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# Efficacy and safety of high-voltage versus standard-voltage pulsed radiofrequency ablation for patients with neuropathic pain: protocol for a systematic review and meta-analysis

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## ABSTRACT

**Introduction** Pulsed radiofrequency (PRF) ablation is commonly used for the treatment of neuropathic pain (NP). However, it is unclear whether increasing the output voltage of PRF can safely improve its efficacy. This study aims to compare the efficacy and safety of high-voltage PRF ablation and standard-voltage PRF ablation for the treatment of patients with NP.

**Methods and analysis** We will search PubMed/MEDLINE, EMBASE, Web of Science, the Cochrane Library, conference proceedings for relevant abstracts, clinical trials registers (ClinicalTrials.gov) and the WHO's International Clinical Trial Registry Platform (from the date of inception until 15 March 2022). Only randomised controlled trials will be included. Two reviewers (YJ and GF) will independently perform study screening and selection, data extraction, risk-of-bias assessment and quality-of-evidence assessment. The primary outcome of this meta-analysis will be the efficiency rate in patients with NP. The secondary outcomes will include numeric rating scale score, visual analogue scale score, time to take effect, rescue drug dosage, quality of life using the health questionnaire (SF-36) and the incidence of adverse events. Meta-analyses will be conducted using standard meta-analysis software (RevMan V.5.3, The Nordic Cochrane Center, The Cochrane Collaboration, Copenhagen, Denmark).

**Ethics and dissemination** The requirement for ethical approval was waived as our systematic review will be based on the published literature. The results of this study will be submitted to a peer-reviewed journal.

**PROSPERO registration number** CRD42022297804.

## STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ To the best of our knowledge, this will be the first systematic review and meta-analysis to evaluate the efficacy and safety of high-voltage pulsed radiofrequency ablation for the treatment of patients with neuropathic pain. To provide unbiased information, only randomised controlled trials will be included.
⇒ The study findings will provide comprehensive information for future study designs in terms of interventional treatment of neuropathic pain.
⇒ The accuracy of our research conclusions might be subjected to language limitations as only studies published in English will be included.

## INTRODUCTION

Neuropathic pain (NP) is a common chronic pain condition caused by lesions or diseases affecting the somatosensory nervous system, including trigeminal neuralgia (TN), peripheral nerve injury pain, painful polyneuropathy, postherpetic neuralgia and central poststroke pain.[1] Epidemiological data have reported that the global prevalence of NP is approximately 6.9%–10%.[2] NP is a refractory pain syndrome with a long duration of occurrence, frequent recurrent attacks and poor response to traditional analgesics. Most patients with NP suffer from ongoing or intermittent spontaneous pain accompanied by burning, pricking and squeezing sensations, and have a poor quality of life (QoL).[3] Therefore, finding an effective treatment option for NP and improving patients' QoL is of great importance.

In recent years, pulsed radiofrequency (PRF) ablation, a new type of neuromodulation technique, has been successfully applied in the treatment of NP.[4–9] Different from continuous radiofrequency, which produces heat by friction and vibration, leading to thermocoagulation, denaturation and necrosis of the target tissue,[10 11] PRF provides pulsed energy waves followed by a 480 ms heat dissipation interval, and the temperature does not exceed 42°C.[12–14] PRF treatment exerts its effect via the modulation of nerve function, which is a result of the electric field effect and not the impedance of pain signal transduction;[15 16] thus, PRF ablation is a

non-destructive technique that can be repeatedly applied without causing nerve tissue damage.

The standard proposed PRF parameters are set as follows: an output voltage of 45 V, temperature of 42°C, pulse frequency of 2 Hz, output frequency of 500 kHz, continuous current action of 20 ms and intermission period of 480 ms. Recently, scholars have attempted to treat patients with NP using high-voltage PRF ablation. Teixeira and Sluijter first reported that a high-voltage PRF ablation of 60 V used to treat patients with discogenic pain attained satisfactory efficacy that lasted over 3 months.[17] In 2013, Luo *et al* found that the postoperative numeric rating scale (NRS) score had a significant negative correlation with the output voltage of PRF.[18] Afterwards, Luo *et al* compared the efficacy of high-voltage PRF with standard-voltage PRF for idiopathic TN patients who responded poorly to oral carbamazepine or nerve blockade by steroid, and the results revealed the 1 year effective rate of high-voltage PRF (69%) was significantly higher than that in the standard-voltage PRF treatment(19%) (p=0.000).[19]Additionally, they compared the efficacy of high-voltage PRF and standard voltage PRF for refractory neuralgia infraorbital nerve therapy, and reported that high-voltage PRF ablation could achieve higher response rates at 1 month, 3 months, 6 months and 1 year post procedure.[20] Jia *et al* retrospectively analysed the medical data of patients with idiopathic TN undergoing PRF. The study found that for patients who did not respond to the first PRF treatment and underwent the second PRF treatment, a higher dose of output voltage than the initial one could achieve improved analgesic effect.[21–23]

