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Trigeminal nerve internal neurolysis for the treatment of trigeminal neuralgia: a systematic review

Neurólisis interna del nervio trigémino para el tratamiento de la neuralgia del trigémino: una revisión sistemática

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ABSTRACT

Internal Neurolysis (IN) is an option to treat recurrent trigeminal neuralgia (TN) or TN lacking neurovascular compression (NVC). This study aimed to investigate the efficacy of IN in TN. A systematic review was conducted following PRISMA guidelines. Five databases were searched and ten studies were included. IN, alone or with microvascular decompression (MVD), achieves high immediate post-operative (PO) pain relief, especially in NVC-free patients and revision surgeries. Five studies examining IN alone reported immediate PO relief of up to 100%. This high initial success is tempered by rising recurrence over time. One long-term study reported decline to 47% pain-free survival at five-year mark. Furthermore, MVD plus IN approach yielded higher success rates compared to MVD alone. While IN demonstrates initial efficacy, its long-term durability is limited. Sensory complications are common immediately post-surgery, and, although studies report gradual improvement, procedure cost-effectiveness requires patient counselling. History of previous surgery for TN was identified as a poor prognostic factor for sustained success. IN is a valuable treatment for TN patients without NVC or prior treatment failure. Benefit of more efficient pain control must be carefully discussed against the possibility of sensory side effects and recurrence.

Keywords: *nerve block; trigeminal neuralgia; microvascular decompression surgery; neurosurgical procedures; postoperative complications; pain management.*

RESUMEN

Neurólisis interna (NI) es una opción para tratar neuralgia del trigémino (NT) recurrente o NT que carece de compresión neurovascular (CNV). Se llevó a cabo una revisión sistemática siguiendo las directrices PRISMA, investigando la eficacia de la NI en NT. Cinco bases de datos fueran buscadas y se incluyeron diez estudios. La NI, por sí sola o acompañada de descompresión microvascular (DMV), logra un alto alivio del dolor inmediatamente postoperatorio (PO), especialmente en pacientes sin CNV y en cirugías de revisión. Cinco estudios examinando únicamente NI reportaron alivio PO inmediato de hasta 100%. Las recurrencias aumentan al largo del tiempo; con datos de 47% de supervivencia libre de dolor en cinco años. DMV con NI produjo tasas de éxito más altas en comparación con DMV sola. Complicaciones sensoriales son comunes inmediatamente después de NI y, aunque los estudios informan una mejora gradual, el procedimiento requiere asesoramiento al paciente. Antecedente de cirugía previa para la NT es factor de mal pronóstico para el éxito sostenido. La NI es una opción para pacientes con NT sin CNV o con fracaso de tratamientos previos y debe discutirse un control del dolor más eficiente frente a la posibilidad de efectos secundarios sensoriales y recurrencia.

Palabras clave: *bloqueo nervioso; neuralgia del trigémino; cirugía de descompresión microvascular; procedimientos neuroquirúrgicos; complicaciones postoperatorias; manejo del dolor.*

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1. INTRODUCTION

Trigeminal neuralgia (TN) is a neuropathic condition characterized by severe, paroxysmal, and lancinating facial pain. The International Classification of Headache Disorders defined the criteria for TN diagnosis. According to these criteria, the patient's pain must: 1) be recurrent, unilateral, and corresponding to one or more branches of the trigeminal nerve, with no irradiation or spreading; 2) last from seconds to two minutes and be characterized as similar to an electric shock, stabbing or sharp; 3) be triggered by non-painful stimulation in the territory innervated by the facial nerve[1,2].

Regarding the illness' epidemiology, it seems to be more prevalent among women and elder people, although incidence is highly variable across literature. Moreover, genetic factors are of consequence to its development, as a family history of cases determines a higher probability of TN[2].

The most widespread and studied cause for TN is demyelination. This can be an idiopathic process, although, classically, it is caused by compression of the nerve trajectory or root by another structure. Traditionally, this derives from neurovascular compression (NVC): when the trigeminal nerve trajectory comes in conflict with a vascular structure (typically an artery), creating close physical contact and generating TN. The pressure from the contact with the blood vessel, along with its pulsation creates friction against the nerve's sheath, causing focal demyelination and hyperactivity of the nerve. The offending artery is most commonly the superior cerebellar artery[1].

The compression of the trigeminal nerve root can also be caused by intracranial tumors, bone lesions, and basilar compression against the petrous ridge. Further expanding the etiologies of TN and out of the compression realm, it can also be caused by multiple sclerosis, viral infections, infiltrative disorders, sarcoidosis, and Lyme disease, among others[3,4].

Now, TN can be managed non-invasively, with pharmacotherapy, or invasively, with surgery. Pharmacotherapy is still first-line treatment. In this realm of non-invasive treatment, carbamazepine is the drug with the most evidence to its efficacy, although other drugs such as gabapentin, pregabalin, baclofen, and lamotrigine are also used. Therefore, carbamazepine and oxcarbazepine are considered first-line pharmacologic treatment. The surgical treatments, on the other hand, are divided into ablative and non-ablative therapies. Furthermore, they can be performed in the periphery of the trigeminal nerve, at the Gasserian ganglion level and within the posterior fossa of the skull[2,5].

At a periphery level, ablative procedures such as nerve block, neurectomy, local laser irradiation, laser puncture and cryoablation can be performed, while at the level of the Gasserian ganglion, among the ablative options would be radio frequency thermocoagulation, glycerol gangliolysis and chemical rhizotomy. Alcohol blocks were performed at both peripheric and Gasserion level, although they have fallen in disrepute due to adverse effects and erratic results. At posterior fossa open exploration, on the other hand, both ablative and non-ablative options are available, such as, respectively, internal neurolysis (IN) and microvascular decompression (MVD). Moreover, stereotactic radiosurgery, local laser irradiation, laser puncture and electroacupuncture can also be pain-controlling options[4].

When NVC can be observed in imaging studies, the first-line surgical treatment for TN is MVD, currently considered the best method for long-term pain relief in these cases. MVD is performed through retrosigmoid craniotomy, durotomy and careful arachnoid dissection. The surgical technique consists of creating a space between the fifth nerve and the conflicting blood vessel. Further on, to guarantee the nerve to remain protected, a Teflon pad or biological glue is often interposed between the structures. Other techniques to accomplish the same effect the Teflon pad have been demonstrated, such as the use of a fenestrated aneurysm clip to transfix the tentorium and fixate the superior cerebellar artery away from the fifth nerve[4,6,7].

