relief. In the context of TN, however, there seems to be no consensus in what should be the primary outcome dimension in trials of

TN. Studies that use either pain intensity or pain relief as their outcome of interest are difficult to compare. Pain intensity refers to “how intense the pain is,” whereas pain relief refers to “how much pain relief” has resulted from a certain treatment and so requires a baseline assessment.⁴⁶⁹ Some authors have attempted to clarify if pain relief ratings and pain intensity ratings are comparable. For example, Jensen et al.⁴⁷⁰ looked at a cohort of 248 postsurgical patients (knee replacement vs. laparoscopy) whose outcomes were pain intensity (VAS and Verbal Rating Scale) and pain relief (VAS). They had hypothesized that the differences in sensitivity to detect change would be similar in both cohorts; however, this was not supported. They

Table 3. Emotional Functioning Domain and Outcome Measures Identified in the Systematic Review

Outcome Dimension	Outcome Measure	Reference Number
Anxiety and depression (12)	Hospital Anxiety and Depression Scale (HADS)	214,344,356,432,446-448,462,463
	Research Diagnostic Criteria (RCD)	341,342
	No outcome measure	82
Depression (5)	Beck Depression Inventory (BDI)	335,372,444
	Hamilton Depression (HDRS)	354
	Patient Health Questionnaire-9 (PHQ9)	67
Anxiety (3)	Beck Anxiety Inventory (BAI)	335,372
	Hamilton Anxiety Scale (HARS)	354
Catastrophizing (1)	Pain Catastrophizing Scale (PCS)	447

have confirmed that even though related, pain relief and intensity mean slightly different things, as patients report pain relief even when pain intensity ratings are the same or even greater than presurgery. Their conclusions point to the need of a clear definition of the primary outcome and a clear choice of a validated tool capable of capturing it.⁴⁷⁰ In addition, pain intensity may remain the same but patient's ability to cope with it may change, and this would be reflected in measures looking at aspects such as activities of daily living. Baseline data before surgical procedures are rarely reported and yet they are crucial to determine the true impact of a treatment. TN is an episodic pain; it is interesting to see that little attention is given to this specific characteristic. To date, no instruments have been designed to capture the effects of treatment on the number and frequency of TN attacks. Degn and Brennum⁴⁵³ have attempted to capture these data in a cohort of patients undergoing glycerol injection, MVD, and rhizotomy by plotting pain intensity (Verbal Numerical Rating Scale) with frequency of daily pain per month. Their data were used to design a pain vector diagram to illustrate, in a composite outcome, the effects of treatment. Another temporal aspect of pain is duration of pain-free status over time, which has been illustrated in the literature with Kaplan–Meier survival curves.⁹ It is almost certain that patients would value information about which treatment provides absence of pain for the longest

period of time, and it might be that plotting pain relief outcome data over time is the correct way of doing it, however, rigorous reporting of follow-up times are essential for data accuracy.

The VAS and BNI intensity scales are the most used tools to capture data on pain intensity. Both scales also were used to retrieve information on pain relief. Given that VAS is a single-item scale and BNI is a composite scale, it is not possible to compare data captured by these instruments, especially as they are measuring different pain dimensions and the BNI includes data on medication use. Despite their wide use in TN, neither the VAS nor the BNI have been validated for their use in TN cohorts.^{7,471,472} It is not clear whether patients complete the scales or whether the data are retrieved from the medical records.

Finally, we should stress that the use of outcomes that are designed specifically for a single study, or which have been modified and derived from other instruments, for example modified BNI^{317,318} and have not been validated for TN are neither reliable nor reproducible and comparison of study results is flawed.

Data-Collection Method

The retrospective collection of data, specifically, the interviewing of patients, months or years after their treatments were done, raises the question of recall bias and it can be influenced, for example, by severity of pain at time of recall.⁴⁷³

Of note, in one of the studies, family members of deceased patients were

contacted to obtain information about their condition.²³⁵ The experience of pain is a very personal one and it is unreasonable to expect that others can provide information, except if stated early on, that the outcome collected is not patient reported. If the information sought is related to effects of treatment on someone's level of pain, then the patient is the only valid source of information.⁴⁷⁴

Domains Other Than Pain

There has been extensive research highlighting the impact of chronic pain in mood and QOL.⁴⁷⁵ Tölle et al.⁴⁷⁶ and Zakrzewska et al.⁴⁴⁷ described the high impact of TN pain on activities of daily living as well as on emotional functioning; however, the reporting of TN impact on QOL has been sparse.⁴⁷⁷ Of the 8 different instruments used for emotional functioning, only one, the Hospital Anxiety and Depression Scale, has been validated for TN. The BPI facial has been validated in a cohort of patients with TN,⁴⁷⁸ but its uptake, in studies published since 2010 and included in this review, is low, being used in 4 studies to assess pain interference^{64,72,442,445} and in one to assess impact on QOL.⁴⁶² Interpreting the effects of TN on the emotional and physical health will also depend on the appropriateness of these instruments for their use in a TN cohort.

The reporting of side effects should go beyond a narrative list and incorporate how individual side effects might affect patients' QOL or what the impact on daily living is. As illustrated by Akram et al.,⁹ the side effects of treatment might impact more on a patient's QOL than the pain itself.

There might be a few practical explanations for the poor reporting on domains other than pain. First, reporting on multiple outcome domains would require more comprehensive questionnaire(s) that could be a burden to patients, risking a poor response rate and validity of results. Second, time might be a limiting factor for researchers who need to administer, collect and analyze all the data. Patients may not be made aware of their relevance and so not complete them. Finally, although attempts have been made to improve reporting of outcomes in studies on TN, journal editors have not insisted on more comprehensive reporting.⁹

Limitations

The inclusion of a large number of studies to summarize information on outcomes and outcome measures in the treatment of TN created a heterogeneous data set, which was challenging to organize. The studies were not appraised on their scientific rigor, as we wanted to capture the diversity of outcomes and outcome measures available in the literature. Due to the volume of results, our data extraction on outcomes was limited to identifying the outcome measure instrument used and for the majority of the studies we failed to retrieve information concerning the timing and method of questionnaire administration. Although guidance from IMMPACT is to be considered in clinical trials, due to the lack of available guidance for the reporting of outcomes in TN studies, we decided to map our results to their recommended 6 core domains. We acknowledge that these outcomes might not comprehensively reflect the ones patients with TN consider important and that fewer may be required when reporting other types of studies. Finally, our search included English-language literature only, and we might have left out relevant research published in other languages (language bias).

Recommendations for Future Research

Following this work, it is our aim to develop a Core Outcome Set (COS) for the treatment of TN. COS is a group of defined outcomes that should be consistently collected and measured in all trials of a specific condition.⁴⁷⁹

We aim to seek guidance from IMMPACT, where possible, but we will not limit it to this, as there might be other outcome dimensions relevant to the TN

population, for example, frequency of pain episodes, duration of pain-free episodes, and fear of attacks in between episodes. We will also follow recommendation from COMET (Core Outcome Measures in Effectiveness Trials) and COSMIN (COnsensus-based Standards for the selection of health Measurement Instruments) initiatives for methodological guidance.⁴⁸⁰ One of the fundamental steps in the COS-development process will be to confirm whether patient's views on outcomes map to the currently used instruments and if not, the validity of tools needs to be tested for their ability to detect change over time—what is the value of a composite measure opposed to a single item measure? For example, patient global impression of change may cover all the required features and has been shown to be useful in neuropathic pain.⁴⁸¹

A TN COS could be used in all prospective trials and could consistently capture data that can be compared between studies improving patient health and reducing health care expenditure. We acknowledge the complexity of this process and that it will take time to take into account all stakeholders views.

CONCLUSIONS

Patients and clinicians currently have no reliable way of comparing outcomes in TN especially between medical or surgical treatments. Trials of medical therapies are said to be positive if 50% of patients are pain free,⁴⁸² whereas surgical outcomes require 100% pain relief if they are said to be successful.

The variability in the reporting outcomes as well as the lack of validation of the instruments highlights the need for a

partnership between different stakeholders—patients, patient groups, clinicians, researchers—in the preparation of a well-defined core set of outcomes and there are examples in the chronic pain field where this partnership has proved to be successful.^{483,484}

Until there is a rigorous process for gathering TN treatment outcome data, which includes defining the primary outcome of importance to patients, the lack of consistency between studies will continue to account for the difficulties patients and clinicians have in identifying the best treatment option for each individual patient as this can vary significantly. This is of particular importance, given the range of treatments currently available for TN and, in addition, as not all patients opt for surgical therapies.

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DECLARATION OF COMPETING INTEREST

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REFERENCES

- Headache Classification Committee of the International Headache Society. The International Classification of Headache Disorders, 3rd edition (beta version). *Cephalalgia*. 2013;33:629-808.
- De Toledo IP, Conti Reus J, Fernandes M, et al. Prevalence of trigeminal neuralgia: a systematic review. *J Am Dent Assoc*. 2016;147:570-576.e572.
- Williamson PR, Altman DG, Bagley H, et al. The COMET Handbook: version 1.0. *Trials*. 2017;18:280.
- Turk DC, Dworkin RH, Allen RR, et al. Core outcome domains for chronic pain clinical trials: IMMPACT recommendations. *Pain*. 2003;106:337-345.
- Shamseer L, Moher D, Clarke M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. *BMJ*. 2015;350:g7647.
- Lopez BC, Hamlyn PJ, Zakrzewska JM. Systematic review of ablative neurosurgical techniques for the treatment of trigeminal neuralgia. *Neurosurgery*. 2004;54:973-982 [discussion: 973-982].
- Zakrzewska JM, Akram H. Neurosurgical interventions for the treatment of classical trigeminal neuralgia. *Cochrane Database Syst Rev*. 2011;9:CD007312.
- Crucchi G, Gronseth G, Alksne J, et al. AAN-EFNS guidelines on trigeminal neuralgia management. *Eur J Neurol*. 2008;15:1013-1028.
- Akram H, Mirza B, Kitchen N, Zakrzewska JM. Proposal for evaluating the quality of reports of surgical interventions in the treatment of trigeminal neuralgia: the Surgical Trigeminal Neuralgia Score. *Neurosurg Focus*. 2013;35:E3.
- Thomas J, Graziosi S, O'Driscoll P. *EPPI-Reviewer: Software for Research Synthesis*. London: EPPI-Centre; 2019.

11. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med*. 2009;6:e1000097.
12. Burchiel KJ. A new classification for facial pain. *Neurosurgery*. 2003;53:1164-1166 [discussion: 1166-1167].
13. Salama H, Ben-Khayal H, Mohamed MA, et al. Outcome of medical and surgical management in intractable idiopathic trigeminal neuralgia. *Ann Indian Acad Neurol*. 2009;12:173-178.
14. Abdulrauf SI, Urquiaga JF, Patel R, et al. Awake microvascular decompression for trigeminal neuralgia: concept and initial results. *World Neurosurg*. 2018;113:e309-e313.
15. Arai Y, Kano H, Lunsford LD, et al. Does the Gamma Knife dose rate affect outcomes in radiosurgery for trigeminal neuralgia? *J Neurosurg*. 2010;113(suppl):168-171.
16. Attia A, Tatter SB, Weller M, et al. CT-only planning for Gamma Knife radiosurgery in the treatment of trigeminal neuralgia: methodology and outcomes from a single institution. *J Med Imaging Radiat Oncol*. 2012;56:490-494.
17. Aykol S, Borcek AO, Emmez H, Ocal O, Pasaoglu A. Results of radiosurgery for trigeminal neuralgia: Ankara experience. *Br J Neurosurg*. 2015;29:54-58.
18. Baschnagel AM, Cartier JL, Dreyer J, et al. Trigeminal neuralgia pain relief after gamma knife stereotactic radiosurgery. *Clin Neurol Neurosurg*. 2014;117:107-111.
19. Berti A, Ibars G, Wu X, et al. Evaluation of CyberKnife radiosurgery for recurrent trigeminal neuralgia. *Cureus*. 2018;10:e2598.
20. Bick SK, Huie D, Sneh G, Eskandar EN. Older patients have better pain outcomes following microvascular decompression for trigeminal neuralgia. *Neurosurgery*. 2019;84:116-122.
21. Chang CS, Huang CW, Chou HH, Lin LY, Huang CF. Outcome of Gamma Knife radiosurgery for trigeminal neuralgia associated with neurovascular compression. *J Clin Neurosci*. 2018;47:174-177.
22. Chen JC, Greathouse HE, Girvigian MR, Miller MJ, Liu A, Rahimian J. Prognostic factors for radiosurgery treatment of trigeminal neuralgia. *Neurosurgery*. 2008;62(5 suppl):A53-A60 [discussion: A51-A60].
23. Chen JC, Rahimian J, Rahimian R, Arellano A, Miller MJ, Girvigian MR. Frameless image-guided radiosurgery for initial treatment of typical trigeminal neuralgia. *World Neurosurg*. 2010;74:538-543.
24. Chen CJ, Paisan G, Buell TJ, et al. Stereotactic radiosurgery for type 1 versus type 2 trigeminal neuralgias. *World Neurosurg*. 2017;108:581-588.
25. Cheng J, Lei D, Zhang H, Mao K. Trigeminal root compression for trigeminal neuralgia in patients with no vascular compression. *Acta Neurochir (Wien)*. 2015;157:323-327.
26. Cheng J, Liu W, Hui X, Lei D, Zhang H. Microvascular decompression for trigeminal neuralgia in patients with failed gamma knife surgery: analysis of efficacy and safety. *Clin Neurol Neurosurg*. 2017;161:88-92.
27. Cheng J, Meng J, Liu W, Zhang H, Hui X, Lei D. Nerve atrophy in trigeminal neuralgia due to neurovascular compression and its association with surgical outcomes after microvascular decompression. *Acta Neurochir (Wien)*. 2017;159:1699-1705.
28. Chivukula S, Kim W, Zhuo X, et al. Radiosurgery for secondary trigeminal neuralgia: revisiting the treatment paradigm. *World Neurosurg*. 2017;99:288-294.
29. Cho KR, Lee MH, Im YS, et al. Gamma knife radiosurgery for trigeminal neuralgia secondary to benign lesions. *Headache*. 2016;56:883-889.
30. Constantoyannis C, Kagadis G, Chroni E. Percutaneous balloon compression for trigeminal neuralgias and autonomic cephalalgia. *Headache*. 2008;48:130-134.
31. Conti A, Pontoriero A, Iati G, et al. Frameless stereotactic radiosurgery for treatment of multiple sclerosis-related trigeminal neuralgia. *World Neurosurg*. 2017;103:702-712.
32. Dai ZF, Huang QL, Liu HP, Zhang W. Efficacy of stereotactic gamma knife surgery and microvascular decompression in the treatment of primary trigeminal neuralgia: a retrospective study of 220 cases from a single center. *J Pain Res*. 2016;9:535-542.
33. Debono B, Lotterie JA, Sol JC, et al. Dedicated linear accelerator radiosurgery for classic trigeminal neuralgia: a single-center experience with long-term follow-up. *World Neurosurg*. 2019;121:e775-e785.
34. Dellaretti M, Reyns N, Touzet G, et al. Clinical outcomes after Gamma Knife surgery for idiopathic trigeminal neuralgia: review of 76 consecutive cases. *J Neurosurg*. 2008;109(suppl):173-178.
35. Ding W, Chen S, Wang R, et al. Percutaneous radiofrequency thermocoagulation for trigeminal neuralgia using neuronavigation-guided puncture from a mandibular angle. *Medicine*. 2016;95:e4940.
36. Du Y, Yang D, Dong X, Du Q, Wang H, Yu W. Percutaneous balloon compression (PBC) of trigeminal ganglion for recurrent trigeminal neuralgia after microvascular decompression (MVD). *Ir J Med Sci*. 2015;184:745-751.
37. Dumot C, Brinzeu A, Berthiller J, Sindou M. Trigeminal neuralgia due to venous neurovascular conflicts: outcome after microvascular decompression in a series of 55 consecutive patients. *Acta Neurochir (Wien)*. 2017;159:237-249.
38. Elaimy AL, Lamm AF, Demakas JJ, et al. Gamma knife radiosurgery for typical trigeminal neuralgia: An institutional review of 108 patients. *Surg Neurol Int*. 2013;4:92.
39. Fariselli L, Marras C, De Santis M, Marchetti M, Milanese I, Broggi G. CyberKnife radiosurgery as a first treatment for idiopathic trigeminal neuralgia. *Neurosurgery*. 2009;64(2 suppl):A96-A101.
40. Fraioli MF, Strigari L, Fraioli C, Lecce M, Lisciani D. Preliminary results of 45 patients with trigeminal neuralgia treated with radiosurgery compared to hypofractionated stereotactic radiotherapy, using a dedicated linear accelerator. *J Clin Neurosci*. 2012;19:1401-1403.
41. Gagliardi F, Spina A, Bailo M, et al. Effectiveness of gamma knife radiosurgery in improving psychophysical performance and patient's quality of life in idiopathic trigeminal neuralgia. *World Neurosurg*. 2018;110:e776-e785.
42. Gao J, Fu Y, Guo SK, Li B, Xu ZX. Efficacy and prognostic value of partial sensory rhizotomy and microvascular decompression for primary trigeminal neuralgia: a comparative study. *Med Sci Monit*. 2017;23:2284-2291.
43. Gellner V, Kurschel S, Kreil W, Holl E, Ofner-Kopeinig P, Unger F. Recurrent trigeminal neuralgia: Long term outcome of repeat gamma knife radiosurgery. *J Neurol Neurosurg Psychiatry*. 2008;79:1405-1407.
44. Gerganov VM, Giordano M, Elolf E, Osamah A, Amir S, Madjid S. Operative management of patients with radiosurgery-related trigeminal neuralgia: analysis of the surgical morbidity and pain outcome. *Clin Neurol Neurosurg*. 2014;122:23-28.
45. Gu W, Zhao W. Microvascular decompression for recurrent trigeminal neuralgia. *J Clin Neurosci*. 2014;21:1549-1553.
46. Han JH, Kim DG, Chung HT, et al. Long-term outcome of gamma knife radiosurgery for treatment of typical trigeminal neuralgia. *Int J Radiat Oncol Biol Phys*. 2009;75:822-827.
47. Han I, Shin D, Chang J, et al. Effect of various surgical modalities in recurrent or persistent trigeminal neuralgia. *Stereotact Funct Neurosurg*. 2010;88:156-162.
48. Hannan C, Shoakazemi A, Quigley G. Microvascular decompression for trigeminal neuralgia: a regional unit's experience. *Ulster Med J*. 2018;87:30-33.
49. Heinskou TB, Rochat P, Maarbjerg S, et al. Prognostic factors for outcome of microvascular decompression in trigeminal neuralgia: a prospective systematic study using independent assessors. *Cephalalgia*. 2019;39:197-208.
50. Helis CA, Lucas JT Jr, Bourland JD, Chan MD, Tatter SB, Laxton AW. Repeat radiosurgery for trigeminal neuralgia. *Neurosurgery*. 2015;77:755-761 [discussion: 761].
51. Honey CM, Kaufmann AM. Trigeminal neuralgia due to vertebralbasilar artery compression. *World Neurosurg*. 2018;118:e155-e160.
52. Ibrahim TF, Garst JR, Burkett DJ, et al. Microsurgical pontine descending tractotomy in cases of intractable trigeminal neuralgia. *Oper Neurosurg (Hagerstown)*. 2015;11:518-529.
53. Inoue T, Hirai H, Shima A, Suzuki F, Fukushima T, Matsuda M. Diagnosis and