However, the number of patients who experienced mild numbness postoperatively was greater in the high-voltage group (27%) than in the standard-voltage group (13%).[20] In addition, a randomised controlled trial (RCT) conducted by Wan *et al* showed that the scores were significantly lower in the high-voltage group than in the standard-voltage group at 3 and 6 months; however, no significant difference was observed at 1 month after treatment.[24] A study by Wan *et al* revealed that the incidence of ecchymoses in the high-voltage group (19.2%) was higher than that in the standard-voltage group (12.1%). As a result, further analysis is required to determine whether the efficacy of high-voltage PRF ablation at different timepoints is superior to that of standard-voltage PRF ablation, and whether high-voltage PRF ablation is a safe treatment method for NP.

The primary objectives of this study will be to compare the efficacy and safety of high-voltage PRF ablation and standard-voltage PRF ablation for the treatment of NP at different timepoints postoperatively through a systematic review and meta-analysis of RCTs.

## METHODS

This protocol was developed according to the reporting guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols statement[25] (checklist in online supplemental file 1). Our systematic review will be conducted in accordance with the recommendations of the Cochrane Handbook for Systematic Reviews of Interventions.[26] Any amendments made to this protocol and the whole review process will be updated in a timely manner on the PROSPERO registration and the final manuscript.

### Criteria for considering eligible studies

#### Types of studies

Only RCTs will be included. All studies must be published in English. Experimental animal studies will be excluded.

#### Participants

Patients with NP conditions recognised and defined by the International Association for the Study of Pain[27] will be included. NP is initiated or caused by a primary lesion or dysfunction of the nervous system. Studies regarding diabetic neuropathy, complex regional pain syndrome type 1, low back pain without radicular pain and postsurgical pain will be excluded.

#### Interventions and comparators

We will examine trials investigating high-voltage PRF treatment for patients with NP. The high-voltage PRF treatment will be set to the manual pulse mode: the initial voltage will be 40 or 45 V, and the output voltage will then be gradually increased to the highest voltage the patient can tolerate (temperature control below 50°C). The comparator will be the standard PRF treatment.

#### Outcome measures

The primary outcome of this meta-analysis is the efficiency rate in patients with NP. The predefined timepoints for the efficiency rate will be 1 month, 3 months and 6 months after the procedure. Additionally, 1-year or 2-year timepoint will also be considered. Treatment efficiency recurrence is defined as a pain reduction of greater than 50% after treatment compared with pre surgery. Secondary outcomes will include (NRS) or visual analogue scale (VAS) score, time to take effect, rescue drug dosage, QoL determined using a health questionnaire (SF-36)[28] at 1 month, 3 months and 6 months postoperatively, and incidence of adverse events (AEs).

### Information sources and search strategy

A computer-based search strategy will be designed by an experienced librarian and revised by another expert librarian according to the Peer Review of Electronic Search Strategies checklist.[29] The primary source of the literature will be the following major electronic databases: PubMed/MEDLINE, EMBASE, Web of Science and the Cochrane Library (from the date of inception until 15 March 2022). The secondary source of potentially relevant research includes conference proceedings for relevant abstracts, clinical trials registers (ClinicalTrials.gov) and the WHO's International Clinical Trial Registry Platform to identify ongoing studies. The search will encompass a broad range of terms and keywords

related to 'high-voltage', 'pulsed radiofrequency', 'neuropathic pain' and 'RCT'. The detailed search strategy is presented in online supplemental file 2.