It is important to point out that the complications most associated with MVD in the existing literature are cerebellar injury during surgery, eighth nerve injury and cerebrospinal fluid leaks[4].

However, a significant management difficulty arises for patients with TN who do not present with NVC. That is, in the absence of NVC, TN has a higher likelihood of not responding to MVD, as well as to recur after a technically successful initial procedure. This perception even challenges the notion that TN is exclusively caused by compression[4,6,8].

For the heterogeneous group of patients which either lacks NVC on imaging, does not have intraoperative NVC aspect, or present with pain recurrence, an optimal treatment strategy has not yet been definitively established[6,8,9].

Therefore, IN has emerged as a promising alternative or adjunctive surgical procedure to address TN in these challenging contexts.

Like MVD, IN is performed through retrosigmoid craniotomy during posterior fossa exploration. After satisfactory exposure of the trigeminal nerve, the outer connective tissue layer of the nerve is opened, and fascicular dissection is initiated and should extend to the deeper portions of the nerve. Once the deep dissection of the nerve is complete, the surgeon is usually capable of seeing the arachnoid cistern through the spaces created between the separated fascicles. Also, the dissection is considered complete when as many fascicles as possible have been separated. This ablative procedure is intended to disrupt the abnormal transmission of pain signals and relieve pain[6,8-10].

As the use of IN becomes more frequent, more clinical studies set out to investigate its efficacy in pain control and its complication rates in comparison to other possible therapies, especially MVD. In this scenario, a study aiming to synthesize this new evidence is in order, aiming to shed light on the role of IN, and clarifying in which circumstances it should be considered in the management of TN pain, the complication profile and prognostic factors to be considered.

This systematic review aims to analyze the available evidence on IN as a surgical strategy for pain control in TN. By critically appraising the literature, this review seeks to define the indications, immediate and long-term efficacy, complication rates and prognostic factors interfering with the results of IN in patients with TN.

The studies targeted for inclusion studied the effects of fifth nerve IN in adults diagnosed with TN, isolated or as opposed to the results accomplished by other procedures aiming to pain control. The outcomes intended are pain control and possible complications. Full PICOS strategy for the present systematic review was as described in Figure 1.

2. METHODS

A systematic review of literature was performed in accordance with PRISMA guidelines.

Medical Subject Headings (MeSH) descriptors "Trigeminal nerve", "Trigeminal neuralgia", "Nerve block" and their entry terms were used to compose the search strategy, combined with Boolean operators ("and" separating term families and "or" between entry terms) and parentheses placement. Medline/PUBMED, Embase, Scielo, Scopus and the Cochrane Database of Systematic Reviews databases were inspected from August 11, 2025 to August 21, 2025.

Filters were applied according to the available options in each database and to the inclusion and exclusion criteria. In all databases, it was possible to filter by the year of publication and study design. In Scielo and Scopus databases, it was possible to also add a language filter.

Inclusion criteria were articles: 1) randomized clinical trials or observational studies; 2) written in English or Portuguese; 3) published between 2014 and 2025; 4) with population diagnosed with trigeminal neuralgia; 5) which studied the outcomes associated with the chosen treatment option.

Exclusion criteria were: 1) observational studies that do not reach a minimum of 70% commitment to STROBE checklist; 2) randomized clinical trials which do not reach a minimum of 80% commitment to CONSORT checklist; 3) studies carried out in experimental models; 4) studies that do not answer the research question.

The use of STROBE and CONSORT thresholds serve the purpose of guaranteeing the methodological rigor applied to the construction process of the evidence analyzed in the present paper.

P opulation	Adults (≥ 18 years old) diagnosed with trigeminal neuralgia.
I ntervention	Trigeminal nerve internal neurolysis
C ontrol	Other surgical interventions for TN or no control
O utcome	Symptom relief and surgical complications
S tudy design	Randomized clinical trials and observational studies

Figure 1. PICOS strategy for the present systematic review.

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Articles were screened for duplicates with the aid of Rayyan software, which presents the two registers suspect of being duplicated and provides the researcher to choose which one to keep, or to keep both. No automation further than that was used in this step. Two blind researchers, assessed the titles and abstracts according to exclusion and inclusion criteria and to the PICOS strategy. Further on, disagreements between the researchers were resolved by a third party, also blinded. The articles included in this step were, then, read in their entirety and assessed for eligibility according, again, to the PICOS strategy and inclusion and exclusion criteria.

Two reviewers conducted data collection. Demographic data, such as age of population, sex and comorbidities were collected, as well as data regarding the treatment applied (which technique was applied and technique combinations) and the outcomes encountered in the population studied. Results of statistical significance determination used in the included studies were collected for appreciation.

The collected outcomes were pain control (immediate and sustained), procedure complications and sequelae associated to the procedure, notably hyperesthesia or anesthesia. Also, when the study analyzed identified prognostic factors within its population, those data were collected. The P value was the main strategy used to express the certainty of the results of the analyzed studies, when provided by the authors. If the P value was not determined in the included study, simple percentages were used for quantitative analysis.

The Rob2 tool was used for risk of bias assessment in the randomized clinical trials and the Newcastle-Ottawa scale for observational studies. The results of this assessment were expressed in the results section in the form of a figure.

To synthesize the results of the included studies, graphics and tables were built with data selected to allow for comparison between studies. Studies were grouped for analysis according to their methodological characteristics, namely: which procedures were compared to IN, statistical method for reporting results, complications observed and quantified.

3. RESULTS

Five databases were searched resulting in ninety-one articles. Rayyan was used to remove duplicates, and thirty-three records were removed. Twenty articles were retrieved for full-text appreciation, and ten were selected to be included in the systematic review (Figure 2).

Of the studies read in their entirety, three articles were excluded for not studying the outcome or intervention of interest to this systematic review, four for not complying to accepted study designs, two for having been published out of the time period chosen and, finally, one was excluded because it was written in language different from English and Portuguese (Figure 2).

Table 1 summarizes the characteristics of the articles included in this review. No randomized clinical trials were included; all studies were observational. Eight studies were retrospective cohorts and three were prospective cohorts. The sample sizes ranged from 9 to 1,261 patients. Three studies analyzed the efficacy of IN combined to MVD to the efficacy of MVD alone and one compared IN alone to MVD combined to IN. One study compared IN to radiofrequency thermocoagulation (RFTC), and other IN to MVD, both alone. Five other studies delved into IN alone, analyzing its efficacy without comparison to other techniques (Table 1).