- management for trigeminal neuralgia caused solely by venous compression. *Acta Neurochir (Wien)*. 2017;159:681-688.
54. Inoue T, Hirai H, Shima A, et al. Long-term outcomes of microvascular decompression and Gamma Knife surgery for trigeminal neuralgia: a retrospective comparison study. *Acta Neurochir (Wien)*. 2017;159:2127-2135.
 55. Jung HH, Park CK, Jung NY, Kim M, Chang WS, Chang JW. Gamma knife radiosurgery for idiopathic trigeminal neuralgia: does the status of offending vessels influence pain control or side effects? *World Neurosurg*. 2017;104:687-693.
 56. Kang IH, Park BJ, Park CK, Malla HP, Lee SH, Rhee BA. A Clinical analysis of secondary surgery in trigeminal neuralgia patients who failed prior treatment. *J Korean Neurosurg Soc*. 2016;59:637-642.
 57. Kano H, Kondziolka D, Yang HC, et al. Outcome predictors after gamma knife radiosurgery for recurrent trigeminal neuralgia. *Neurosurgery*. 2010;67:1637-1644 [discussion: 1635-1644].
 58. Kano H, Awan NR, Flannery TJ, et al. Stereotactic radiosurgery for patients with trigeminal neuralgia associated with petroclival meningiomas. *Stereotact Funct Neurosurg*. 2011;89:17-24.
 59. Karam SD, Tai A, Snider JW, et al. Refractory trigeminal neuralgia treatment outcomes following CyberKnife radiosurgery. *Radiat Oncol*. 2014;9:257.
 60. Karam SD, Tai A, Wooster M, et al. Trigeminal neuralgia treatment outcomes following Gamma Knife radiosurgery with a minimum 3-year follow-up. *J Radiat Oncol*. 2014;3:125-130.
 61. Kerolus MG, Sen N, Mayekar S, et al. Truebeam radiosurgery for the treatment of trigeminal neuralgia: preliminary results at a single institution. *Cureus*. 2017;9:e1362.
 62. Kim SK, Kim DG, Se Y-B, et al. Gamma Knife surgery for tumor-related trigeminal neuralgia: targeting both the tumor and the trigeminal root exit zone in a single session. *J Neurosurg*. 2016;125:838-844.
 63. Kimball BY, Sorenson JM, Cunningham D. Repeat Gamma Knife surgery for trigeminal neuralgia: long-term results. *J Neurosurg*. 2010;113(suppl):178-183.
 64. Ko AL, Ozpinar A, Lee A, Raslan AM, McCartney S, Burchiel KJ. Long-term efficacy and safety of internal neurolysis for trigeminal neuralgia without neurovascular compression. *J Neurosurg*. 2015;122:1048-1057.
 65. Kondziolka D, Zorro O, Lobato-Polo J, et al. Gamma Knife stereotactic radiosurgery for idiopathic trigeminal neuralgia. *J Neurosurg*. 2010;112:758-765.
 66. Kotecha R, Kotecha R, Modugula S, et al. Trigeminal neuralgia treated with stereotactic radiosurgery: the effect of dose escalation on pain control and treatment outcomes. *Int J Radiat Oncol Biol Phys*. 2016;96:142-148.
 67. Kotecha R, Miller JA, Modugula S, et al. Stereotactic radiosurgery for trigeminal neuralgia improves patient-reported quality of life and reduces depression. *Int J Radiat Oncol Biol Phys*. 2017;98:1078-1086.
 68. Lai GH, Tang YZ, Wang XP, Qin HJ, Ni JX. CT-guided percutaneous radiofrequency thermocoagulation for recurrent trigeminal neuralgia after microvascular decompression: a cohort study. *Medicine (Baltimore)*. 2015;94:e1176.
 69. Lee CC, Chen CJ, Chong ST, et al. Early stereotactic radiosurgery for medically refractory trigeminal neuralgia. *World Neurosurg*. 2018;112:e569-e575.
 70. Li P, Wang W, Liu Y, Zhong Q, Mao B. Clinical outcomes of 114 patients who underwent gamma-knife radiosurgery for medically refractory idiopathic trigeminal neuralgia. *J Clin Neurosci*. 2012;19:71-74.
 71. Liang X, Dong X, Zhao S, Ying X, Du Y, Yu W. A retrospective study of neurocombing for the treatment of trigeminal neuralgia without neurovascular compression. *Ir J Med Sci*. 2017;186:1033-1039.
 72. Little AS, Shetter AG, Shetter ME, Bay C, Rogers CL. Long-term pain response and quality of life in patients with typical trigeminal neuralgia treated with gamma knife stereotactic radiosurgery. *Neurosurgery*. 2008;63:915-923 [discussion: 914-923].
 73. Little AS, Shetter AG, Shetter ME, Kakarla UK, Rogers CL. Salvage gamma knife stereotactic radiosurgery for surgically refractory trigeminal neuralgia. *Int J Radiat Oncol Biol Phys*. 2009;74:522-527.
 74. Lloyd S, Chung DH, Colaco RJ, Goodrich I, Cardinale FS. The effect of dose and other parameters on outcomes in CyberKnife stereotactic radiosurgery for trigeminal neuralgia. *J Radiat Oncol*. 2015;4:387-394.
 75. Marshall K, Chan MD, McCoy TP, et al. Predictive variables for the successful treatment of trigeminal neuralgia with gamma knife radiosurgery. *Neurosurgery*. 2012;70:566-572 [discussion: 563-572].
 76. Mathieu D, Effendi K, Blanchard J, Seguin M. Comparative study of Gamma Knife surgery and percutaneous retrogasserian glycerol rhizotomy for trigeminal neuralgia in patients with multiple sclerosis. *J Neurosurg*. 2012;117(suppl):175-180.
 77. Matsuda S, Nagano O, Serizawa T, Higuchi Y, Ono J. Trigeminal nerve dysfunction after Gamma Knife surgery for trigeminal neuralgia: a detailed analysis. *J Neurosurg*. 2010;113(suppl):184-190.
 78. McLaughlin N, Buxey F, Chaw K, Martin NA. Value-based neurosurgery: the example of microvascular decompression surgery. *J Neurosurg*. 2014;120:462-472.
 79. Montano N, Papacci F, Cioni B, Di Bonaventura R, Meglio M. Percutaneous balloon compression for the treatment of trigeminal neuralgia in patients with multiple sclerosis. Analysis of the potentially prognostic factors. *Acta Neurochir (Wien)*. 2012;154:779-783.
 80. Montano N, Papacci F, Cioni B, Di Bonaventura R, Meglio M. The role of percutaneous balloon compression in the treatment of trigeminal neuralgia recurring after other surgical procedures. *Acta Neurol Belg*. 2014;114:59-64.
 81. Mousavi SH, Niranjan A, Huang MJ, et al. Early radiosurgery provides superior pain relief for trigeminal neuralgia patients. *Neurology*. 2015;85:2159-2165.
 82. Mousavi SH, Sekula RF, Gildengers A, Gardner P, Lunsford LD. Concomitant depression and anxiety negatively affect pain outcomes in surgically managed young patients with trigeminal neuralgia: long-term clinical outcome. *Surg Neurol Int*. 2016;7:98.
 83. Mousavi SH, Niranjan A, Akpınar B, et al. A proposed plan for personalized radiosurgery in patients with trigeminal neuralgia. *J Neurosurg*. 2018;128:452-459.
 84. Nanda A, Javalkar V, Zhang S, Ahmed O. Long term efficacy and patient satisfaction of microvascular decompression and gamma knife radiosurgery for trigeminal neuralgia. *J Clin Neurosci*. 2015;22:818-822.
 85. Niranjan A, Lunsford LD. Radiosurgery for the management of refractory trigeminal neuralgia. *Neurol India*. 2016;64:624-629.
 86. Noorani I, Lodge A, Vajramani G, Sparrow O. Comparing percutaneous treatments of trigeminal neuralgia: 19 years of experience in a single centre. *Stereotact Funct Neurosurg*. 2016;94:75-85.
 87. Park KJ, Kano H, Berkowitz O, et al. Computed tomography-guided gamma knife stereotactic radiosurgery for trigeminal neuralgia. *Acta Neurochir (Wien)*. 2011;153:1601-1609.
 88. Park SH, Hwang SK. Outcomes of gamma knife radiosurgery for trigeminal neuralgia after a minimum 3-year follow-up. *J Clin Neurosci*. 2011;18:645-648.
 89. Park SH, Hwang SK, Kang DH, Park J, Hwang JH, Sung JK. The retrogasserian zone versus dorsal root entry zone: comparison of two targeting techniques of gamma knife radiosurgery for trigeminal neuralgia. *Acta Neurochir (Wien)*. 2010;152:1165-1170.
 90. Park YS, Kim JP, Chang WS, Kim HY, Park YG, Chang JW. Gamma knife radiosurgery for idiopathic trigeminal neuralgia as primary vs. secondary treatment option. *Clin Neurol Neurosurg*. 2011;113:447-452.
 91. Park KJ, Kondziolka D, Berkowitz O, et al. Repeat gamma knife radiosurgery for trigeminal neuralgia. *Neurosurgery*. 2012;70:295-305 [discussion: 305].
 92. Park KJ, Kondziolka D, Kano H, et al. Outcomes of Gamma Knife surgery for trigeminal neuralgia secondary to vertebrobasilar ectasia. *J Neurosurg*. 2012;116:73-81.
 93. Park SC, Kwon DH, Lee DH, Lee JK. Repeat gamma-knife radiosurgery for refractory or recurrent trigeminal neuralgia with consideration about the optimal second dose. *World Neurosurg*. 2016;86:371-383.