## Data selection and analysis

### Study selection

We will use the Population, Intervention, Comparison, Outcome model[30] to determine the specific criteria for selecting studies. Two reviewers (YJ and GF) will independently screen and select the relevant studies. During the initial screening, reviewers will determine whether the study could be included by screening the titles and abstracts retrieved via database search. We will screen the full texts retained from the initial selection of articles to include studies that meet the eligibility criteria. Disagreements between the two reviewers will be resolved by a third reviewer (TeW). If several studies present data from the same study population or multiple publications from the same study are published in chronological order, the study with the most direct interventions or the largest sample size will be selected. The same methods will be used for citation, reference screening and selection, as well as for protocols registered in clinical trial registries.

## Data extraction

A standardised electronic form for data extraction will be created by ZW. Two reviewers (YJ and GF) will independently extract the following data: study characteristics (eg, name of the first author, year of publication, type of study, sample size), population characteristics (eg, age, gender, disease duration, medical history, preoperative pain intensity and follow-up period) and outcome data (eg, primary and secondary outcomes and any AEs caused by PRF treatment). Similarly, a third reviewer will be required to resolve any discrepancies. We will attempt to contact the study authors by email or post for further information in case of any ambiguity or insufficient information. Table 1 presents the characteristics of the studies that will be included.

## Assessment of risk-of-bias and quality-of-evidence assessment

Two reviewers (YJ and GF) will independently assess the risk of bias (RoB) and a third reviewer (ZW) will resolve discrepancies. The RoB of RCTs will be assessed according to items in the Cochrane Collaboration's tool.[26]

We will evaluate the overall quality of the body of evidence in accordance with the Grading of Recommendations Assessment, Development and Evaluation methodology,[31] which examines study design, RoB, inconsistency, indirectness and imprecision. Accordingly, quality of evidence will be rated as high, moderate, low or very low.

## Data synthesis and analysis

Meta-analyses will be conducted using the standard meta-analysis software (RevMan V.5.3, The Nordic Cochrane Center, The Cochrane Collaboration, Copenhagen, Denmark). We will compute standardised mean differences and 95% CIs for continuous outcomes and risk ratios with 95% CI for binary outcomes. A two-tailed p value<0.05 will be considered statistically significant. We will assess the intervention effects between high-voltage PRF and standard-voltage PRF using preintervention to postintervention changes. When the data in the literature are expressed as median values and quartiles, we will use mathematical operations to transform them into mean and SD.[32 33] Additionally, we will use forest plots to visualise pooled estimates and the extent of heterogeneity among studies. Heterogeneity will be assessed using the $I^2$ statistic. $I^2$>50% is an indication of substantial heterogeneity, and in such cases the random effects model will be used to analyse the outcomes; otherwise, a fixed-effect model will be applied. If heterogeneity is observed, we will perform subgroup analysis according to prespecified variables, such as study design, intervention characteristics or RoB. The sources of heterogeneity will be explored using sensitivity analysis. A funnel plot[34] or Egger test[35] will be used to assess publication bias.

## Patient and public involvement

Since our study is a systematic review based on published literature, no patients will be involved.

# DISCUSSION

Our study aims to compare the efficacy and safety of high-voltage PRF ablation and standard-voltage PRF ablation

**Table 1** Main characteristics of RCTs comparing the efficacy and safety of high-voltage PRF and standard-voltage PRF for the treatment of NP

| Study ID | Sample size | Types of neuropathic pain | Setting | Duration | Number of female (%)/ male (%) patients | Age (years) | Preoperative pain (VAS/ NRS) | Preoperative QoL | Postoperative pain (VAS/ NRS) | Postoperative QoL | Complications |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A | | | | | | | | | | | |
| B | | | | | | | | | | | |
| C | | | | | | | | | | | |
| ..... | | | | | | | | | | | |

NP, neuropathic pain; NRS, numeric rating scale; PRF, pulsed radiofrequency; QoL, quality of life; RCT, randomized controlled trials; VAS, visual analog scale.

for NP therapy and provide clinical evidence for the selection of PRF modes in clinical practice via synthesising RCTs in journal publications. This study has some limitations. The sample size of the eligible RCTs might not be large and the accuracy of our research conclusions might be biased due to language limitations, as we will only include studies published in English. Overall, the study findings will provide comprehensive information for future study designs in terms of interventional treatment of NP.

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**Competing interests** None declared.

**Patient and public involvement** Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

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