Bias risk assessment was carried out using the Newcastle-Ottawa Score, since all included studies were cohorts. This score assigns stars to the methods used in the patient selection, comparability (between groups) and outcome measures used by the study. The maximum number of assigned stars is 9 per study. Liu et al.[12] and Zhou et al.[13] lost a star in the "adequacy of follow up of cohorts" criteria, in the outcome section of the Newcastle-Ottawa Score, for failing to provide information on loss of follow up. Lavergne et al.[10], Amagasaki et al.[14], Zhou et al.[13], Ko et al.[8] and Zhao et al.[15] lost the two stars that could be assigned to the comparability section, for they only studied IN, not presenting with a comparator (Figure 3)[8,10,12-14].

In turn, table 2 summarizes the findings in each individual study. All studies found success rates above 73% for IN or MVD combined with IN (Table 2)[9,10,12-14,16-21].

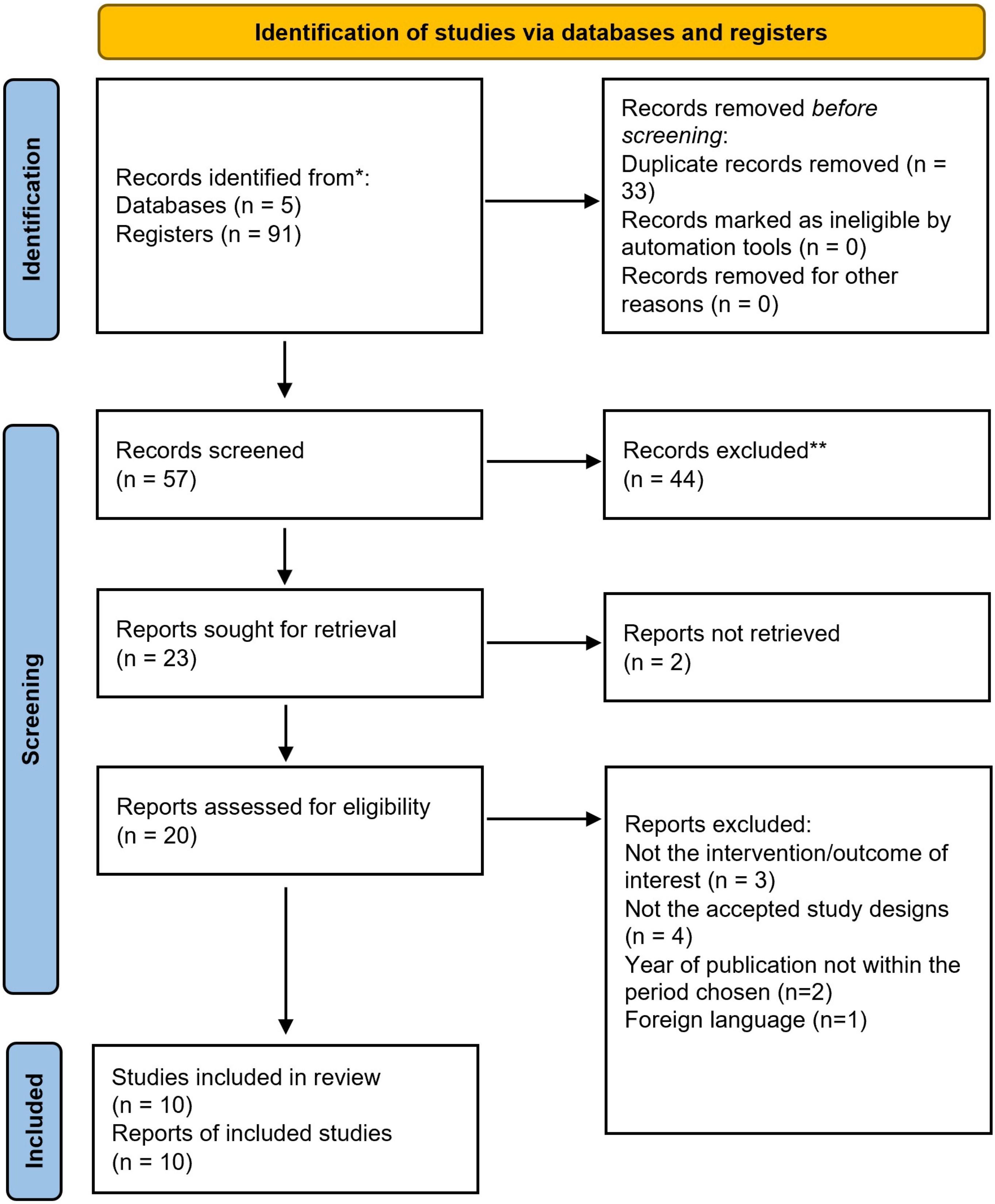

Figure 2. PRISMA 2020 flow diagram. Source: [11].

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Table 1. Characteristics of included studies.

IN alone studies					
Authors	**Year**	**Study Design**	**Sample size**	**Intervention**	**Outcome**
Amagasaki K., Tatebayashi K., Naemura K.	2024	Prospective cohort	18	IN	BNI-PS and BNI-HS
Ko A.L., Ozpinar A., Lee A., et al.	2015	Retrospective cohort	27	IN	BNI and BPIFacial
Lavergne P., Piper K., Vinjamuri S., et al.	2024	Retrospective cohort	18	IN	Self-reported pain relief and dermatomes numbness
Zhao H., Zhang X., Tang D., et al.	2017	Retrospective cohort	15	IN	Pain relief, facial numbness and complications
Comparative studies					
Authors	**Year**	**Study Design**	**Sample size**	**Intervention**	**Outcome**
Liu M.-X., Zhong J., Xia L., et al.	2021	Retrospective cohort	1261	MVD versus MVD with IN	Pain relief and facial numbness
Sabourin V., Mazza J., Gárzón-Muvdi T.,	2020	Retrospective cohort	32	IN with or without MVD	BNI-PS and BNI-HS
Yang D.-B., Wang Z.-M.	2019	Retrospective cohort	298	IN versus MVD	Pain relief (according to criteria of UCSF), facial numbness, hyperesthesia and complications
Zhang X., Xu L., Zhao H., et al.	2017	Retrospective cohort	148	IN with MVD versus re-do MVD	Pain relief, facial numbness, hyperesthesia and complications
Zheng W., Dong X., Wang D.,	2021	Prospective cohort	29	MVD with IN versus MVD alone	Facial numbness, pain control, recurrence of symptoms
Zhou X., Liu Y., Yue Z., et al.	2016	Prospective cohort	105	IN versus RFTC	Questionnaire to assess pain relief (UCSF), recurrence, complication and need for additional treatment

BNI-FNS: Barrow Neurology Institute face numbness scale. BNI-HS: Barrow Neurology Institute hyperesthesia scale. BNI-PS: Barrow Neurology Institute pain scale. IN: Internal neurolysis. MVD: Microvascular decompression. RFTC: Radiofrequency thermocoagulation. UCSF: University of California at San Francisco.