94. Pokhrel D, Sood S, McClintock C, et al. Linac-based stereotactic radiosurgery (SRS) in the treatment of refractory trigeminal neuralgia: detailed description of SRS procedure and reported clinical outcomes. *J Appl Clin Med Phys*. 2017;18:136-143.
95. Raygor KP, Wang DD, Ward MM, Barbaro NM, Chang EF. Long-term pain outcomes for recurrent idiopathic trigeminal neuralgia after stereotactic radiosurgery: a prospective comparison of first-time microvascular decompression and repeat stereotactic radiosurgery [e-pub ahead of print]. *J Neurosurg*. 2018. <https://doi.org/10.3171/2018.5.JNS172243>, accessed May 25, 2019.
96. Regis J, Tuleasca C, Resseguier N, et al. The very long-term outcome of radiosurgery for classical trigeminal neuralgia. *Stereotact Funct Neurosurg*. 2016;94:24-32.
97. Regis J, Tuleasca C, Resseguier N, et al. Long-term safety and efficacy of Gamma Knife surgery in classical trigeminal neuralgia: a 497-patient historical cohort study. *J Neurosurg*. 2016;124:1079-1087.
98. Riesenburger RI, Hwang SW, Schirmer CM, et al. Outcomes following single-treatment Gamma Knife surgery for trigeminal neuralgia with a minimum 3-year follow-up. *J Neurosurg*. 2010;112:766-771.
99. Romanelli P, Conti A, Bianchi L, Bergantin A, Martinotti A, Beltramo G. Image-guided robotic radiosurgery for trigeminal neuralgia. *Neurosurgery*. 2018;83:1023-1030.
100. Ruiz-Juretschke F, Vargas AJ, Gonzalez-Quarante LH, Gil de Sagredo OL, Montalvo A, Fernandez-Carballal C. Microsurgical treatment of trigeminal neuralgia in patients older than 70 years: an efficacy and safety study. *Neurologia*. 2017;32:424-430.
101. Setty P, Volkov AA, D'Andrea KP, Pieper DR. Endoscopic vascular decompression for the treatment of trigeminal neuralgia: clinical outcomes and technical note. *World Neurosurg*. 2014;81:603-608.
102. Sharim J, Lo WL, Kim W, et al. Radiosurgical target distance from the root entry zone in the treatment of trigeminal neuralgia. *Pract Radiat Oncol*. 2017;7:221-227.
103. Sheehan JP, Ray DK, Monteith S, et al. Gamma Knife radiosurgery for trigeminal neuralgia: the impact of magnetic resonance imaging-detected vascular impingement of the affected nerve. *J Neurosurg*. 2010;113:53-58.
104. Shields LBE, Shanks TS, Shearer AJ, et al. Frameless image-guided radiosurgery for trigeminal neuralgia. *Surg Neurol Int*. 2017;8:87.
105. Son BC, Kim HS, Kim IS, Yang SH, Lee SW. Percutaneous radiofrequency thermocoagulation under fluoroscopic image-guidance for idiopathic trigeminal neuralgia. *J Korean Neurosurg Soc*. 2011;50:446-452.
106. Steinberg JA, Sack J, Wilson B, et al. Tentorial sling for microvascular decompression in patients with trigeminal neuralgia: a description of operative technique and clinical outcomes [e-pub ahead of print]. *J Neurosurg*. 2018. <https://doi.org/10.3171/2017.10.JNS17971>, accessed May 25, 2019.
107. Sun S, Jiang W, Wang J, et al. Clinical analysis and surgical treatment of trigeminal neuralgia caused by vertebralbasilar dolichoectasia: a retrospective study. *Int J Surg*. 2017;41:183-189.
108. Taich ZJ, Goetsch SJ, Monaco E, et al. Stereotactic radiosurgery treatment of trigeminal neuralgia: clinical outcomes and prognostic factors. *World Neurosurg*. 2016;90:604-612 e611.
109. Tang YZ, Jin D, Li XY, Lai GH, Li N, Ni JX. Repeated CT-guided percutaneous radiofrequency thermocoagulation for recurrent trigeminal neuralgia. *Eur Neurol*. 2014;72:54-59.
110. Tuleasca C, Carron R, Resseguier N, et al. Decreased probability of initial pain cessation in classic trigeminal neuralgia treated with gamma knife surgery in case of previous microvascular decompression: a prospective series of 45 patients with >1 year of follow-up. *Neurosurgery*. 2015;77:87-94 [discussion: 85-94].
111. Tuleasca C, Carron R, Resseguier N, et al. Repeat Gamma Knife surgery for recurrent trigeminal neuralgia: long-term outcomes and systematic review. *J Neurosurg*. 2014;121(suppl):210-221.
112. Tuleasca C, Carron R, Resseguier N, et al. Trigeminal neuralgia related to megadolichobasilar artery compression: a prospective series of twenty-nine patients treated with gamma knife surgery, with more than one year of follow-up. *Stereotact Funct Neurosurg*. 2014;92:170-177.
113. Tuleasca C, Carron R, Resseguier N, et al. Multiple sclerosis-related trigeminal neuralgia: a prospective series of 43 patients treated with gamma knife surgery with more than one year of follow-up. *Stereotact Funct Neurosurg*. 2014;92:203-210.
114. ul Haq N, Ali M, Khan HM, Ishaq M, Khattak MI. Immediate pain relief by microvascular decompression for idiopathic trigeminal neuralgia. *J Ayub Med Coll Abbottabad*. 2016;28:52-55.
115. Verheul JB, Hanssens PE, Lie ST, Leenstra S, Piersma H, Beute GN. Gamma Knife surgery for trigeminal neuralgia: a review of 450 consecutive cases. *J Neurosurg*. 2010;113(suppl):160-167.
116. Wan Q, Zhang D, Cao X, Zhang Y, Zhu M, Zuo W. CT-guided selective percutaneous radiofrequency thermocoagulation via the foramen rotundum for isolated maxillary nerve idiopathic trigeminal neuralgia. *J Neurosurg*. 2018;128:211-214.
117. Wang L, Zhao ZW, Qin HZ, et al. Repeat gamma knife radiosurgery for recurrent or refractory trigeminal neuralgia. *Neurol India*. 2008;56:36-41.
118. Wang Y, Zhang S, Wang W, et al. Gamma knife surgery for recurrent trigeminal neuralgia in cases with previous microvascular decompression. *World Neurosurg*. 2018;110:e593-e598.
119. Wei Y, Zhao W, Pu C, et al. Clinical features and long-term surgical outcomes in 39 patients with tumor-related trigeminal neuralgia compared with 360 patients with idiopathic trigeminal neuralgia. *Br J Neurosurg*. 2017;31:101-106.
120. Wolf A, Tyburczy A, Ye JC, Fatterpekar G, Silverman JS, Kondziolka D. The relationship of dose to nerve volume in predicting pain recurrence after stereotactic radiosurgery in trigeminal neuralgia. *J Neurosurg*. 2018;128:891-896.
121. Xu Z, Mathieu D, Heroux F, et al. Stereotactic radiosurgery for trigeminal neuralgia in patients with multiple sclerosis: a multicenter study. *Neurosurgery*. 2019;84:499-505.
122. Yao P, Deng YY, Hong T, et al. Radiofrequency thermocoagulation for V2/V3 idiopathic trigeminal neuralgia: effect of treatment temperatures on long-term clinical outcomes: a cohort study. *Medicine (Baltimore)*. 2016;95:e4019.
123. Yao P, Hong T, Wang ZB, et al. Treatment of bilateral idiopathic trigeminal neuralgia by radiofrequency thermocoagulation at different temperatures. *Medicine (Baltimore)*. 2016;95:e4274.
124. Yao P, Hong T, Zhu YQ, et al. Efficacy and safety of continuous radiofrequency thermocoagulation plus pulsed radiofrequency for treatment of V1 trigeminal neuralgia: a prospective cohort study. *Medicine (Baltimore)*. 2016;95:e5247.
125. Ying X, Wang H, Deng S, Chen Y, Zhang J, Yu W. Long-term outcome of percutaneous balloon compression for trigeminal neuralgia patients elder than 80 years: a STROBE-compliant article. *Medicine (Baltimore)*. 2017;96:e8199.
126. Zahra H, Teh BS, Paulino AC, et al. Stereotactic radiosurgery for trigeminal neuralgia utilizing the BrainLAB Novalis system. *Technol Cancer Res Treat*. 2009;8:407-412.
127. Zeng YJ, Zhang H, Yu S, Zhang W, Sun XC. Efficacy and safety of microvascular decompression and gamma knife surgery treatments for patients with primary trigeminal neuralgia: a prospective study. *World Neurosurg*. 2018;116:e113-e117.
128. Zhang H, Lei D, You C, Mao BY, Wu B, Fang Y. The long-term outcome predictors of pure microvascular decompression for primary trigeminal neuralgia. *World Neurosurg*. 2013;79:756-762.
129. Zhang X, Li P, Zhang S, Gong F, Yang S, Wang W. Effect of radiation dose on the outcomes of gamma knife treatment for trigeminal neuralgia: a multi-factor analysis. *Neurol India*. 2014;62:400-405.
130. Zhao H, Fan SQ, Wang XH, et al. Evaluation of microvascular decompression as rescue therapy for trigeminal neuralgia in patients with failed gamma knife surgery. *World Neurosurg*. 2018;116:e86-e91.
131. Zhao Y, Zhang X, Yao J, Li H, Jiang Y. Microvascular decompression for trigeminal neuralgia due to venous compression alone. *J Craniofac Surg*. 2018;29:178-181.
132. Zhao YX, Miao SH, Tang YZ, et al. Trigeminal somatosensory-evoked potential: a neurophysiological tool to monitor the extent of lesion of ganglion radiofrequency thermocoagulation in idiopathic trigeminal neuralgia: a case-control study. *Medicine (Baltimore)*. 2017;96:e5872.

133. Zhao H, Shen Y, Yao D, Xiong N, Abdelmaksoud A, Wang H. Outcomes of two-isocenter gamma knife radiosurgery for patients with typical trigeminal neuralgia: pain response and quality of life. *World Neurosurg.* 2018;109: e531-e538.
134. Zorro O, Lobato-Polo J, Kano H, Flickinger JC, Lunsford LD, Kondziolka D. Gamma knife radiosurgery for multiple sclerosis-related trigeminal neuralgia. *Neurology.* 2009;73:1149-1154.
135. Bigder MG, Krishnan S, Cook EF, Kaufmann AM. Microsurgical rhizotomy for trigeminal neuralgia in MS patients: technique, patient satisfaction, and clinical outcomes [e-pub ahead of print]. *J Neurosurg.* 2018. <https://doi.org/10.3171/2017.12.JNS171647>, accessed May 25, 2019.
136. Cohen J, Mousavi SH, Faraji AH, et al. Stereotactic Radiosurgery as initial surgical management for elderly patients with trigeminal neuralgia. *Stereotact Funct Neurosurg.* 2017;95: 158-165.
137. Chen AY, Hsieh Y, McNair S, Li Q, Xu KY, Pappas C. Frame and frameless linear accelerator-based radiosurgery for idiopathic trigeminal neuralgia. *J Radiosurg SBRT.* 2015;3: 259-270.
138. Abdel-Rahman KA, Elawamy AM, Mostafa MF, et al. Combined pulsed and thermal radiofrequency versus thermal radiofrequency alone in the treatment of recurrent trigeminal neuralgia after microvascular decompression: a double blinded comparative study. *Eur J Pain.* 2020;24: 338-345.
139. Montano N, Gaudino S, Giordano C, et al. Possible prognostic role of magnetic resonance imaging findings in patients with trigeminal neuralgia and multiple sclerosis who underwent percutaneous balloon compression: report of our series and literature review. *World Neurosurg.* 2019; 125:e575-e581.
140. Panczykowski DM, Jani RH, Hughes MA, Sekula RF. Development and evaluation of a preoperative trigeminal neuralgia scoring system to predict long-term outcome following microvascular decompression [e-pub ahead of print]. *Neurosurgery.* 2019. <https://doi.org/10.1093/neuros/ny2376>, accessed May 25, 2019.
141. Staudt MD, Joswig H, Pickett GE, MacDougall KW, Parrent AG. Percutaneous glycerol rhizotomy for trigeminal neuralgia in patients with multiple sclerosis: a long-term retrospective cohort study [e-pub ahead of print]. *J Neurosurg.* 2019. <https://doi.org/10.3171/2019.1.JNS183093>, accessed May 25, 2019.
142. Stone LE, Falowski SM. A retrospective review of the outcomes and utility of percutaneous radiofrequency rhizotomy for trigeminal neuralgia using anatomic landmark guidance in asleep patients [e-pub ahead of print]. *Oper Neurosurg (Hagerstown).* 2019. <https://doi.org/10.1093/ons/op2215>, accessed May 25, 2019.
143. Xie E, Garzon-Muvdi T, Bender M, et al. Association between radiofrequency rhizotomy parameters and duration of pain relief in trigeminal neuralgia patients with recurrent pain. *World Neurosurg.* 2019;129:e128-e133.
144. Alahmadi H, Zadeh G, Laperriere N, et al. Trigeminal nerve integrated dose and pain outcome after gamma knife radiosurgery for trigeminal neuralgia. *J Radiosurg SBRT.* 2012;1:295-301.
145. Alvarez-Pinzon AM, Wolf AL, Swedberg HN, et al. Comparison of percutaneous retrogasserian balloon compression and Gamma knife radiosurgery for the treatment of trigeminal neuralgia in multiple sclerosis. *World Neurosurg.* 2017;97: 590-594.
146. Ariai MS, Mallory GW, Pollock BE. Outcomes after microvascular decompression for patients with trigeminal neuralgia and suspected multiple sclerosis. *World Neurosurg.* 2014;81:599-603.
147. Asplund P, Linderth B, Bergenheim AT. The predictive power of balloon shape and change of sensory functions on outcome of percutaneous balloon compression for trigeminal neuralgia. *J Neurosurg.* 2010;113:498-507.
148. Asplund P, Blomstedt P, Bergenheim AT. Percutaneous balloon compression vs percutaneous retrogasserian glycerol rhizotomy for the primary treatment of trigeminal neuralgia. *Neurosurgery.* 2016;78:421-428 [discussion: 428].
149. Aydoseli A, Akcakaya MO, Aras Y, et al. Neuro-navigation-assisted percutaneous balloon compression for the treatment of trigeminal neuralgia: the technique and short-term clinical results. *Br J Neurosurg.* 2015;29:552-558.
150. Chai Y, Chen M, Zhang W, Zhang W. Predicting the outcome of microvascular decompression for primary trigeminal neuralgia by the use of magnetic resonance tomographic angiography. *J Craniofac Surg.* 2013;24:1699-1702.
151. Chakravarthy PS, Ghanta R, Kattimani V. Microvascular decompression treatment for trigeminal neuralgia. *J Craniofac Surg.* 2011;22:894-898.
152. Chandan S, Halli R, Sane VD. Peripheral neurectomy: minimally invasive surgical modality for trigeminal neuralgia in Indian population: a retrospective analysis of 20 cases. *J Maxillofac Oral Surg.* 2014;13:295-299.
153. Chen J-F, Lee S-T. Comparison of percutaneous trigeminal ganglion compression and microvascular decompression for the management of trigeminal neuralgia. *Clin Neurol Neurosurg.* 2003;105: 203-208.
154. Chen JF, Tu PH, Lee ST. Long-term follow-up of patients treated with percutaneous balloon compression for trigeminal neuralgia in Taiwan. *World Neurosurg.* 2011;76:586-591.
155. Chen JF, Tu PH, Lee ST. Repeated percutaneous balloon compression for recurrent trigeminal neuralgia: a long-term study. *World Neurosurg.* 2012;77:352-356.
156. Chen JN, Yu WH, Du HG, Jiang L, Dong XQ, Cao J. Prospective comparison of redo microvascular decompression and percutaneous balloon compression as primary surgery for recurrent trigeminal neuralgia. *J Korean Neurosurg Soc.* 2018;61:747-752.
157. Erdem E, Alkan A. Peripheral glycerol injections in the treatment of idiopathic trigeminal neuralgia: retrospective analysis of 157 cases. *J Oral Maxillofac Surg.* 2001;59:1176-1180.
158. Fraioli MF, Cristino B, Moschettoni L, Cacciotti G, Fraioli C. Validity of percutaneous controlled radiofrequency thermocoagulation in the treatment of isolated third division trigeminal neuralgia. *Surg Neurol.* 2009;71:180-183.
159. Fromm GH, Terrence CF, Chattha AS. Baclofen in the treatment of trigeminal neuralgia: double-blind study and long-term follow-up. *Ann Neurol.* 1984;15:240-244.
160. Fromm GH, Terrence CF. Comparison of L-baclofen and racemic baclofen in trigeminal neuralgia. *Neurology.* 1987;37:1725-1728.
161. Goodwin CR, Yang JX, Bettgowda C, et al. Glycerol rhizotomy via a retrosigmoid approach as an alternative treatment for trigeminal neuralgia. *Clin Neurol Neurosurg.* 2013;115:2454-2456.
162. Gunther T, Gerganov VM, Stieglitz L, Ludemann W, Samii A, Samii M. Microvascular decompression for trigeminal neuralgia in the elderly: long-term treatment outcome and comparison with younger patients. *Neurosurgery.* 2009; 65:477-482 [discussion: 482].
163. Hamasaki T, Yano S, Nakamura K, Yamada K. Pregabalin as a salvage preoperative treatment for refractory trigeminal neuralgia. *J Clin Neurosci.* 2018;47:240-244.
164. Han KR, Chae YJ, Lee JD, Kim C. Trigeminal nerve block with alcohol for medically intractable classic trigeminal neuralgia: long-term clinical effectiveness on pain. *Int J Med Sci.* 2017;14:29-36.
165. Harries AM, Mitchell RD. Percutaneous glycerol rhizotomy for trigeminal neuralgia: safety and efficacy of repeat procedures. *Br J Neurosurg.* 2011; 25:268-272.
166. Hart MG, Nowell M, Coakham HB. Radiofrequency thermocoagulation for trigeminal neuralgia without intra-operative patient waking. *Br J Neurosurg.* 2012;26:392-396.
167. Hayashi M. Trigeminal neuralgia. *Prog Neurol Surg.* 2009;22:182-190.
168. Hayashi M, Chernov M, Tamura N, et al. Stereotactic radiosurgery of essential trigeminal neuralgia using Leksell Gamma Knife model C with automatic positioning system: technical nuances and evaluation of outcome in 130 patients with at least 2 years follow-up after treatment. *Neurosurg Rev.* 2011;34:497-508.
169. Holland MT, Teferi N, Noeller J, et al. Stereotactic radio surgery and radio frequency rhizotomy for trigeminal neuralgia in multiple sclerosis: a single institution experience. *Clin Neurol Neurosurg.* 2017;162:80-84.
170. Huang Y, Ni J, Wu B, He M, Yang L, Wang Q. Percutaneous radiofrequency thermocoagulation for the treatment of different types of trigeminal neuralgia: evaluation of quality of life and outcomes. *J Huazhong Univ Sci Technolog Med Sci.* 2010; 30:403-407.
171. Huibin Q, Jianxing L, Guangyu H, Dianen F. The treatment of first division idiopathic trigeminal