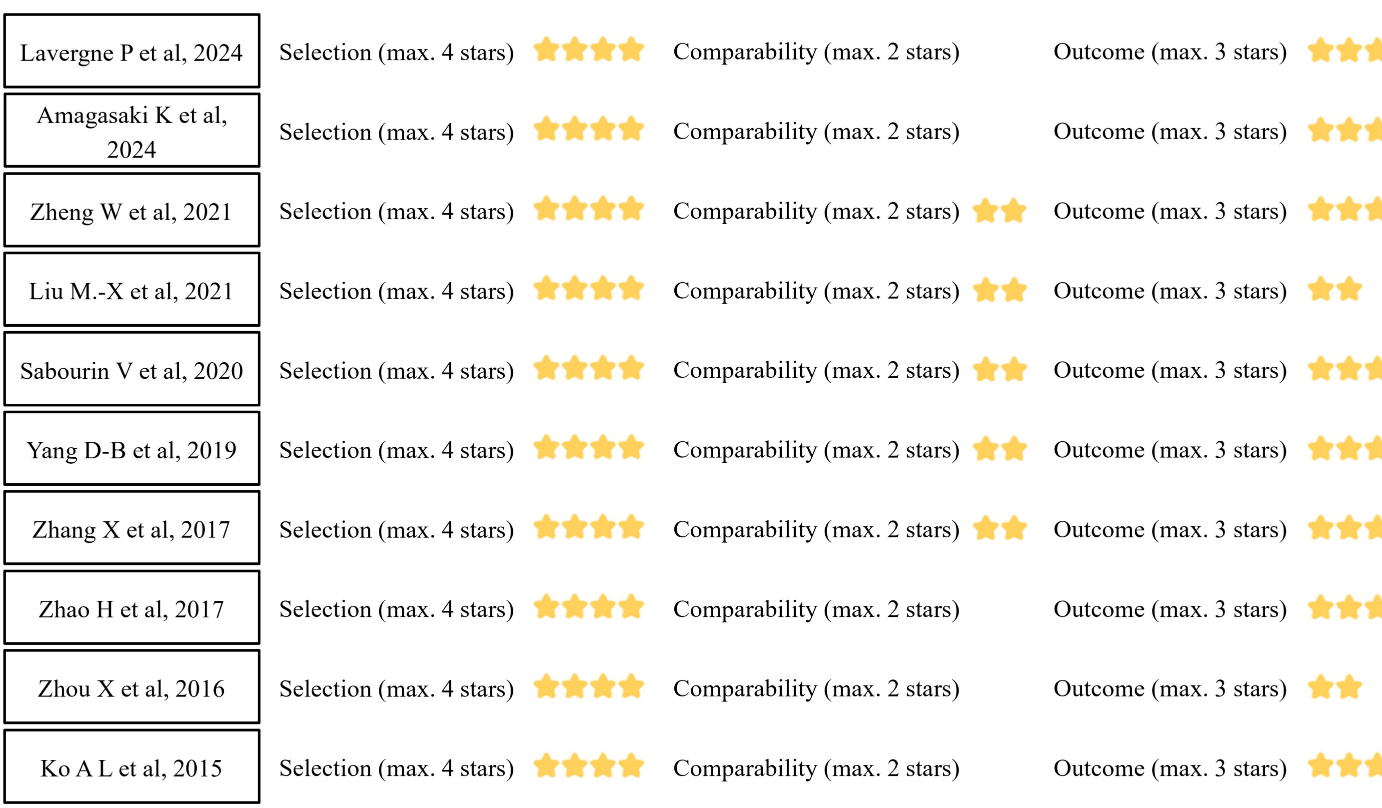

Figure 3. Representation of the results obtained from the application of the Newcastle-Ottawa Scale to analyse the bias risk of the included studies. max.: maximum.

Table 2. Results of included studies.