- neuralgia with radiofrequency thermocoagulation of the peripheral branches compared to conventional radiofrequency. *J Clin Neurosci*. 2009;16:1425-1429.
172. Jaffee DJ, Zakrzewska JM. Long-term pain relief at five years after medical, repeat surgical procedures or no management for recurrence of trigeminal neuralgia after microvascular decompression: analysis of a historical cohort. *Br J Neurosurg*. 2019;33:31-36.
173. Kabatas S, Albayrak SB, Cansever T, Heppgul KT. Microvascular decompression as a surgical management for trigeminal neuralgia: a critical review of the literature. *Neurol India*. 2009;57:134-138.
174. Khan SA, Khan B, Khan AA, et al. Microvascular decompression for trigeminal neuralgia. *J Ayub Med Coll Abbottabad*. 2015;27:539-542.
175. Kosugi S, Shiotani M, Otsuka Y, et al. Long-term outcomes of percutaneous radiofrequency thermocoagulation of gasserian ganglion for 2nd- and multiple-division trigeminal neuralgia. *Pain Pract*. 2015;15:223-228.
176. Kouzounias K, Lind G, Schechtmann G, Winter J, Linderth B. Comparison of percutaneous balloon compression and glycerol rhizotomy for the treatment of trigeminal neuralgia. *J Neurosurg*. 2010;113:486-492.
177. Kouzounias K, Schechtmann G, Lind G, Winter J, Linderth B. Factors that influence outcome of percutaneous balloon compression in the treatment of trigeminal neuralgia. *Neurosurgery*. 2010;67:925-934 [discussion: 934].
178. Kuncz A, Voros E, Barzo P, et al. Comparison of clinical symptoms and magnetic resonance angiographic (MRA) results in patients with trigeminal neuralgia and persistent idiopathic facial pain. Medium-term outcome after microvascular decompression of cases with positive MRA findings. *Cephalalgia*. 2006;26:266-276.
179. Lazzara BM, Ortiz O, Bordia R, et al. Cyberknife radiosurgery in treating trigeminal neuralgia. *J Neurointerv Surg*. 2013;5:81-85.
180. Liao C, Zhang W, Yang M, Zhong W, Liu P, Li S. Microvascular decompression for trigeminal neuralgia: the role of mechanical allodynia. *World Neurosurg*. 2016;91:468-472.
181. Lichter T, Mullan JF. A 10-year follow-up review of percutaneous microcompression of the trigeminal ganglion. *J Neurosurg*. 1990;72:49-54.
182. Liu P, Zhong W, Liao C, Yang M, Zhang W. The role of percutaneous radiofrequency thermocoagulation for persistent or recurrent trigeminal neuralgia after surgery. *J Craniofac Surg*. 2016;27:e752-e755.
183. Loescher AR, Radatz M, Kemeny A, Rowe J. Stereotactic radiosurgery for trigeminal neuralgia: outcomes and complications. *Br J Neurosurg*. 2012;26:45-52.
184. Martinez-Anda JJ, Barges-Coll J, Ponce-Gomez JA, Perez-Pena N, Revuelta-Gutierrez R. Surgical management of trigeminal neuralgia in elderly patients using a small retrosigmoidal approach: analysis of efficacy and safety. *J Neurol Surg A Cent Eur Neurosurg*. 2015;76:39-45.
185. Meglio M, Cioni B, Moles A, Visocchi M. Microvascular decompression versus percutaneous procedures for typical trigeminal neuralgia: personal experience. *Stereotact Funct Neurosurg*. 1990;54-55:76-79.
186. Mizobuchi Y, Ohtani M, Satomi J, Fushimi K, Matsuda S, Nagahiro S. The current status of microvascular decompression for the treatment of trigeminal neuralgia in Japan: An analysis of 1619 patients using the Japanese Diagnosis Procedure Combination Database. *Neurol Med Chir (Tokyo)*. 2018;58:10-16.
187. Nally FF. A 22-year study of paroxysmal trigeminal neuralgia in 211 patients with a 3-year appraisal of the role of cryotherapy. *Oral Surg Oral Med Oral Pathol*. 1984;58:17-23.
188. Obermann M, Yoon MS, Sensen K, Maschke M, Diener HC, Katsarava Z. Efficacy of pregabalin in the treatment of trigeminal neuralgia. *Cephalalgia*. 2008;28:174-181.
189. Oesman C, Mooij JJ. Long-term follow-up of microvascular decompression for trigeminal neuralgia. *Skull Base*. 2011;21:313-322.
190. Omeis I, Smith D, Kim S, Murali R. Percutaneous balloon compression for the treatment of recurrent trigeminal neuralgia: long-term outcome in 29 patients. *Stereotact Funct Neurosurg*. 2008;86:259-265.
191. Pandia MP, Dash HH, Bithal PK, Chouhan RS, Jain V. Does egress of cerebrospinal fluid during percutaneous retrogasserian glycerol rhizotomy influence long term pain relief? *Reg Anesth Pain Med*. 2008;33:222-226.
192. Pathmanaban ON, O'Brien F, Al-Tamimi YZ, Hammerbeck-Ward CL, Rutherford SA, King AT. Safety of superior petrosal vein sacrifice during microvascular decompression of the trigeminal nerve. *World Neurosurg*. 2017;103:84-87.
193. Revuelta-Gutierrez R, Martinez-Anda JJ, Coll JB, Campos-Romo A, Perez-Pena N. Efficacy and safety of root compression of trigeminal nerve for trigeminal neuralgia without evidence of vascular compression. *World Neurosurg*. 2013;80:385-389.
194. Ryu H, Yamamoto S, Sugiyama K, Yokota N, Tanaka T. Neurovascular decompression for trigeminal neuralgia in elderly patients. *Neurol Med Chir (Tokyo)*. 1999;39:226-229 [discussion: 229-230].
195. Siwawetpikul P, Leing-Udom A. A "reposition technique" microvascular decompression in trigeminal neuralgia: clinical outcomes and complications. *J Med Assoc Thai*. 2016;99(suppl 3):S39-S46.
196. Son DW, Choi CH, Cha SH. Epidermoid tumors in the cerebellopontine angle presenting with trigeminal neuralgia. *J Korean Neurosurg Soc*. 2010;47:271-277.
197. Song ZX, Qian W, Wu YQ, et al. Effect of the gamma knife treatment on the trigeminal nerve root in Chinese patients with primary trigeminal neuralgia. *Turk Neurosurg*. 2014;24:163-169.
198. Stajcic Z, Juniper RP, Todorovic L. Peripheral streptomycin/lidocaine injections versus lidocaine alone in the treatment of idiopathic trigeminal neuralgia. A double blind controlled trial. *J Craniomaxillofac Surg*. 1990;18:243-246.
199. Sturman RH, O'Brien FH. Non-surgical treatment of tic douloureux with carbamazepine (G32883). *Headache*. 1969;9:88-91.
200. Taylor JC, Brauer S, Espir ML. Long-term treatment of trigeminal neuralgia with carbamazepine. *Postgrad Med J*. 1981;57:16-18.
201. Teixeira MJ, Siqueira SR, Almeida GM. Percutaneous radiofrequency rhizotomy and neurovascular decompression of the trigeminal nerve for the treatment of facial pain. *Arq Neuropsiquiatr*. 2006;64:983-989.
202. Tempel ZJ, Chivukula S, Monaco EA 3rd, et al. The results of a third Gamma Knife procedure for recurrent trigeminal neuralgia. *J Neurosurg*. 2015;122:169-179.
203. Teo MK, Suttner NJ. Effective management of lower division pain in trigeminal neuralgia using balloon traction. *Br J Neurosurg*. 2015;29:343-346.
204. Trojnik T, Smigoc T. Percutaneous trigeminal ganglion balloon compression rhizotomy: experience in 27 patients. *ScientificWorldJournal*. 2012;2012:328936.
205. Udupi BP, Chouhan RS, Dash HH, Bithal PK, Prabhakar H. Comparative evaluation of percutaneous retrogasserian glycerol rhizolysis and radiofrequency thermocoagulation techniques in the management of trigeminal neuralgia. *Neurosurgery*. 2012;70:407-412 [discussion: 403-412].
206. von Eckardstein KL, Mielke D, Akhavan-Sigari R, Rohde V. Enlightening the cerebellopontine angle: intraoperative indocyanine green angiography in microvascular decompression for trigeminal neuralgia. *J Neurol Surg A Cent Eur Neurosurg*. 2017;78:161-166.
207. Walsh TJ, Smith JL. Treatment of tic douloureux with tegretol. *Am J Ophthalmol*. 1966;61:550-552.
208. Walsh TJ, Smith JL. Tegretol—a new treatment for tic douloureux. *Headache*. 1968;8:62-64.
209. Xu SJ, Zhang WH, Chen T, Wu CY, Zhou MD. Neuronavigator-guided percutaneous radiofrequency thermocoagulation in the treatment of intractable trigeminal neuralgia. *Chin Med J (Engl)*. 2006;119:1528-1535.
210. Xu Z, Schlesinger D, Moldovan K, et al. Impact of target location on the response of trigeminal neuralgia to stereotactic radiosurgery. *J Neurosurg*. 2014;120:716-724.
211. Xu W, Jiang C, Yu C, Liang W. Percutaneous balloon compression for persistent or recurrent trigeminal neuralgia after microvascular decompression: personal experience of 28 patients. *Acta Neurol Belg*. 2018;118:561-566.
212. Xu-Hui W, Chun Z, Guang-Jian S, et al. Long-term outcomes of percutaneous retrogasserian glycerol rhizotomy in 3370 patients with trigeminal neuralgia. *Turk Neurosurg*. 2011;21:48-52.