Authors	Year	Intervention	Results
IN alone studies			
Authors	**Year**	**Intervention**	**Results**
Amagasaki K., Tatebayashi K., Naemura K.	2024	IN	**Pain relief** 17 out of 19 patients had a decrease of the BNI-PS after IN. 6 patients presented with no pain immediately after surgery. One year later, 7 patients remained pain-free, 6 had BNI-PS II, 2 had BNI-PS III and 3 had BNI-PS IV. **Complications** 12 patients had BNI-HS II immediately post-surgery, and 9 patients still reported hyperesthesia at one-year follow up. No effect estimate provided.
Ko A.L., Ozpinar A., Lee A., et al.	2015	IN	**Pain relief (Kaplan-Meyer survival analysis)** Immediate post-operative results with 85% of patients pain free and 96% with successful pain relief. Pain-free survival at 1 and 5 years follow up was 58% and 47%, respectively. Median pain free survival was 24.8 months. No effect estimate provided. **Complications** 96% of patients reported some degree of subjective numbness or hyperesthesia (P=0.00). History of a previous treatment for TN was a poor prognostic factor (P = 0.006), shortening recurrence time to a median of 8.6 months.
Lavergne P., Piper K., Vinjamuri S., et al.	2024	IN	**Pain relief** 83.3% pain free by 14th POD. 36% of patients who were pain free at first POD had pain at 1 year follow-up. No effect estimate provided. **Facial numbness** Patients with normal nerve consistency had facial numbness progressively worsening until one year follow-up (P=0.95), while patients with soft nerve consistency had facial numbness peaking at 14th POD (P=0.312) and getting better until one year follow-up (P=0.204). Patients with moderate to extensive neurolysis extent were more numb by 14th POD (P=0.46 and P=0.26, respectively) and significantly numb at one year follow up (P=0.499 and P=0.695, respectively). None of the findings related to numbness were statistically significant.
Zhao H., Zhang X., Tang D., et al.	2017	IN	**Pain relief** Long term excellent pain relief in 73.3% patients. In all cases with residual pain, it was not intense enough to require medication **Complications** 3 (out of 15) patients reported facial numbness, which disappeared by 4 months post-operation. No effect estimate provided.
Comparative studies			
Authors	**Year**	**Intervention**	**Results**
Liu M.-X., Zhong J., Xia L., et al.	2021	MVD versus MVD with IN	**Pain relief** Higher rates of immediate relief and relief after one year in the MVD plus group (P=0.05). **Complications** 90% rate of facial numbness among MVD plus group versus 20% among traditional MVD group (p < 0.05), with a tendency to reduce and become similar in both groups in 3 months (p > 0.05).
Sabourin V., Mazza J., Gárzón-Muvdi T.,	2020	IN with or without MVD	**Pain relief** No significant differences (P >0.05) were seen in any of the outcome measures (BNI-PS) between the MVD plus IN group and the IN alone group. For MVD+IN, 100% of patients achieved adequate control, versus 85% for IN alone. Significantly more patients without previous treatment had had successful pain control post operatively (95% vs. 54%; P<0.05). Patients with a previous procedure were found to be significantly (P<0.05) more likely to have experienced any return of pain compared with patients who had not undergone a previous procedure (39% vs. 5%) **Complications** No significant differences were seen in the BNI-HS scores between the groups
Yang D.-B., Wang Z.-M.	2019	IN versus MVD	**Pain relief** For IN group (n=34), excellent (30) and good (4) pain relief. 5 patients had worsening pain in the long term follow up. In turn, for MVD group (n=264), excellent (245), good (25) and poor (4) pain relief. 17 patients had worsening of pain on extended follow up. No statistical significance (P>0.05) **Complications** Facial numbness observed in 26 patients in IN group and 6 patients in MVD group (P<0.001).
Zhang X., Xu L., Zhao H., et al.	2017	IN with MVD versus re-do MVD	**Pain relief** Higher success rates for MVD+IN group than MVD only group (P< 0.004). MVD group reached success rate of 78.95% and MVD+IN group reached 93.75%. **Complications** No significant differences between the simple MVD group and the MVD+IN group in the incidence rates of facial numbness at 1 day (P=0.15), 7 days (P=0.20),1 month (P=0.19), 3 months (P=0.49), and 1 year (P=0.50) after surgery
Zheng W., Dong X., Wang D.,	2021	MVD with IN versus MVD alone	**Pain relief** In MVD+IN group the efficacy was 88.6%, the cure rate was 77.1% and the inefficiency was 11.4%. There was no significant difference in efficacy and cure rate between the two groups (p>0.05).The cure rate of patients with MVD+IN unable to fully release arachnoid adhesions was higher than that of the MVD group (p<0.05) **Complications** 65.7% of patients in MVD+IN group had ipsilateral numbness. 87% had numbness improvement after 6 months. Incidence of facial numbness higher in MVD+IN group (P< 0,01). The incidence of facial numbness in the two groups had no statistically significant difference in the long term (>6 months) postoperative period (p>0.05).
Zhou X., Liu Y., Yue Z., et al.	2016	IN versus RFTC	**Pain relief** Achieved satisfactory pain control in 82% IN group and 76.4% in RFTC group (P>0.05). **Complications** Higher rates of complications such as dysesthesia and facial nerve lesion in IN group (P<0.05)

IN: Internal neurolysis. MVD: Microvascular decompression. POD: Post-operative day. RF: Radiofrequency thermocoagulation

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Studies on IN alone

Lavergne et al.[10], Amagasaki et al.[14], Zhao et al.[15], and Ko et al.[8] looked directly at IN procedure without a comparator. Immediate success rates found by these studies ranged up from 83.3%, reached by Lavergne et al.[10]. However, at one year follow up, all authors reported recurrence rates, and those working with longer follow-up times reported rising in those numbers [9,10,12,19-21].

It is important to note that Lavergne et al.[10] did not provide effect estimates for their pain relief outcomes, as well as Zhao et al.[15] and Amagasaki et al.[14].

Ko et al.[8] was the only one to perform Kaplan-Meier survival analysis, reporting a pain free survival of 47% at 5 years follow up and finding a median pain-free survival of 24.8 months[8].

Regarding the surgical complications on this same cluster of studies, the rates of facial numbness or hyperesthesia post-operatively varied, going as high as 96%, found by Ko et al.[8] (P=0.00). Amagasaki et al.[14] and Zhao et al.[15] described complication rates of, respectively, 47.6% and 20% (Figure 4). Moreover, Amagasaki et al.[14] reported that these symptoms were sustained one year after the surgery, while Zhao et al. sustained that those symptoms disappeared 4 months after operation, with no effect estimate provided[8,14,15].

Lavergne et al.[10] tried to identify intraoperative factors influencing rates of postoperative facial numbness. Although they failed to prove statistical significance to their findings, they reported that patients with a normal nerve consistency tended to have worsening numbness as the follow-up period progressed, while patients with a soft nerve consistency had a peak in numbness by the 14th post-operative day and got better by the one-year follow-up mark. The extent of the numb region did not seem to be affected by the nerve consistency. In turn, Lavergne et al.[10] also described that patients who had undergone minimal neurolysis were maximally numb by one year follow-up, while patients who had moderate to extensive neurolysis had their numbness peaking at 14th day of follow-up. Again, these findings were also not statistically significant[10].

Ko et al.[8] also described history of failed previous pain control procedures was a strong prognostic factor for shortened recurrence time, with patients having return of pain up to 8.6 months sooner (P=0.006)[8].

Comparative studies

Three studies compared the efficacy of simple MVD to that of MVD paired with IN (Liu et al.[12], Zhang et al.[18] and Zheng et al.[9]). All three found higher success rates for the groups subjected to MVD with IN, although Zheng et al.[9] did not find statistical significance[9,12,17].

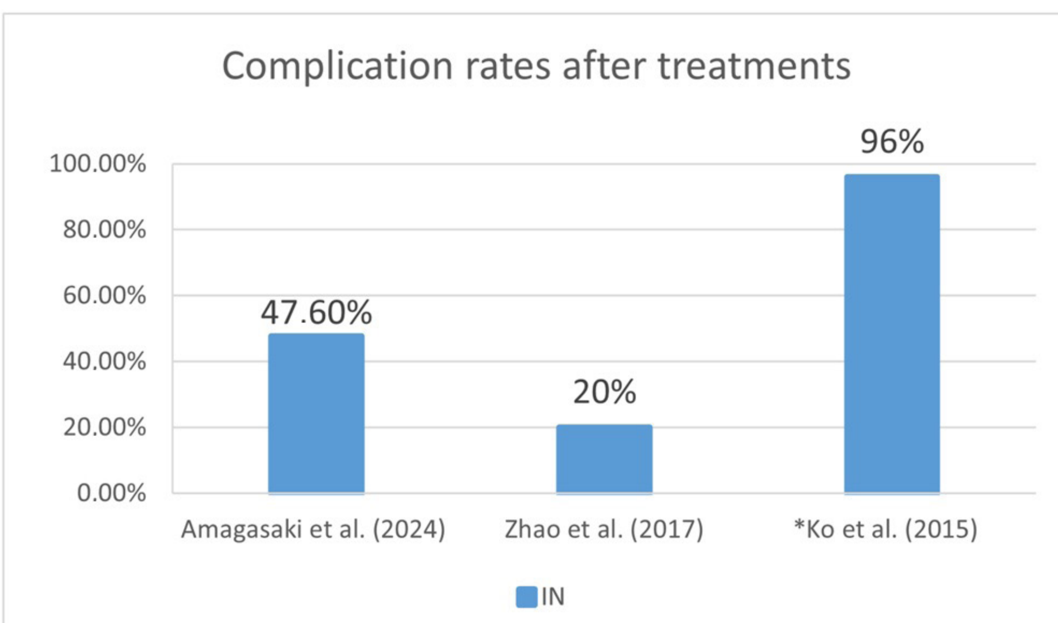

Figure 4. Rates of numbness and/or hyperesthesia after surgical interventions for trigeminal neuralgia, as described by IN only studies. * Statistically significant findings. IN: Internal neurolysis.

Additionally, Sabourin et al.[21] compared IN alone to MVD paired with IN, finding no relevant differences in procedure success rates among groups. On the other hand, Yang et al.[19] compared MVD to IN, both isolated, also not finding statistically significant differences among groups[19,21].

Therefore, in this cluster of comparative studies, only Liu et al.[12] and Zhang et al.[17] could find statistically significant differences between groups (Figure 5)[9,12,17,19,21].

It is important to point out that both Liu et al.[12] and Zhang et al.[17] only performed MVD plus IN in those patients who had no obvious microvascular conflict identified during surgery, although Zhang et al.[17]'s population was composed of patients with previous history of unsuccessful MVD[12,17].

Yang et al.[19] was the only study comparing IN directly to MVD. They compared the pain control achieved by 34 patients subjected to IN and 264 patients subjected to MVD. In the IN group, there was no poor pain control reported (100% efficacy), all the results were rated as either excellent or good. In the MVD group, four patients had poor pain control (89.4% efficacy). These findings were not statistically significant. Furthermore, on the long-term follow-up, five patients referred return of pain in the IN group, versus 17 in the MVD group (14.7% versus 6.4%, respectively), also with a P value higher than 0.05[19].

Zhou et al.[13] also differed from other studies included in this review, for it compared IN to RFTC. Although they described better pain control in the IN group (82% in IN versus 76.4% in RFTC group), the finding had no statistic significance[13].