213. Yadav S, Mittal HC, Sachdeva A, Verma A, Dhupar V, Dhupar A. A retrospective study of 72 cases diagnosed with idiopathic trigeminal neuralgia in Indian populace. *J Clin Exp Dent*. 2015;7: e40-e44.
214. Zakrzewska JM, Patsalos PN. Long-term cohort study comparing medical (oxcarbazepine) and surgical management of intractable trigeminal neuralgia. *Pain*. 2002;95:259-266.
215. Zhang LW, Liu YG, Wu CY, Xu SJ, Zhu SG. Radiofrequency thermocoagulation rhizotomy for recurrent trigeminal neuralgia after microvascular decompression. *Chin Med J (Engl)*. 2011;124: 3726-3730.
216. Zhang LW, Zhang Y, Li C, Zhu SG. Surgical treatment of primary trigeminal neuralgia: comparison of the effectiveness between MVD and MVD plus PSR in a series of 210 patients. *Turk Neurosurg*. 2012;22:32-38.
217. Zhao H, Tang Y, Zhang X, Li S. Microvascular decompression for idiopathic primary trigeminal neuralgia in patients over 75 years of age. *J Craniofac Surg*. 2016;27:1295-1297.
218. Zhu X. Electro-acupuncture combined with the trigger point needle-embedding for treatment of primary trigeminal neuralgia in 31 cases. *J Tradit Chin Med*. 2008;28:13-14.
219. Han KR, Kim C, Chae YJ, Kim DW. Efficacy and safety of high concentration lidocaine for trigeminal nerve block in patients with trigeminal neuralgia. *Int J Clin Pract*. 2008;62:248-254.
220. Walker J, Akhanjee LK, Cooney MM. Laser therapy for pain of trigeminal neuralgia. *Pain*. 1987;30(suppl 1):S85. Poster no: 165.
221. Tiwari AK, Agrawal A, Pathak AK, Kumar S, Goel K, Chandel S. Repeated peripheral alcohol injection is an effective treatment of Trigeminal Neuralgia in non-drug compliance patients. *Natl J Maxillofac Surg*. 2019;10:56-58.
222. Yilmaz N, Akdemir G, Akbay Y, Aslantürk Y, Ergüngör F. Microvascular decompression treatment of trigeminal neuralgia. *Eur J Gen Med*. 2005; 2:114-119.
223. Zhou X, Liu Y, Yue Z, Luan D, Zhang H, Han J. Comparison of nerve combing and percutaneous radiofrequency thermocoagulation in the treatment for idiopathic trigeminal neuralgia. *Braz J Otorhinolaryngol*. 2016;82:574-579.
224. Bender M, Pradilla G, Batra S, et al. Effectiveness of repeat glycerol rhizotomy in treating recurrent trigeminal neuralgia. *Neurosurgery*. 2012;70: 1125-1133 [discussion: 1124-1133].
225. Zhu S, Rong Q, Chen S, Li X. Pterygopalatine fossa segment neurectomy of maxillary nerve through maxillary sinus route in treating trigeminal neuralgia. *J Craniomaxillofac Surg*. 2013;41: 652-656.
226. Zhao S, Deng M, Cai H, et al. Clinical efficacy evaluation for treating trigeminal neuralgia using a personalized digital guide plate-assisted temperature-controlled radiofrequency. *J Craniofac Surg*. 2018;29:1322-1326.
227. Zhao H, Zhang X, Tang D, Li S. Nerve combing for trigeminal neuralgia without vascular compression. *J Craniofac Surg*. 2017;28:e15-e16.
228. Zhang X, Zhao H, Tang YD, Zhu J, Wang XH, Li ST. Comparison of the efficacy of reoperation, percutaneous radiofrequency thermocoagulation when microvascular decompression of trigeminal neuralgia is invalid. *J Craniofac Surg*. 2016;27: E688-E690.
229. Abdennebi B, Guenane L. Technical considerations and outcome assessment in retrogasserian balloon compression for treatment of trigeminal neuralgia. Series of 901 patients. *Surg Neurol Int*. 2014;5:118.
230. Adler JR Jr, Bower R, Gupta G, et al. Non-isocentric radiosurgical rhizotomy for trigeminal neuralgia. *Neurosurgery*. 2009;64(2 suppl): A84-A90.
231. Agrawal SM, Kambalimath DH. Peripheral neurectomy: a minimally invasive treatment for trigeminal neuralgia. A retrospective study. *J Maxillofac Oral Surg*. 2011;10:195-198.
232. Amagasaki K, Watanabe S, Naemura K, Shono N, Nakaguchi H. Safety of microvascular decompression for elderly patients with trigeminal neuralgia. *Clin Neurol Neurosurg*. 2016;141: 77-81.
233. Arias MJ. Percutaneous retrogasserian glycerol rhizotomy for trigeminal neuralgia. A prospective study of 100 cases. *J Neurosurg*. 1986;65:32-36.
234. Artz GJ, Hux FJ, Larouere MJ, Bojrab DI, Babu S, Pieper DR. Endoscopic vascular decompression. *Otol Neurotol*. 2008;29:995-1000.
235. Aubuchon AC, Chan MD, Lovato JF, et al. Repeat gamma knife radiosurgery for trigeminal neuralgia. *Int J Radiat Oncol Biol Phys*. 2011;81: 1059-1065.
236. Beck DW, Olson JJ, Urig EJ. Percutaneous retrogasserian glycerol rhizotomy for treatment of trigeminal neuralgia. *J Neurosurg*. 1986;65:28-31.
237. Bender MT, Pradilla G, Batra S, et al. Glycerol rhizotomy and radiofrequency thermocoagulation for trigeminal neuralgia in multiple sclerosis. *J Neurosurg*. 2013;118:329-336.
238. Berk C, Constantoyannis C, Honey CR. The treatment of trigeminal neuralgia in patients with multiple sclerosis using percutaneous radiofrequency rhizotomy. *Can J Neurol Sci*. 2003;30: 220-223.
239. Blitz AM, Northcutt B, Shin J, et al. Contrast-Enhanced CISS Imaging for Evaluation of Neurovascular Compression in Trigeminal Neuralgia: Improved Correlation with Symptoms and Prediction of Surgical Outcomes. *AJNR Am J Neuro-radiol*. 2018;39:1724-1732.
240. Bozkurt M, Al-Beyati ES, Ozdemir M, et al. Management of bilateral trigeminal neuralgia with trigeminal radiofrequency rhizotomy: a treatment strategy for the life-long disease. *Acta Neurochir (Wien)*. 2012;154:785-791 [discussion: 782-791].
241. Brisman R. Constant face pain in typical trigeminal neuralgia and response to gamma knife radiosurgery. *Stereotact Funct Neurosurg*. 2013;91: 122-128.
242. Chen L, Xu M, Zou Y. Treatment of trigeminal neuralgia with percutaneous glycerol injection into Meckel's cavity: experience in 4012 patients. *Cell Biochem Biophys*. 2010;58:85-89.
243. Cheshire WP Jr. Defining the role for gabapentin in the treatment of trigeminal neuralgia: a retrospective study. *J Pain*. 2002;3:137-142.
244. Chua NH, Halim W, Beems T, Vissers KC. Pulsed radiofrequency treatment for trigeminal neuralgia. *Anesth Pain Med*. 2012;1:257-261.
245. Davis EH. Clinical trials of tegretol in trigeminal neuralgia. *Headache*. 1969;9:77-82.
246. Dubey A, Yadav N, Ratte S, Parihar VS, Yadav YR. Full endoscopic vascular decompression in trigeminal neuralgia: experience of 230 patients. *World Neurosurg*. 2018;113:e612-e617.
247. Dvorak T, Finn A, Price LL, et al. Retreatment of trigeminal neuralgia with Gamma Knife radiosurgery: is there an appropriate cumulative dose? Clinical article. *J Neurosurg*. 2009;111:359-364.
248. Elawamy A, Abdalla EEM, Shehata GA. Effects of pulsed versus conventional versus combined radiofrequency for the treatment of trigeminal neuralgia: a prospective study. *Pain Physician*. 2017;20:E873-E881.
249. Graham JG, Zilkha KJ. Treatment of trigeminal neuralgia with carbamazepine: a follow-up study. *Br Med J*. 1966;1:210-211.
250. Grewal SS, Kerezoudis P, Garcia O, Quinones-Hinojosa A, Reimer R, Wharen RE. Results of percutaneous balloon compression in trigeminal pain syndromes. *World Neurosurg*. 2018;114: e892-e899.
251. Hai J, Li ST, Pan QG. Treatment of atypical trigeminal neuralgia with microvascular decompression. *Neurol India*. 2006;54:53-56 [discussion: 57].
252. Hong W, Zheng X, Wu Z, et al. Clinical features and surgical treatment of trigeminal neuralgia caused solely by venous compression. *Acta Neurochir (Wien)*. 2011;153:1037-1042.
253. Huang CF, Tu HT, Liu WS, Lin LY. Gamma Knife surgery for trigeminal pain caused by benign brain tumors. *J Neurosurg*. 2008;109(suppl): 154-159.
254. Huang C-F, Tu H-T, Liu W-S, Chiou S-Y, Lin L-Y. Gamma Knife surgery used as primary and repeated treatment for idiopathic trigeminal neuralgia. *J Neurosurg*. 2008;109(suppl):179-184.
255. Huang C, Wan Z, Wan C, Li Y, Zhong R. Clinical factors and safety of microvascular decompression in the treatment of trigeminal neuralgia. *Biomed Res (India)*. 2018;29:1845-1851.
256. Jagannath PM, Venkataramana NK, Bansal A, Ravichandra M. Outcome of microvascular decompression for trigeminal neuralgia using

- autologous muscle graft: a five-year prospective study. *Asian J Neurosurg.* 2012;7:125-130.
257. Jie H, Xuanchen Z, Deheng L, et al. The long-term outcome of nerve combing for trigeminal neuralgia. *Acta Neurochir (Wien).* 2013;155:1703-1708 [discussion: 1707].
258. Kang JH, Yoon YS, Kang DW, Chung SS, Chang JW. Gamma knife radiosurgery for medically refractory idiopathic trigeminal neuralgia. *Acta Neurochir Suppl.* 2008;101:35-38.
259. Kanpolat Y, Savas A, Bekar A, Berk C. Percutaneous controlled radiofrequency trigeminal rhizotomy for the treatment of idiopathic trigeminal neuralgia: 25-year experience with 1,600 patients. *Neurosurgery.* 2001;48:524-532 [discussion: 524-532].
260. Kher Y, Yadav N, Yadav YR, Parihar V, Ratre S, Bajaj J. Endoscopic vascular decompression in trigeminal neuralgia. *Turk Neurosurg.* 2017;27:998-1006.
261. Knafo H, Kenny B, Mathieu D. Trigeminal neuralgia: outcomes after gamma knife radiosurgery. *Can J Neurol Sci.* 2009;36:78-82.
262. Kondziolka D, Lunsford L, Flickinger JC. Stereotactic radiosurgery for the treatment of trigeminal neuralgia. *Clin J Pain.* 2002;18:42-47.
263. Koning MV, Koning NJ, Koning HM, van Kleef M. Relationship between sensory stimulation and side effects in percutaneous radiofrequency treatment of the trigeminal ganglion. *Pain Pract.* 2014;14:581-587.
264. Koning MV, Koning NJ, Koning HM. Reduced effect of percutaneous retrogasserian glycerol rhizolysis in trigeminal neuralgia affecting the third branch. *Pain Pract.* 2015;15:217-222.
265. Li S-T, Wang X, Pan Q, et al. Studies on the operative outcomes and mechanisms of microvascular decompression in treating typical and atypical trigeminal neuralgia. *Clin J Pain.* 2005;21:311-316.
266. Li X, Ni J, Yang L, et al. A prospective study of Gasserian ganglion pulsed radiofrequency combined with continuous radiofrequency for the treatment of trigeminal neuralgia. *J Clin Neurosci.* 2012;19:824-828.
267. Lovely TJ, Jannetta PJ. Microvascular decompression for trigeminal neuralgia. Surgical technique and long-term results. *Neurosurg Clin N Am.* 1997;8:11-29.
268. Mallory GW, Atkinson JL, Stien KJ, Keegan BM, Pollock BE. Outcomes after percutaneous surgery for patients with multiple sclerosis-related trigeminal neuralgia. *Neurosurgery.* 2012;71:581-586 [discussion: 586].
269. Martin S, Teo M, Suttner N. The effectiveness of percutaneous balloon compression in the treatment of trigeminal neuralgia in patients with multiple sclerosis. *J Neurosurg.* 2015;123:1507-1511.
270. Miller JP, Magill ST, Acar F, Burchiel KJ. Predictors of long-term success after microvascular decompression for trigeminal neuralgia. *J Neurosurg.* 2009;110:620-626.
271. Nanjappa M, Kumaraswamy SV, Keerthi R, et al. Percutaneous radiofrequency rhizotomy in treatment of trigeminal neuralgia: a prospective study. *J Maxillofac Oral Surg.* 2013;12:35-41.
272. Nicol CF. A four year double-blind study of tegretol in facial pain. *Headache.* 1969;9:54-57.
273. Park SS, Lee MK, Kim JW, Jung JY, Kim IS, Ghang CG. Percutaneous balloon compression of trigeminal ganglion for the treatment of idiopathic trigeminal neuralgia: experience in 50 patients. *J Korean Neurosurg Soc.* 2008;43:186-189.
274. Pickett GE, Bisnaire D, Ferguson GG. Percutaneous retrogasserian glycerol rhizotomy in the treatment of tic douloureux associated with multiple sclerosis. *Neurosurgery.* 2005;56:537-545 [discussion: 537-545].
275. Pollock BE, Schiefer TK, Stien KJ. Posterior fossa exploration for trigeminal neuralgia patients older than 70 years of age. *J Neurosurg.* 2010;113:A437.
276. Pollock BE, Schoeberl KA. Prospective comparison of posterior fossa exploration and stereotactic radiosurgery dorsal root entry zone target as primary surgery for patients with idiopathic trigeminal neuralgia. *Neurosurgery.* 2010;67:633-638 [discussion: 638-639].
277. Pollock BE, Stein KJ. Surgical management of trigeminal neuralgia patients with recurrent or persistent pain despite three or more prior operations. *World Neurosurg.* 2010;73:523-528.
278. Rustagi A, Roychoudhury A, Bhutia O, Trikha A, Srivastava MV. Lamotrigine versus pregabalin in the management of refractory trigeminal neuralgia: a randomized open label crossover trial. *J Maxillofac Oral Surg.* 2014;13:409-418.
279. Safi MT, Iftikhar M. Effectiveness of microvascular decompression of trigeminal nerve for the treatment of trigeminal neuralgia. *J Med Sci (Peshawar).* 2015;23:38-41.
280. Sarsam Z, Garcia-Finana M, Nurmikko TJ, Varma TR, Eldridge P. The long-term outcome of microvascular decompression for trigeminal neuralgia. *Br J Neurosurg.* 2010;24:18-25.
281. Sekula RF, Frederickson AM, Jannetta PJ, Bhatia S, Quigley MR, Abdel Aziz KM. Microvascular decompression in patients with isolated maxillary division trigeminal neuralgia, with particular attention to venous pathology. *Neurosurg Focus.* 2009;27:E10.
282. Sekula RF Jr, Frederickson AM, Jannetta PJ, Bhatia S, Quigley MR. Microvascular decompression after failed Gamma Knife surgery for trigeminal neuralgia: a safe and effective rescue therapy? *J Neurosurg.* 2010;113:45-52.
283. Smith ZA, Gorgulho AA, Bezrukiy N, et al. Dedicated linear accelerator radiosurgery for trigeminal neuralgia: a single-center experience in 179 patients with varied dose prescriptions and treatment plans. *Int J Radiat Oncol Biol Phys.* 2011;81:225-231.
284. Stomal-Slowinska M, Slowinski J, Lee TK, et al. Correlation of clinical findings and results of percutaneous balloon compression for patients with trigeminal neuralgia. *Clin Neurol Neurosurg.* 2011;113:14-21.
285. Tang YZ, Wu BS, Yang LQ, et al. The long-term effective rate of different branches of idiopathic trigeminal neuralgia after single radiofrequency thermocoagulation: a cohort study. *Medicine (Baltimore).* 2015;94:e1994.
286. Tang YZ, Yang LQ, Yue JN, Wang XP, He LL, Ni JX. The optimal radiofrequency temperature in radiofrequency thermocoagulation for idiopathic trigeminal neuralgia: a cohort study. *Medicine (Baltimore).* 2016;95:e4103.
287. Terrier LM, Amelot A, Francois P, Destrieux C, Zemmoura I, Velut S. Therapeutic failure in trigeminal neuralgia: from a clarification of trigeminal nerve somatotopy to a targeted partial sensory rhizotomy. *World Neurosurg.* 2018;117:e138-e145.
288. Theodros D, Rory Goodwin C, Bender MT, et al. Efficacy of primary microvascular decompression versus subsequent microvascular decompression for trigeminal neuralgia. *J Neurosurg.* 2017;126:1691-1697.
289. Wongsirisuwan M. Short- and long-term effectiveness of keyhole microvascular decompression for trigeminal neuralgia. *J Med Assoc Thai.* 2018;101:209-216.
290. Wu A, Doshi T, Hung A, et al. Immediate and Long-Term Outcomes of Microvascular Decompression for Mixed Trigeminal Neuralgia. *World Neurosurg.* 2018;117:e300-e307.
291. Yang XS, Li ST, Zhong J, et al. Microvascular decompression on patients with trigeminal neuralgia caused by ectatic verteobasilar artery complex: technique notes. *Acta Neurochir (Wien).* 2012;154:793-797 [discussion: 797].
292. Zakrzewska JM, Chaudhry Z, Nurmikko TJ, Patton DW, Mullens EL. Lamotrigine (lamictal) in refractory trigeminal neuralgia: results from a double-blind placebo controlled crossover trial. *Pain.* 1997;73:223-230.
293. Zheng X, Feng B, Hong W, et al. Management of intraneural vessels during microvascular decompression surgery for trigeminal neuralgia. *World Neurosurg.* 2012;77:771-774.
294. Ali Eissa AA, Reyad RM, Saleh EG, El-Saman A. The efficacy and safety of combined pulsed and conventional radiofrequency treatment of refractory cases of idiopathic trigeminal neuralgia: a retrospective study. *J Anesth.* 2015;29:728-733.
295. Zhang Y-P, Wang Y, Xia W-G, Song A-Q. Triple puncture for primary trigeminal neuralgia: a randomized clinical trial. *Curr Med Sci.* 2019;39:638-644.
296. Lai G, Ni J, Wu B, et al. Computed tomography-guided percutaneous radiofrequency thermocoagulation for primary trigeminal neuralgia in older and younger patients. *Neural Regen Res.* 2011;6:1888-1893.
297. Ali FM, Prasant M, Pai D, Aher VA, Kar S, Safiya T. Peripheral neurectomies: a treatment option for trigeminal neuralgia in rural practice. *J Neurosci Rural Pract.* 2012;3:152-157.