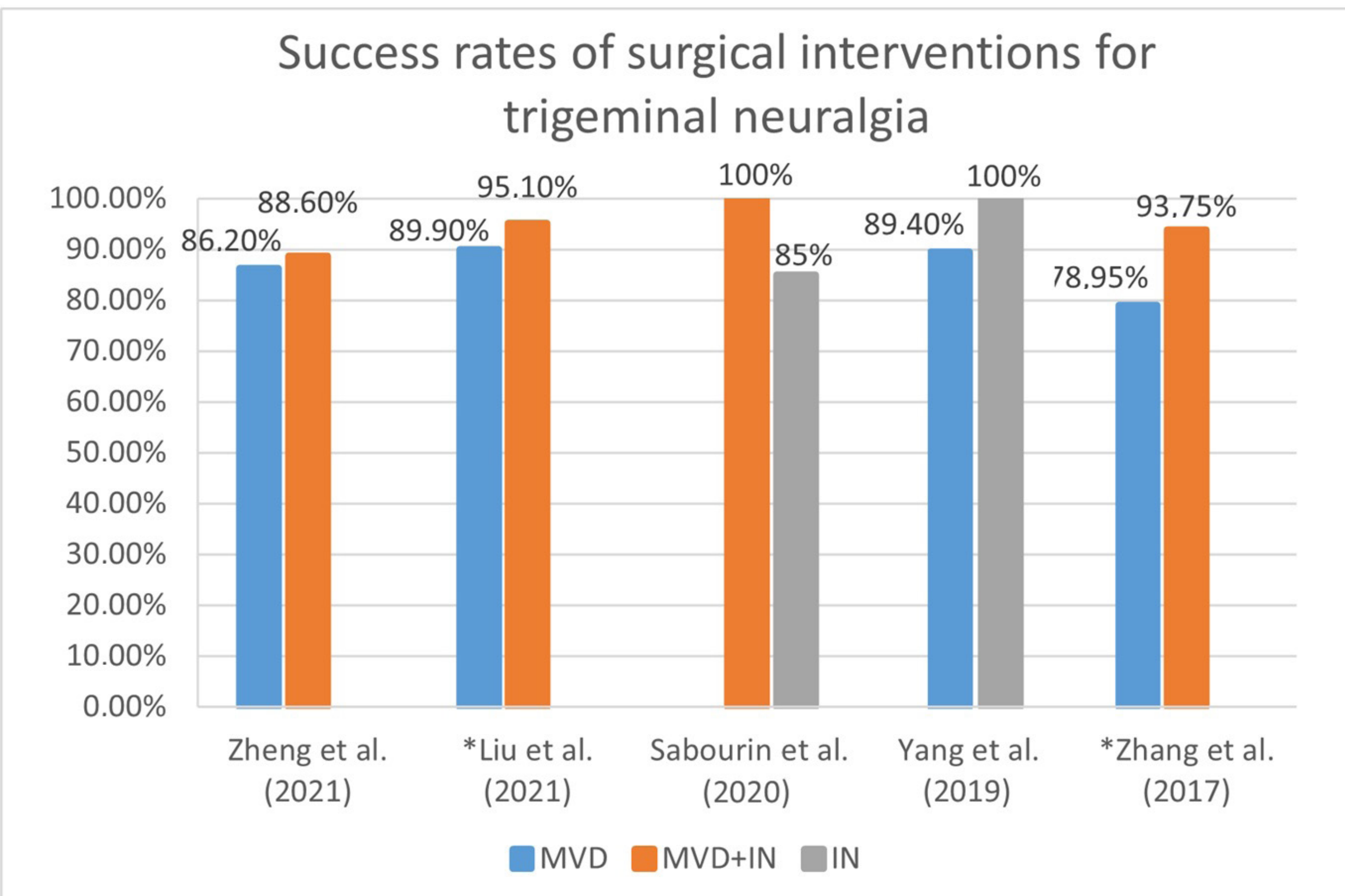

Figure 5. Chart comparing the immediate success rates found by five studies comparing the same surgical procedures. * Statistically significant findings. MVD: microvascular decompression. IN: Internal neurolysis. MVD+IN: Microvascular decompression with internal neurolysis.

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Regarding complications, several of the included studies brought data on the post-operative incidence of numbness and hyperesthesia, with great variations to their numbers. The viable data were compiled in a graphic for comparison effect (Figure 6)[9,12,13,17,19,21].

Among the studies comparing MVD to MVD plus IN technique, Zheng et al.[9] and Liu et al.[12] could prove statistically significant findings regarding complication rates. Zheng et al.[9] found a complication rate of 10.3% for MVD, compared to a 65.7% for MVD plus IN ($P<0.05$), while Liu et al.[12] found 20% and 90%, respectively, for MVD and MVD plus IN ($P<0.05$). Zhang et al.[17] and Sabourin et al.[21] also compared MVD and MVD plus IN and, although they could not attribute statistical significance to their findings, they described, respectively, a 48.39% and 79% complication rate in MVD, versus 60.47% and 42% for MVD plus IN (Figure 6)[9,12,17,21].

On other note, Liu et al.[12] reported that the facial numbness tended to reduce in three months and become similar in both MVD and MVD plus IN groups ($P>0.05$). Although the former was not a statistically relevant finding, Zheng et al.[9], similarly, described that, after six months post-operative period, the difference of complication incidence among groups was no longer significant statistically. In their study[9], 87% of IN patients who had numbness reported improvement in six months ($P<0.01$)[9,12].

As the only study comparing IN to MVD directly, Yang et al.[19] described a complication rate of 76,47% for IN against a 2.27% complication rate for MVD ($P<0.001$)[19].

Zhou et al.[13], comparing IN to radio frequency thermocoagulation, found complications such as dysesthesia and facial nerve lesion were more frequent in the IN group ($P<0.05$)[13].

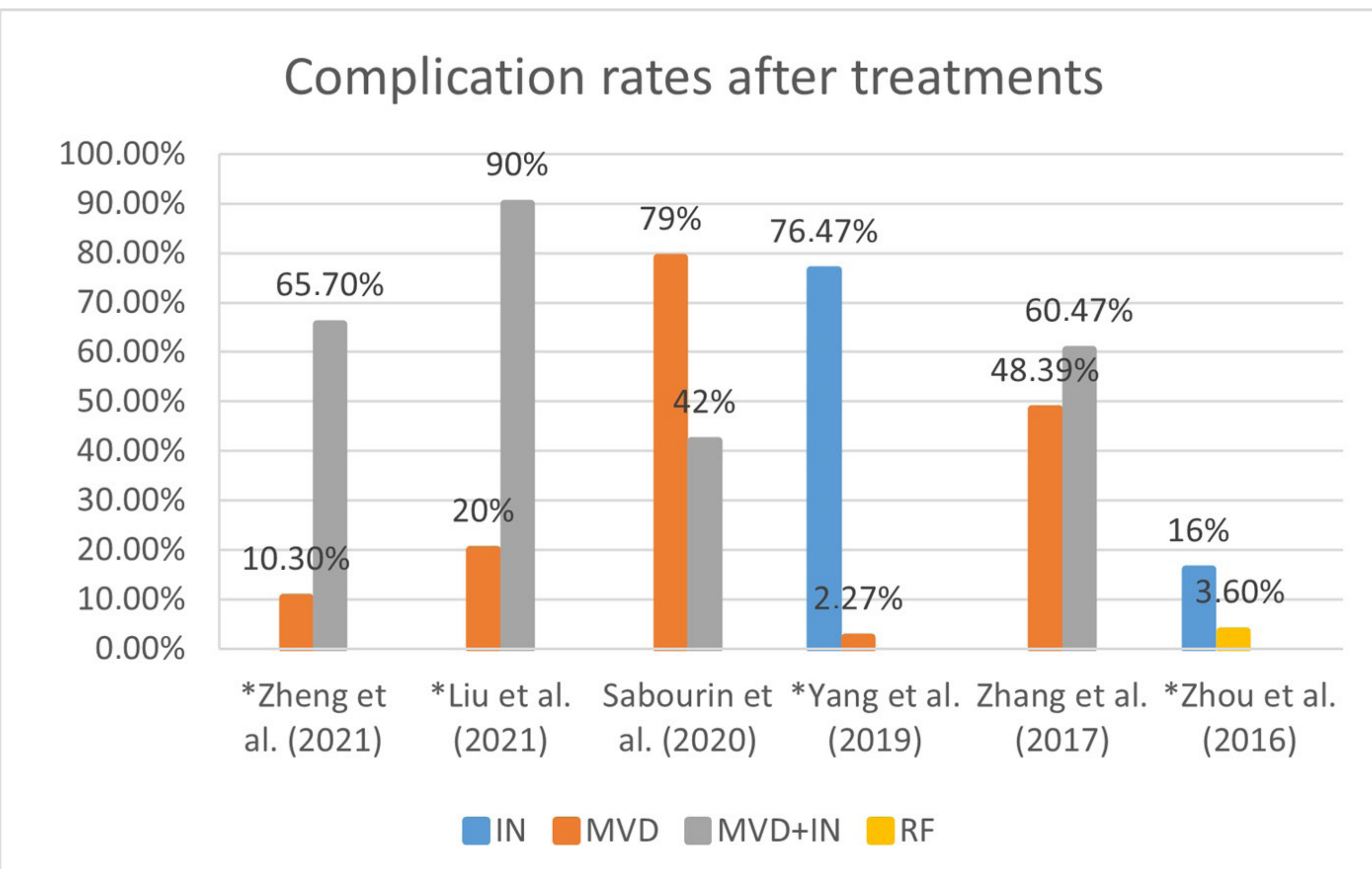

Figure 6. Rates of numbness and/or hyperesthesia after surgical interventions for trigeminal neuralgia, as described by six comparative studies. * Statistically significant findings. MVD: microvascular decompression. IN: Internal neurolysis. MVD+IN: Microvascular decompression with internal neurolysis. RF: Radiofrequency thermocoagulation.