298. Arici T, Kurcaloglu M, Kilic E, Erhan E. Radiofrequency thermocoagulation combined with pulsed radiofrequency for gasserian ganglion blockage. *Agri*. 2018;30:179-182.
299. Elsheikh NA, Amr YM. Calcitonin as an Additive to Local Anesthetic and Steroid Injection Using a Modified Coronoid Approach in Trigeminal Neuralgia. *Pain Physician*. 2016;19:457-464.
300. Fouad W. Management of trigeminal neuralgia by radiofrequency thermocoagulation. *Alexandria J Med*. 2011;47:79-86.
301. Hitchon PW, Holland M, Noeller J, et al. Options in treating trigeminal neuralgia: experience with 195 patients. *Clin Neurol Neurosurg*. 2016;149:166-170.
302. Huang Q, Liu X, Chen J, et al. The effectiveness and safety of thermocoagulation radiofrequency treatment of the ophthalmic division (V1) and/or maxillary (V2) and mandibular (V3) division in idiopathic trigeminal neuralgia: an observational study. *Pain Physician*. 2016;19:E1041-1047.
303. Linskey ME, Ratanatharathorn V, Penagaricano J. A prospective cohort study of microvascular decompression and Gamma Knife surgery in patients with trigeminal neuralgia. *J Neurosurg*. 2008;109(suppl):160-172.
304. Nie F, Su D, Shi Y, et al. A prospective study of X-ray imaging combined with skin stimulation potential-guided percutaneous radiofrequency thermocoagulation of the Gasserian ganglion for treatment of trigeminal neuralgia. *Pain Med*. 2014;15:1464-1469.
305. Sandel T, Eide PK. Long-term results of microvascular decompression for trigeminal neuralgia and hemifacial spasms according to preoperative symptomatology. *Acta Neurochir (Wien)*. 2013;155:1681-1692 [discussion: 1692].
306. Sandell T, Eide PK. Effect of microvascular decompression in trigeminal neuralgia patients with or without constant pain. *Neurosurgery*. 2008;63:93-99 [discussion: 99-100].
307. Sandell T, Eide PK. The effect of microvascular decompression in patients with multiple sclerosis and trigeminal neuralgia. *Neurosurgery*. 2010;67:749-753 [discussion: 744-753].
308. Tang CT, Chang SD, Tseng KY, Liu MY, Ju DT. CyberKnife stereotactic radiosurgical rhizotomy for refractory trigeminal neuralgia. *J Clin Neurosci*. 2011;18:1449-1453.
309. Vilming ST, Lyberg T, Lataste X. Tizanidine in the management of trigeminal neuralgia. *Cephalalgia*. 1986;6:181-182.
310. Weng Z, Zhou X, Liu X, Wei J, Xu Q, Yao S. Perioperative pain in patients with trigeminal neuralgia undergoing radiofrequency thermocoagulation of the Gasserian ganglion. *J Craniofac Surg*. 2013;24:1298-1302.
311. Yu R, Wang C, Qu C, et al. Study on the therapeutic effects of trigeminal neuralgia with microvascular decompression and stereotactic gamma knife surgery in the elderly. *J Craniofac Surg*. 2019;30:e77-e80.
312. Huang B, Yao M, Feng Z, et al. CT-guided percutaneous infrazygomatic radiofrequency neurolysis through foramen rotundum to treat V2 trigeminal neuralgia. *Pain Med*. 2014;15:1418-1428.
313. Jiao Y, Yan Z, Che S, et al. Improved microvascular decompression in treating trigeminal neuralgia: application of nest-shaped teflon fibers. *World Neurosurg*. 2018;110:e1-e5.
314. Jin HS, Shin JY, Kim YC, et al. Predictive factors associated with success and failure for radiofrequency thermocoagulation in patients with trigeminal neuralgia. *Pain Physician*. 2015;18:537-545.
315. Kodeeswaran M, Ramesh VG, Saravanan N, Udeshr R. Percutaneous retrogasserian glycerol rhizotomy for trigeminal neuralgia: a simple, safe, cost-effective procedure. *Neurol India*. 2015;63:889-894.
316. Niki Y, Kanai A, Hoshi K, Okamoto H. Immediate analgesic effect of 8% lidocaine applied to the oral mucosa in patients with trigeminal neuralgia. *Pain Med*. 2014;15:826-831.
317. Bond AE, Zada G, Gonzalez AA, Hansen C, Giannotta SL. Operative strategies for minimizing hearing loss and other major complications associated with microvascular decompression for trigeminal neuralgia. *World Neurosurg*. 2010;74:172-177.
318. Lee JK, Choi HJ, Ko HC, Choi SK, Lim YJ. Long term outcomes of gamma knife radiosurgery for typical trigeminal neuralgia—minimum 5-year follow-up. *J Korean Neurosurg Soc*. 2012;51:276-280.
319. Park SC, Lee DH, Lee JK. Two-session tumor and retrogasserian trigeminal nerve-targeted Gamma knife radiosurgery for secondary trigeminal neuralgia associated with benign tumors. *World Neurosurg*. 2016;96:136-147.
320. Fukuoka T, Nishimura Y, Hara M, et al. Flat posterior cranial fossa affects outcomes of microvascular decompression for trigeminal neuralgia. *World Neurosurg*. 2018;111:e519-e526.
321. Wang H, Ying X, Yu WH, et al. Suprafloccular approach via the petrosal fissure and venous corridors for microvascular decompression of the trigeminal nerve: technique notes and clinical outcomes. *J Neurosurg*. 2018;129:324-333.
322. Dos Santos MA, Perez de Salcedo JB, Gutierrez Diaz JA, et al. Outcome for patients with essential trigeminal neuralgia treated with linear accelerator stereotactic radiosurgery. *Stereotact Funct Neurosurg*. 2011;89:220-225.
323. Martinez Moreno NE, Gutierrez-Sarraga J, Rey-Portoles G, Jimenez-Huete A, Martinez Alvarez R. Long-term outcomes in the treatment of classical trigeminal neuralgia by gamma knife radiosurgery: a retrospective study in patients with minimum 2-year follow-up. *Neurosurgery*. 2016;79:879-888.
324. Young B, Shivazad A, Kryscio RJ, St Clair W, Bush HM. Long-term outcome of high-dose gamma knife surgery in treatment of trigeminal neuralgia. *J Neurosurg*. 2013;119:1166-1175.
325. Aghamohammadi D, Amirnaseri R, Peirovifar A, et al. Gasserian ganglion block with or without low-intensity laser therapy in trigeminal neuralgia. *Neurosurg Q*. 2012;22:228-232.
326. Amanat D, Ebrahimi H, Lavaee F, Alipour A. The adjunct therapeutic effect of lasers with medication in the management of orofacial pain: double blind randomized controlled trial. *Photomed Laser Surg*. 2013;31:474-479.
327. An JX, Liu H, Chen RW, et al. Computed tomography-guided percutaneous ozone injection of the Gasserian ganglion for the treatment of trigeminal neuralgia. *J Pain Res*. 2018;11:255-263.
328. Ariyawardana A, Kularajasingham A, Vithanaarachchi N, Sitheequ M, Ranasinghe AW. Management of trigeminal neuralgia—retrospective analysis of 61 patients from Sri Lanka. *Asian J Oral Maxillofac Surg*. 2003;15:171-175.
329. Ariyawardana A, Pallegama R, Sitheequ M, Ranasinghe A. Use of single- and multi-drug regimens in the management of classic (idiopathic) trigeminal neuralgia: an 11-year experience at a single Sri Lankan institution. *J Investig Clin Dent*. 2012;3:98-102.
330. Bittar GT, Graff-Radford SB. The effects of streptomycin/lidocaine block on trigeminal neuralgia: a double blind crossover placebo controlled study. *Headache*. 1993;33:155-160.
331. Caldera MC, Senanayake SJ, Perera SP, Perera NN, Gamage R, Gooneratne IK. Efficacy of botulinum toxin type A in trigeminal neuralgia in a South Asian cohort. *J Neurosci Rural Pract*. 2018;9:100-105.
332. Campos WK, Linhares MN. A prospective study of 39 patients with trigeminal neuralgia treated with percutaneous balloon compression. *Arq Neuropsiquiatr*. 2011;69:221-226.
333. Chen KT, Lin MH, Tsai YH, Lee MH, Yang JT. Application of MRI and intraoperative CT fusion images with integrated neuronavigation in percutaneous radiofrequency trigeminal rhizotomy. *Acta Neurochir (Wien)*. 2015;157:1443-1448 [discussion: 1448].
334. Chen ST, Yang JT, Yeh MY, Weng HH, Chen CF, Tsai YH. Using diffusion tensor imaging to evaluate microstructural changes and outcomes after radiofrequency rhizotomy of trigeminal nerves in patients with trigeminal neuralgia. *PLoS One*. 2016;11:e0167584.
335. Cheng J, Long J, Hui X, Lei D, Zhang H. Effects of microvascular decompression on depression and anxiety in trigeminal neuralgia: a prospective cohort study focused on risk factors and prognosis. *Clin Neurol Neurosurg*. 2017;161:59-64.
336. Dergin G, Gocmen G, Sener BC. Treatment of trigeminal neuralgia with bupivacaine HCL using a temporary epidural catheter and pain pump: preliminary study. *J Craniofac Surg*. 2012;40:124-128.
337. Ebrahimi H, Najafi S, Khayamzadeh M, Zahedi A, Mahdavi A. Therapeutic and analgesic efficacy of laser in conjunction with