Like in Ko et al.[8]'s study, history of previous procedures aiming for pain control was identified by Sabourin et al.[21] as poor prognostic factor to the success of the new procedure (P<0.05). Sabourin et al.[21] established that patients who had previously undergone unsuccessful procedures to control pain had a 39% chance of experiencing return of pain versus a 5% chance for patients who had not[8,21].

4. DISCUSSION

This systematic review analyzed the available evidence concerning IN during posterior fossa exploration as a surgical strategy for pain control in TN.

IN by itself or combined with MVD can achieve high rates of initial pain relief in trigeminal neuralgia. This is particularly true when no clear NVC is found, as studies clearly reported only performing IN in that condition. The studies in this review often approached 100% immediate post IN pain relief[8,10,13,14,16-22].

However, the pain control achieved with the procedure seems to deteriorate over time, with studies' recurrence rates rising over time in those with longer follow-up periods and those doing Kaplan-Meyer survival analysis. Therefore, while initial success is high, recurrence remains a concern, as analyzing only immediate pain control, as many included studies did, is less than adequate for determining efficacy of a procedure like IN. Additionally, Sabourin et al.[6], in their systematic review, found statistically significant rates of recurrence between 3.6% to 25% [8,10,13,14,16-22].

These findings follow the trend seen in recent systematic reviews: excellent-to-good outcomes (BNI-PS I-III) in above 80% of patients on average, but with relatively high long-term recurrence rates[6,8,10,13,14,16-22].

The results found by Yang et al.[19], although suggesting superiority of IN, are not statistically significant. It is important to point out that the total of patients in each group varied in number, which reduces the power of comparison and further weakens this study's findings[19].

Another finding of this systematic review is the apparent synergistic benefit of combining IN to MVD. Studies that compared MVD plus IN to MVD alone (especially in cases of recurrent TN or unclear vascular compression) found higher success with the combined approach. Sabourin et al.[6] reached a similar conclusion in their review [6,9,12,17].

The mechanisms underlying this synergistic effect likely relate to IN's ability to mechanically disrupt the abnormal transmission of pain signals through the longitudinal division of the nerve root bundles. This ablative component provides an additional therapeutic layer that is essential when the pain is either not solely caused by NVC or when NVC is technically difficult to address completely[6,9,12,17].

In comparison with RFTC, the difference of IN tends to be slight and not significant. However, it is relevant that the history of previous RFTC is associated to worse success rates for IN[2,5,13].

Complications, especially facial numbness or hyperesthesia, have been common in IN, in the cluster of studies analyzed, which is also reflected in other literature and reported by Wu et al.[23]. Five studies reported high rates in the immediately post-op, with P value < 0.05 (Figure 6). However, Zhang et al.[18] and Sabourin et al.[21] found no difference in complication rates among the groups studied. The heterogeneity in sample sizes, study designs and methodological rigor could explain the differing results[9,12,13,15,17,21].

Moreover, many articles report that much of this sensory morbidity decreases over time. In this note, Zheng et al.[9] reported that at six months post-operative follow up, the difference was no longer significant[9,10,12,13,15,17,18].

It remains unclear whether nerve consistency and extension of neurolysis correlates to the rates of facial numbness or hyperesthesia post-operatively, and to their persistency on the longer run, as suggested by Lavergne et al.[10], since they could not attribute statistical significance to their findings[6,10].

The history of previous surgical procedures to control the pain of TN was identified with statistical significance as a poor prognostic factor by two studies in this review (Ko et al.[8] and Sabourin et al.[21]), a finding which aligns with pre-existing evidence and is also reported by Sabourin et al.[6]. This factor shortened the pain-free survival of patients and reduced their likelihood of a successful procedure.

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Furthermore, surgical treatment-naïve patients have a higher chance of remaining pain-free[6,8,21,23].

The major limitation of the current body of evidence is the lack of randomized clinical trials (RCTs), as all studies included in this review were observational. This systematic review also could not reach thesis and studies yet not published, as the search was not conducted in repositories. Grey literature was not included in the search strategy.

The heterogeneity in methodologies is also a strong limitation, as follow-up periods and sample sizes across the studies differed greatly. This could justify the wide range of success and complication rates found, as well as eventual opposing conclusions across included papers. The high level of evidence variability makes it harder to clearly define IN's full impact. Furthermore, retrospective studies appeared in this review in greater number than prospective ones.

Lastly, the included studies had rather short follow-up times, which reduces their capacity to ascertain long-term efficacy of IN. Furthermore, the small sample sizes diminish the studies' statistical power, making the drawing of clear conclusions hard.

5. CONCLUSIONS

This review concluded that IN is a promising treatment option in patients with TN, still in process of having its indications clearly outlined, although literature suggests a stronger recommendation for patients without NVC or with a history of prior failed MVD.

Long-term pain-free survival declines over time and the possibility of recurrence should be weighed in clinical decision-making. Sensory complications, such as facial numbness and hyperesthesia, are common, though it should not be ignored that evidence shows a likelihood of immediate post-operative symptoms reducing with time.

Therefore, the trade-off between the possibility of more efficient pain control versus the chance of recurrence and higher rates of initial sensory alterations must be discussed with patients.

Patients with a history of failed past surgical treatments for pain control in TN should be advised about their higher likelihood of recurrence and shorter pain-free survival, as this has been well established as a poor prognostic factor across literature.

Finally, further long-term research is needed to better define the role of IN, alone, combined with MVD or against other pain-controlling treatments. The role of nerve consistency and neurolysis extent in outcome, the surgical techniques most beneficial, and the predictors of patients who will benefit most are also to be better defined. Prospective studies should be prioritized.

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