- pharmaceutical therapy for trigeminal neuralgia. *J Lasers Med Sci*. 2018;9:63-68.
338. Erdine S, Ozyalcin NS, Cimen A, Celik M, Talu GK, Disci R. Comparison of pulsed radiofrequency with conventional radiofrequency in the treatment of idiopathic trigeminal neuralgia. *Eur J Pain*. 2007;11:309-313.
339. Guo H, Song G, Wang X, Bao Y. Surgical treatment of trigeminal neuralgia with no neurovascular compression: a retrospective study and literature review. *J Clin Neurosci*. 2018;58:42-48.
340. Haider MN, Akther M, Molla MR, Hossain MA. Comparative study on cryosurgery with carbamazepine and alcohol injection in trigeminal neuralgia. *Bangladesh J Med Sci*. 2012;11:197-200.
341. Ichida MC, de Almeida AN, da Nobrega JC, Teixeira MJ, de Siqueira JT, de Siqueira SR. Sensory abnormalities and masticatory function after microvascular decompression or balloon compression for trigeminal neuralgia compared with carbamazepine and healthy controls. *J Neurosurg*. 2015;122:1315-1323.
342. Ichida MC, Zemuner M, Hosomi J, et al. Acupuncture treatment for idiopathic trigeminal neuralgia: a longitudinal case-control double blinded study. *Chin J Integr Med*. 2017;23:829-836.
343. Hitchon PW, Zanaty M, Moritani T, et al. Microvascular decompression and MRI findings in trigeminal neuralgia and hemifacial spasm. A single center experience. *Clin Neurol Neurosurg*. 2015;139:216-220.
344. Jorns TP, Johnston A, Zakrzewska JM. Pilot study to evaluate the efficacy and tolerability of levetiracetam (Keppra®) in treatment of patients with trigeminal neuralgia. *Eur J Neurol*. 2009;16:740-744.
345. Kanai A, Saito M, Hoka S. Subcutaneous sumatriptan for refractory trigeminal neuralgia. *Headache*. 2006;46:577-582 [discussion: 574-583].
346. Kanai A, Suzuki A, Kobayashi M, Hoka S. Intranasal lidocaine 8% spray for second-division trigeminal neuralgia. *Br J Anaesth*. 2006;97:559-563.
347. Kanai A, Suzuki A, Osawa S, Hoka S. Sumatriptan alleviates pain in patients with trigeminal neuralgia. *Clin J Pain*. 2006;22:677-680.
348. Kim JH, Yu HY, Park SY, Lee SC, Kim YC. Pulsed and conventional radiofrequency treatment: which is effective for dental procedure-related symptomatic trigeminal neuralgia? *Pain Med*. 2013;14:430-435.
349. Lemos L, Flores S, Oliveira P, Almeida A. Gabapentin supplemented with ropivacain block of trigger points improves pain control and quality of life in trigeminal neuralgia patients when compared with gabapentin alone. *Clin J Pain*. 2008;24:64-75.
350. Li S, Lian Y-J, Chen Y, et al. Therapeutic effect of botulinum toxin-A in 88 patients with trigeminal neuralgia with 14-month follow-up. *J Headache Pain*. 2014;15:43.
351. Liu S. A comparative study of efficacy between acupuncture therapy and drug therapy for primary trigeminal neuralgia. *Int J Clin Exp Med*. 2018;11:8544-8549.
352. Meybodi AT, Habibi Z, Miri M, Tabatabaie SA. Microvascular decompression for trigeminal neuralgia using the 'Stitched Sling Retraction' technique in recurrent cases after previous microvascular decompression. *Acta Neurochir (Wien)*. 2014;156:1181-1187 [discussion: 1187].
353. Miles JB, Eldridge PR, Haggett CE, Bowsher D. Sensory effects of microvascular decompression in trigeminal neuralgia. *J Neurosurg*. 1997;86:193-196.
354. Mitsikostas DD, Pantes GV, Avramidis TG, et al. An observational trial to investigate the efficacy and tolerability of levetiracetam in trigeminal neuralgia. *Headache*. 2010;50:1371-1377.
355. Pan HC, Sheehan J, Huang CF, Sheu ML, Yang DY, Chiu WT. Quality-of-life outcomes after Gamma Knife surgery for trigeminal neuralgia. *J Neurosurg*. 2010;113(suppl):191-198.
356. Perez C, Navarro A, Saldana M, Martinez S, Rejas J. Patient-reported outcomes in subjects with painful trigeminal neuralgia receiving pregabalin: evidence from medical practice in primary care settings. *Cephalalgia*. 2009;29:781-790.
357. Perez C, Saldana MT, Navarro A, Martinez S, Rejas J. Trigeminal neuralgia treated with pregabalin in family medicine settings: its effect on pain alleviation and cost reduction. *J Clin Pharmacol*. 2009;49:582-590.
358. Piovesan EJ, Teive HG, Kowacs PA, Della Coletta MV, Werneck LC, Silberstein SD. An open study of botulinum-A toxin treatment of trigeminal neuralgia. *Neurology*. 2005;65:1306-1308.
359. Puri N, Rathore A, Dharmdeep G, et al. A clinical study on comparative evaluation of the effectiveness of carbamazepine and combination of carbamazepine with baclofen or capsaicin in the management of trigeminal neuralgia. *Niger J Surg*. 2018;24:95-99.
360. Reddy VK, Parker SL, Lockney DT, Patrawala SA, Su PF, Mericle RA. Percutaneous stereotactic radiofrequency lesioning for trigeminal neuralgia: determination of minimum clinically important difference in pain improvement for patient-reported outcomes. *Neurosurgery*. 2014;74:262-266 [discussion: 266].
361. Reddy VK, Parker SL, Patrawala SA, Lockney DT, Su PF, Mericle RA. Microvascular decompression for classic trigeminal neuralgia: determination of minimum clinically important difference in pain improvement for patient reported outcomes. *Neurosurgery*. 2013;72:749-754 [discussion: 754].
362. Regis J, Metellus P, Hayashi M, Roussel P, Donnet A, Bille-Turc F. Prospective controlled trial of gamma knife surgery for essential trigeminal neuralgia. *J Neurosurg*. 2006;104:913-924.
363. Shaikh S, Yaacob HB, Abd Rahman RB. Lamotrigine for trigeminal neuralgia: efficacy and safety in comparison with carbamazepine. *J Chin Med Assoc*. 2011;74:243-249.
364. Shehata HS, El-Tamawy MS, Shalaby NM, Ramzy G. Botulinum toxin-type A: could it be an effective treatment option in intractable trigeminal neuralgia? *J Headache Pain*. 2013;14:92.
365. Singh R, Davis J, Sharma S. Stereotactic Radio-surgery for Trigeminal Neuralgia: A Retrospective Multi-Institutional Examination of Treatment Outcomes. *Cureus*. 2016;8:e554.
366. Singh S, Verma R, Kumar M, Rastogi V, Bogra J. Experience with conventional radiofrequency thermorhizotomy in patients with failed medical management for trigeminal neuralgia. *Korean J Pain*. 2014;27:260-265.
367. Singla S, Prabhakar V, Singla RK. Role of transcutaneous electric nerve stimulation in the management of trigeminal neuralgia. *J Neurosci Rural Pract*. 2011;2:150-152.
368. Stavropoulou E, Argyra E, Zis P, Vadalouca A, Siafaka I. The effect of intravenous lidocaine on trigeminal neuralgia: a randomized double blind placebo controlled trial. *ISRN Pain*. 2014;2014:853826.
369. Suslu H, Suslu HT, Ozdogan S, Guclu B, Duzkalir AH. Percutaneous radiofrequency trigeminal rhizotomy for the treatment of idiopathic trigeminal neuralgia: experience in 106 patients. *Neurol Sci Neurophys*. 2018;35:91-96.
370. Taheri A, Firouzi-Marani S, Khoshbin M, Beygi M. A retrospective review of efficacy of combination therapy with pregabalin and carbamazepine versus pregabalin and amitriptyline in treatment of trigeminal neuralgia. *Anaesth Pain Intensive Care*. 2015;19:8-12.
371. Tanaka T, Shiiba S, Yoshino N, et al. Predicting the therapeutic effect of carbamazepine in trigeminal neuralgia by analysis of neurovascular compression utilizing magnetic resonance cisternography. *Int J Oral Maxillofac Surg*. 2019;48:480-487.
372. Tang Y, Ma L, Li N, et al. Percutaneous trigeminal ganglion radiofrequency thermocoagulation alleviates anxiety and depression disorders in patients with classic trigeminal neuralgia: a cohort study. *Medicine (Baltimore)*. 2016;95:e5379.
373. Tucer B, Ekici MA, Demirel S, Basarslan SK, Koc RK, Guclu B. Microvascular decompression for primary trigeminal neuralgia: short-term follow-up results and prognostic factors. *J Korean Neurosurg Soc*. 2012;52:42-47.
374. Weng Z, Halawa MA, Liu X, Zhou X, Yao S. Analgesic effects of preoperative peripheral nerve block in patients with trigeminal neuralgia undergoing radiofrequency thermocoagulation of gasserian ganglion. *J Craniofac Surg*. 2013;24:479-482.
375. Yang JT, Lin M, Lee MH, Weng HH, Liao HH. Percutaneous trigeminal nerve radiofrequency rhizotomy guided by computerized tomography with three-dimensional image reconstruction. *Chang Gung Med J*. 2010;33:679-683.
376. Wu CJ, Lian YJ, Zheng YK, et al. Botulinum toxin type A for the treatment of trigeminal neuralgia: results from a randomized, double-blind,

- placebo-controlled trial. *Cephalalgia*. 2012;32:443-450.
377. Xue T, Yang W, Guo Y, Yuan W, Dai J, Zhao Z. 3D image-guided percutaneous radiofrequency thermocoagulation of the maxillary branch of the trigeminal nerve through foramen rotundum for the treatment of trigeminal neuralgia. *Medicine (Baltimore)*. 2015;94:e1954.
378. Yameen F, Shahbaz NN, Hasan Y, Fauz R, Abdullah M. Efficacy of transcutaneous electrical nerve stimulation and its different modes in patients with trigeminal neuralgia. *J Pak Med Assoc*. 2011;61:437-439.
379. Zhang H, Lian Y, Ma Y, et al. Two doses of botulinum toxin type A for the treatment of trigeminal neuralgia: observation of therapeutic effect from a randomized, double-blind, placebo-controlled trial. *J Headache Pain*. 2014;15:65.
380. Zhang H, Lian Y, Xie N, Chen C, Zheng Y. Single-dose botulinum toxin type a compared with repeated-dose for treatment of trigeminal neuralgia: a pilot study. *J Headache Pain*. 2017;18:81.
381. Zhao WX, Wang Q, He MW, Yang LQ, Wu BS, Ni JX. Radiofrequency thermocoagulation combined with pulsed radiofrequency helps relieve postoperative complications of trigeminal neuralgia. *Genet Mol Res*. 2015;14:7616-7623.
382. Zuniga C, Piedimonte F, Diaz S, Micheli F. Acute treatment of trigeminal neuralgia with onabotulinum toxin A. *Clin Neuropharmacol*. 2013;36:146-150.
383. Gao J, Zhao C, Jiang W, Zheng B, He Y. Effect of acupuncture on cognitive function and quality of life in patients with idiopathic trigeminal neuralgia. *J Nerv Ment Dis*. 2019;207:171-174.
384. Altinok A, Karanci T, Ozbek A, Albayrak SB. Instant and early efficacy of gamma knife treatment on trigeminal neuralgia. *Turk J Oncol*. 2018;33:154-158.
385. Dhople AA, Adams JR, Maggio WW, Naqvi SA, Regine WF, Kwok Y. Long-term outcomes of Gamma Knife radiosurgery for classic trigeminal neuralgia: implications of treatment and critical review of the literature. *Clin article. J Neurosurg*. 2009;111:351-358.
386. Huang CF, Chiou SY, Wu MF, Tu HT, Liu WS. Gamma Knife surgery for recurrent or residual trigeminal neuralgia after a failed initial procedure. *J Neurosurg*. 2010;113(suppl):172-177.
387. Hussain MA, Konteas A, Sunderland G, et al. Re-exploration of microvascular decompression in recurrent trigeminal neuralgia and intraoperative management options. *World Neurosurg*. 2018;117:e67-e74.
388. Krishnan S, Bigder M, Kaufmann AM. Long-term follow-up of multimodality treatment for multiple sclerosis-related trigeminal neuralgia. *Acta Neurochir (Wien)*. 2018;160:135-144.
389. Lucas JT Jr, Nida AM, Isom S, et al. Predictive nomogram for the durability of pain relief from gamma knife radiation surgery in the treatment of trigeminal neuralgia. *Int J Radiat Oncol Biol Phys*. 2014;89:120-126.
390. Nunta-Aree S, Patiwech K, Sitthinamsuwan B. Microvascular decompression for treatment of trigeminal neuralgia: factors that predict complete pain relief and study of efficacy and safety in older patients. *World Neurosurg*. 2018;110:e979-e988.
391. Obermueller K, Shiban E, Obermueller T, Meyer B, Lehmeberg J. Working ability and use of healthcare resources for patients with trigeminal neuralgia treated via microvascular decompression. *Acta Neurochir (Wien)*. 2018;160:2521-2527.
392. Oh IH, Choi SK, Park BJ, Kim TS, Rhee BA, Lim YJ. The treatment outcome of elderly patients with idiopathic trigeminal neuralgia: micro-vascular decompression versus Gamma knife radiosurgery. *J Korean Neurosurg Soc*. 2008;44:199-204.
393. Przybylowski CJ, Cole TS, Baranoski JF, Little AS, Smith KA, Shetter AG. Radiosurgery for multiple sclerosis-related trigeminal neuralgia: retrospective review of long-term outcomes [e-pub ahead of print]. *J Neurosurg*. 2018. <https://doi.org/10.3171/2018.5.JNS173194>, accessed May 25, 2019.
394. Rashid A, Pintea B, Kinf TM, Surber G, Hamm K, Bostrom JP. LINAC stereotactic radiosurgery for trigeminal neuralgia—retrospective two-institutional examination of treatment outcomes. *Radiat Oncol*. 2018;13:153.
395. Shulev YA, Gordienko KS, Trashin AV, Pechiborshch DA, Rzyayev DA. Venous compression as a cause of trigeminal neuralgia. *Zh Vopr Neirokhir Im N N Burdenko*. 2016;80:21-30 [in Russian].
396. Tarricone R, Aguzzi G, Musi F, Fariselli L, Casasco A. Cost-effectiveness analysis for trigeminal neuralgia: Cyberknife vs microvascular decompression. *Neuropsychiatr Dis Treat*. 2008;4:647-652.
397. Tuleasca C, Carron R, Resseguier N, et al. Patterns of pain-free response in 497 cases of classic trigeminal neuralgia treated with Gamma Knife surgery and followed up for least 1 year. *J Neurosurg*. 2012;117(suppl):181-188.
398. Unal TC, Unal OF, Barlas O, et al. Factors determining the outcome in trigeminal neuralgia treated with percutaneous balloon compression. *World Neurosurg*. 2017;107:69-74.
399. Wang DD, Raygor KP, Cage TA, et al. Prospective comparison of long-term pain relief rates after first-time microvascular decompression and stereotactic radiosurgery for trigeminal neuralgia. *J Neurosurg*. 2018;128:68-77.
400. Weller M, Marshall K, Lovato JF, et al. Single-institution retrospective series of gamma knife radiosurgery in the treatment of multiple sclerosis-related trigeminal neuralgia: factors that predict efficacy. *Stereotact Funct Neurosurg*. 2014;92:53-58.
401. Wu M, Fu X, Ji Y, et al. Microvascular decompression for classical trigeminal neuralgia caused by venous compression: novel anatomic classifications and surgical strategy. *World Neurosurg*. 2018;113:e707-e713.
402. Wu M, Jiang X, Niu C, Fu X. Outcome of internal neurolysis for trigeminal neuralgia without neurovascular compression and its relationship with intraoperative trigeminocardiac reflex. *Stereotact Funct Neurosurg*. 2018;96:305-310.
403. Zhang M, Lamsam LA, Schoen MK, et al. Brainstem dose constraints in nonisometric radiosurgical treatment planning of trigeminal neuralgia: a single-institution experience. *World Neurosurg*. 2018;113:e399-e407.
404. Zhang X, Xu L, Zhao H, et al. Long-term efficacy of nerve combing for patients with trigeminal neuralgia and failed prior microvascular decompression. *World Neurosurg*. 2017;108:711-715.
405. Zhao H, Wang XH, Zhang Y, et al. Management of primary bilateral trigeminal neuralgia with microvascular decompression: 13-case series. *World Neurosurg*. 2018;109:e724-e730.
406. Zhong J, Li ST, Zhu J, et al. A clinical analysis on microvascular decompression surgery in a series of 3000 cases. *Clin Neurol Neurosurg*. 2012;114:846-851.
407. Abhinav K, Love S, Kalantzis G, Coakham HB, Patel NK. Clinicopathological review of patients with and without multiple sclerosis treated by partial sensory rhizotomy for medically refractory trigeminal neuralgia: a 12-year retrospective study. *Clin Neurol Neurosurg*. 2012;114:361-365.
408. Amador N, Pollock BE. Repeat posterior fossa exploration for patients with persistent or recurrent idiopathic trigeminal neuralgia. *J Neurosurg*. 2008;108:916-920.
409. Benoliel R, Zini A, Khan J, Almozino G, Sharav Y, Haviv Y. Trigeminal neuralgia (part II): factors affecting early pharmacotherapeutic outcome. *Cephalalgia*. 2016;36:747-759.
410. Campbell FG, Graham JG, Zilkha KJ. Clinical trial of carbamazepine (tegretol) in trigeminal neuralgia. *J Neurol Neurosurg Psychiatry*. 1966;29:265-267.
411. Chen F, Chen L, Li W, et al. Pre-operative declining proportion of fractional anisotropy of trigeminal nerve is correlated with the outcome of micro-vascular decompression surgery. *BMC Neurol*. 2016;16:106.
412. Fusco BM, Alessandri M. Analgesic effect of capsaicin in idiopathic trigeminal neuralgia. *Anesth Analg*. 1992;74:375-377.
413. Lunardi G, Leandri M, Albano C, et al. Clinical effectiveness of lamotrigine and plasma levels in essential and symptomatic trigeminal neuralgia. *Neurology*. 1997;48:1714-1717.
414. Massager N, Murata N, Tamura M, Devriendt D, Levivier M, Regis J. Influence of nerve radiation dose in the incidence of trigeminal dysfunction after trigeminal neuralgia radiosurgery. *Neurosurgery*. 2007;60:681-687 [discussion: 687-688].
415. Masuoka J, Matsushima T, Inoue K, Nakahara Y, Takase Y, Kawashima M. Outcome of microvascular decompression for trigeminal neuralgia treated with the stitched sling retraction

- technique. *Neurosurg Rev.* 2015;38:361-365 [discussion: 365].
416. Matsuda S, Serizawa T, Nagano O, Ono J. Comparison of the results of 2 targeting methods in Gamma Knife surgery for trigeminal neuralgia. *J Neurosurg.* 2008;109(suppl):185-189.
 417. Miller JP, Acar F, Burchiel KJ. Classification of trigeminal neuralgia: clinical, therapeutic, and prognostic implications in a series of 144 patients undergoing microvascular decompression. *J Neurosurg.* 2009;111:1231-1234.
 418. North RB, Kidd DH, Piantadosi S, Carson BS. Percutaneous retrogasserian glycerol rhizotomy. Predictors of success and failure in treatment of trigeminal neuralgia. *J Neurosurg.* 1990;72:851-856.
 419. Omoriegbe OF, Okoh M. Early response to medical treatment of trigeminal neuralgia in a Nigerian population. *Niger Med J.* 2015;56:381-384.
 420. Rasmussen P, Riishede J. Facial pain treated with carbamazepin (Tefretol). *Acta Neurol Scand.* 1970;46:385-408.
 421. Sathasivam HP, Ismail S, Ahmad AR, et al. Trigeminal neuralgia: a retrospective multicentre study of 320 Asian patients. *Oral Surg Oral Med Oral Pathol Oral Radiol.* 2017;123:51-57.
 422. Sekula RF Jr, Frederickson AM, Jannetta PJ, Quigley MR, Aziz KM, Arnone GD. Microvascular decompression for elderly patients with trigeminal neuralgia: a prospective study and systematic review with meta-analysis. *J Neurosurg.* 2011;114:172-179.
 423. Sekula RF, Marchan EM, Fletcher LH, Casey KF, Jannetta PJ. Microvascular decompression for trigeminal neuralgia in elderly patients. *J Neurosurg.* 2008;108:689-691.
 424. Shi L, Gu X, Sun G, et al. After microvascular decompression to treat trigeminal neuralgia, both immediate pain relief and recurrence rates are higher in patients with arterial compression than with venous compression. *Oncotarget.* 2017;8:44819-44823.
 425. Shibahashi K, Morita A, Kimura T. Surgical results of microvascular decompression procedures and patient's postoperative quality of life: review of 139 cases. *Neurol Med Chir (Tokyo).* 2013;53:360-364.
 426. Shiiba S, Tanaka T, Sakamoto E, et al. Can the neurovascular compression volume of the trigeminal nerve on magnetic resonance cisternography predict the success of local anesthetic block after initial treatment by the carbamazepine? *Oral Surg Oral Med Oral Pathol Oral Radiol.* 2014;117:e15-21.
 427. Sindou M, Leston JM, Decullier E, Chapuis F. Microvascular decompression for trigeminal neuralgia: the importance of a noncompressive technique—Kaplan—Meier analysis in a consecutive series of 330 patients. *Neurosurgery.* 2008;63(4 suppl 2):341-350 [discussion: 341-350].
 428. Vergani F, Panaretos P, Penalosa A, English P, Nicholson C, Jenkins A. Preoperative MRI/MRA for microvascular decompression in trigeminal neuralgia: consecutive series of 67 patients. *Acta Neurochir (Wien).* 2011;153:2377-2381 [discussion: 2382].
 429. Fang L, Tao W, Jingjing L, Nan J. Comparison of high-voltage- with standard-voltage pulsed radiofrequency of gasserian ganglion in the treatment of idiopathic trigeminal neuralgia. *Pain Pract.* 2015;15:595-603.
 430. Koizuka S, Saito S, Sekimoto K, Tobe M, Obata H, Koyama Y. Percutaneous radiofrequency thermocoagulation of the Gasserian ganglion guided by high-speed real-time CT fluoroscopy. *Neuroradiology.* 2009;51:563-566.
 431. Lan M, Zipu J, Ying S, Hao R, Fang L. Efficacy and safety of CT-guided percutaneous pulsed radiofrequency treatment of the Gasserian ganglion in patients with medically intractable idiopathic trigeminal neuralgia. *J Pain Res.* 2018;11:2877-2885.
 432. Lemos L, Alegria C, Oliveira J, Machado A, Oliveira P, Almeida A. Pharmacological versus microvascular decompression approaches for the treatment of trigeminal neuralgia: clinical outcomes and direct costs. *J Pain Res.* 2011;4:233-244.
 433. Lemos L, Fontes R, Flores S, Oliveira P, Almeida A. Effectiveness of the association between carbamazepine and peripheral analgesic block with ropivacaine for the treatment of trigeminal neuralgia. *J Pain Res.* 2010;3:201-212.
 434. Luo F, Meng L, Wang T, Yu X, Shen Y, Ji N. Pulsed radiofrequency treatment for idiopathic trigeminal neuralgia: a retrospective analysis of the causes for ineffective pain relief. *Eur J Pain.* 2013;17:1189-1192.
 435. Luo F, Wang T, Shen Y, Meng L, Lu J, Ji N. High voltage pulsed radiofrequency for the treatment of refractory neuralgia of the infraorbital nerve: a prospective double-blinded randomized controlled study. *Pain Physician.* 2017;20:271-279.
 436. Sanchez-Larsen A, Sopolana D, Diaz-Maroto I, et al. Assessment of efficacy and safety of eslicarbazepine acetate for the treatment of trigeminal neuralgia. *Eur J Pain.* 2018;22:1080-1087.
 437. Seada Yi Nofel R, Sayed HM. Comparison between trans-cranial electromagnetic stimulation and low-level laser on modulation of trigeminal neuralgia. *J Phys Ther Sci.* 2013;25:911-914.
 438. Zakrzewska JM, Palmer J, Morisset V, et al. Safety and efficacy of a Nav1.7 selective sodium channel blocker in patients with trigeminal neuralgia: a double-blind, placebo-controlled, randomised withdrawal phase 2a trial. *Lancet Neurol.* 2017;16:291-300.
 439. Shih-Ping Hung P, Tohyama S, Zhang JY, Hodaie M. Temporal disconnection between pain relief and trigeminal nerve microstructural changes after Gamma Knife radiosurgery for trigeminal neuralgia [e-pub ahead of print]. *J Neurosurg.* 2019. <https://doi.org/10.3171/2019.4.JNS19380>, accessed May 25, 2019.
 440. Tsai P-J, Lee M-H, Chen K-T, Huang W-C, Yang J-T, Lin MH-C. Foramen ovale cannulation guided by intraoperative computed tomography with magnetic resonance image fusion plays a role in improving the long-term outcome of percutaneous radiofrequency trigeminal rhizotomy. *Acta Neurochir (Wien).* 2019;161:1427-1434.
 441. Besi E, Boniface DR, Cregg R, Zakrzewska JM. Comparison of tolerability and adverse symptoms in oxcarbazepine and carbamazepine in the treatment of trigeminal neuralgia and neuralgiform headaches using the Liverpool Adverse Events Profile (AEP). *J Headache Pain.* 2015;16:563.
 442. Bohman LE, Pierce J, Stephen JH, Sandhu S, Lee JY. Fully endoscopic microvascular decompression for trigeminal neuralgia: technique review and early outcomes. *Neurosurg Focus.* 2014;37:E18.
 443. Chao ST, Thakkar VV, Barnett GH, et al. Prospective study of the short-term adverse effects of gamma knife radiosurgery. *Technol Cancer Res Treat.* 2012;11:117-122.
 444. Di Stani F, Ojango C, Dugoni D, et al. Combination of pharmacotherapy and lidocaine analgesic block of the peripheral trigeminal branches for trigeminal neuralgia: a pilot study. *Atq Neuropsiquiatr.* 2015;73:660-664.
 445. Lee JY, Sandhu S, Miller D, Solberg T, Dorsey JF, Alonso-Basanta M. Higher dose rate Gamma Knife radiosurgery may provide earlier and longer-lasting pain relief for patients with trigeminal neuralgia. *J Neurosurg.* 2015;123:961-968.
 446. Zakrzewska JM, Lopez BC, Kim SE, Coakham HB. Patient reports of satisfaction after microvascular decompression and partial sensory rhizotomy for trigeminal neuralgia. *Neurosurgery.* 2005;56:1304-1311 [discussion: 1302-1311].
 447. Zakrzewska JM, Wu J, Mon-Williams M, Phillips N, Pavitt SH. Evaluating the impact of trigeminal neuralgia. *Pain.* 2017;158:1166-1174.
 448. Zakrzewska JM, Jassim S, Bulman JS. A prospective, longitudinal study on patients with trigeminal neuralgia who underwent radiofrequency thermocoagulation of the Gasserian ganglion. *Pain.* 1999;79:51-58.
 449. Bakker NA, Van Dijk JM, Immenga S, Wagemakers M, Metzemaekers JD. Repeat microvascular decompression for recurrent idiopathic trigeminal neuralgia. *J Neurosurg.* 2014;121:936-939.
 450. Di Stefano G, La Cesa S, Truini A, Cruccu G. Natural history and outcome of 200 outpatients with classical trigeminal neuralgia treated with carbamazepine or oxcarbazepine in a tertiary centre for neuropathic pain. *J Headache Pain.* 2014;15:34.
 451. Solaro C, Messmer Uccelli M, Uccelli A, Leandri M, Mancardi GL. Low-dose gabapentin combined with either lamotrigine or carbamazepine can be useful therapies for trigeminal neuralgia in multiple sclerosis. *Eur Neurol.* 2000;44:45-48.
 452. Steardo L, Leo A, Marano E. Efficacy of baclofen in trigeminal neuralgia and some other painful conditions. A clinical trial. *Eur Neurol.* 1984;23:51-55.

453. Degen J, Brennum J. Surgical treatment of trigeminal neuralgia. Results from the use of glycerol injection, microvascular decompression, and rhizotomy. *Acta Neurochir (Wien)*. 2010;152:2125-2132.
454. Hagenacker T, Bude V, Naegel S, et al. Patient-conducted anodal transcranial direct current stimulation of the motor cortex alleviates pain in trigeminal neuralgia. *J Headache Pain*. 2014;15:78.
455. Verma S, Ravi Prakash SM, Patil RG, Singh U, Singh A. Duloxetine: an effective drug for the treatment of trigeminal neuralgia. *Res J Pharm Biol Chem Sci*. 2014;5:1680-1685.
456. Gomez-Arguelles JM, Dorado R, Sepulveda JM, et al. Oxcarbazepine monotherapy in carbamazepine-unresponsive trigeminal neuralgia. *J Clin Neurosci*. 2008;15:516-519.
457. Parekh S, Shah K, Kotdawalla H, Gandhi I. Baclofen in carbamazepine resistant trigeminal neuralgia—a double blind clinical trial. *Cephalalgia*. 1989;9(suppl 10):392-393.
458. Walker JB, Akhanjee LK, Cooney MM, Goldstein J, Tamayoshi S, Segal Gidan F. Laser therapy for pain of trigeminal neuralgia. *Clin J Pain*. 1988;3(4):183-187.
459. Court JE, Kase CS. Treatment of tic douloureux with a new anticonvulsant (clonazepam). *J Neurosurg Neurosurg Psychiatry*. 1976;39:297-299.
460. Azar M, Yahyavi ST, Bitaraf MA, et al. Gamma knife radiosurgery in patients with trigeminal neuralgia: quality of life, outcomes, and complications. *Clin Neurol Neurosurg*. 2009;111:174-178.
461. Gao J, Zhao C, Jiang W, Zheng B, He Y. Effect of acupuncture on cognitive function and quality of life in patients with idiopathic trigeminal neuralgia. *J Nerv Ment Dis*. 2019;207:171-174.
462. Tentolouris-Piperas V, Lee G, Reading J, O'Keefe AG, Zakrzewska JM, Cregg R. Adverse effects of anti-epileptics in trigeminal neuralgiform pain. *Acta Neurol Scand*. 2018;137:566-574.
463. Jafree DJ, Williams AC, Zakrzewska JM. Impact of pain and postoperative complications on patient-reported outcome measures 5 years after microvascular decompression or partial sensory rhizotomy for trigeminal neuralgia. *Acta Neurochir (Wien)*. 2018;160:125-134.
464. Lee JYK, Pierce JT, Sandhu SK, Petrov D, Yang AI. Endoscopic versus microscopic microvascular decompression for trigeminal neuralgia: equivalent pain outcomes with possibly decreased postoperative headache after endoscopic surgery. *J Neurosurg*. 2017;126:1676-1684.
465. Schulz KF, Altman DG, Moher D. CONSORT 2010 Statement: updated guidelines for reporting parallel group randomised trials. *BMJ*. 2010;340:c332.
466. von Elm E, Altman DG, Egger M, Pocock SJ, Gotsche PC, Vandenbroucke JP. The Strengthening of Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *Lancet*. 2007;370:1453-1457.
467. Farrar JT. What is clinically meaningful: outcome measures in pain clinical trials. *Clin J Pain*. 2000;16(2 suppl):S106-112.
468. Angst MS, Brose WG, Dyck JB. The relationship between the visual analog pain intensity and pain relief scale changes during analgesic drug studies in chronic pain patients. *Anesthesiology*. 1999;91:34-41.
469. Jensen MP. Pain assessment in clinical trials. In: Carr DB, Wittink H, eds. *Pain Management: Evidence, Outcomes and Quality of Life—A Sourcebook*. New York: Elsevier; 2008:57-82.
470. Jensen MP, Chen C, Brugger AM. Postsurgical pain outcome assessment. *Pain*. 2002;99:101-109.
471. Zakrzewska JM, Relton C. Future directions for surgical trial designs in trigeminal neuralgia. *Neurosurg Clin N Am*. 2016;27:353-363.
472. Chen HI, Lee JY. The measurement of pain in patients with trigeminal neuralgia. *Clin Neurosurg*. 2010;57:129-133.
473. Turk DC, Melzack RE, eds. *Handbook of Pain Assessment*. 2011. New York: Guilford Press; 1992.
474. Stull DE, Leidy NK, Parasuraman B, Chassany O. Optimal recall periods for patient-reported outcomes: challenges and potential solutions. *Curr Med Res Opin*. 2009;25:929-942.
475. Turk DC, Fillingim RB, Ohrbach R, Patel KV. Assessment of psychosocial and functional impact of chronic pain. *J Pain*. 2016;17(9 suppl):T21-T49.
476. Tölle T, Dukes E, Sadosky A. Patient burden of trigeminal neuralgia: results from a cross-sectional survey of health state impairment and treatment patterns in six European countries. *Pain Pract*. 2006;6:153-160.
477. Barker FG 2nd. Quality of life and individual treatment choice in trigeminal neuralgia. *Pain*. 2007;131:234-236.
478. Lee JY, Chen HI, Urban C, et al. Development of and psychometric testing for the Brief Pain Inventory-Facial in patients with facial pain syndromes. *J Neurosurg*. 2010;113:516-523.
479. Tunis SR, Clarke M, Gorst SL, et al. Improving the relevance and consistency of outcomes in comparative effectiveness research. *J Comp Eff Res*. 2016;5:193-205.
480. Prinsen CAC, Vohra S, Rose MR, et al. How to select outcome measurement instruments for outcomes included in a "Core Outcome Set"—a practical guideline. *Trials*. 2016;17:1745-6215 [Electronic].
481. Perrot S, Lanteri-Minet M. Patients' Global Impression of Change in the management of peripheral neuropathic pain: clinical relevance and correlations in daily practice. *Eur J Pain*. 2019;23:1117-1128.
482. Dworkin RH, Turk DC, Wyrwich KW, et al. Interpreting the clinical importance of treatment outcomes in chronic pain clinical trials: IMMPACT recommendations. *J Pain*. 2008;9:105-121.
483. Chiarotto A, Deyo RA, Terwee CB, et al. Core outcome domains for clinical trials in non-specific low back pain. *Eur Spine J*. 2015;24:1127-1142.
484. Kaiser U, Kopkow C, Deckert S, et al. Developing a core outcome domain set to assessing effectiveness of interdisciplinary multimodal pain therapy: the VAPAIN consensus statement on core outcome domains. *Pain*. 2018;159:673-683.

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