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Pulsed radiofrequency for low-back pain and sciatica

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1. Introduction

Low-back pain is usually defined as pain, muscle tension, or stiffness localized below the costal margin and above the inferior gluteal folds, with or without leg pain (sciatica). The annual prevalence of low-back pain with leg pain traveling below the knee lies between 9.9% and 25% [1].

About 90% of patients with low-back pain will have symptoms without a clear-specific cause. The presence of nerve root problems is an indicator of possible underlying pathology [2]: the most common cause of lumbar radicular pain is intervertebral disc herniation (DH), followed by failed back surgery (FBSS) and spinal stenosis (SS) [3].

Medication (paracetamol, NSAIDs, opioids) is a possible option for the treatment of radicular pain, but there is a lack of evidence to support the prescription of any particular drug [4]. Noninvasive – pharmacological interventions, which consist in physical exercise (biomechanical, aerobic, mind-body or a combination of approaches) with or without manual therapy (spinal manipulation, mobilization, and massage) or psychological therapy have outcomes that are often not long-lasting [5,6].

Epidural corticosteroid injection has been widely used in clinical practice for many years, but it should be recommended as a means of reducing pain in the short term although no long-term effects can be expected, with a complication rate ranging between 0% and 9.65%. Transforaminal injection (TFESI) under radiological guidance seems to be more effective than epidural injection [4].

Surgery (discectomy, microdiscectomy, and other microsurgical techniques) is usually recommended in selected patients with severe symptoms and no benefit from conservative treatment, or in case of major neurologic impairment. Surgery provides for a better short-term pain relief as compared to prolonged conservative care, but no significant differences have been found between surgery and conservative treatment after one or 2 years [7]. Moreover, surgery is associated with several side effects [8].

Pulsed radiofrequency (PRF) is a relatively new noninvasive technique that relies on the intermittent administration of high-frequency current, avoiding temperature to rise beyond the critical level of 42°C, described as the threshold for neuronal damage. Thus, PRF is based on a different mechanism of action from conventional continuous radiofrequency (CRF), where temperature easily rises above this critical value because of continuous administration, inducing tissue heating and thermal coagulation.

PRF has shown promising results in many fields of application, including different spinal pain condition like cervical radicular pain, posterior degenerative spinal disease, disc-related pathology, sacroiliac joint pain, spondylolisthesis, and infection [9].

This review aims to show how PRF on dorsal root ganglion (DRG) is usually performed and its potential mechanisms of action and to summarize the most relevant currently available results in the literature.

2. Procedure and mechanisms of action

CRF to DRG is a heat destructive technique that has been used for more than 30 years for the treatment of chronic pain: CRF exposes target nerves to a continuous electrical stimulation that increases the temperature around the needle tip (between 60°C and 80°C), thus destroying the fibers that conduct the nociceptive input. CRF has been applied for the treatment of cervicogenic headaches, occipital neuralgia, cervical radicular pain, lumbar radicular pain, discogenic pain, and pain associated with the sacroiliac joint [9–11].

PRF is a relatively new minimal invasive procedure that uses intermitted administration of high-frequency current, thus allowing heat to disperse to the surrounding tissues, avoiding temperature rise over the critical level of 42°C: typically RF current (50,000 Hz) is applied in 20 ms pulses, at a frequency of 2 per second for 120 s.

PRF procedure requires an imaging guidance, that is commonly represented by fluoroscopy or, in some more advanced centers, CT. A 20–22 G needle-electrode with an active tip is introduced and advanced toward target DRG. RF current should be activated only if imaging results confirmed the exact positioning of the needle on target symptomatic DRG (usually within 8 mm). Before the actual treatment, as further security step, the optimal location is confirmed delivering low-frequency electrical sensory stimulation. Treatments are generally performed without local anesthesia or after the local injection of Lidocaine 1–2%.
Currently, PRF therapeutic principles are not fully understood, since there is no clear evidence of the actual mechanism of action. No irreversible effect of thermal damage has been demonstrated [12] with minimal histological changes in targeted tissues, as revealed in electron microscopic studies [13]. It has been suggested that PRF may have a neuromodulatory effect, that is the alteration of nerve activity obtained by stimulating a targeted site. PRF on DRG induces expression of the early gene c-Fos, a marker for neuronal activity, in the dorsal horn [13] and determines ATF3 upregulation, a marker of cellular stress. The latter activity appears to be selective in targeting small-diameter axons (C and A delta fibers) [14]. Furthermore, in animal models, PRF reduces mechanical allodynia and enhances the bulbospinal descending pain inhibitory pathways [15]. Recently it has been suggested that PRF on DRG may play a role in the modulation of Calcitonin gene-related peptide (CGRP) expression in the pain transduction pathway [16].

3. Results in literature

To date, according to the available literature, PRF adjacent to DRG has demonstrated a high-security profile, with a few minor side effects as the most frequently reported complications, such as headache or procedure-related pain.

Most of results about the efficacy of PRF are retrospective with small and heterogeneous cohorts of patients and short-term follow-up periods. Besides, parameters of PRF, such as the duration of pulse delivery, have not been established, with most studies applying PRF for 120 s, but others applying it for a longer time. Furthermore, criteria for assessing the clinical efficacy of PRF treatment are not well defined, thus the outcomes assessed are extremely variable among the different reports. The most used outcomes to assess pain relief and functional improvement over time are the Visual Analogue Scale (VAS), the Numerical Rating Scale (NRS), the Oswestry Disability Index (ODI) score, and the Global Perceived Effect (GPE).

On the identified studies about PRF, we found only one randomized, double-blind, sham-controlled investigation [17] which failed to find a statistically significant difference between PRF and sham (only needle positioning) for the treatment of chronic lumbar radicular pain: VAS and ODI score were better in the PRF group at the different time points of follow-up; however, the clinical difference, calculated as 50% of pain reduction, was quite small. The absence of any statistically significant results may be due to the small cohort of patients recruited, which comprised 32 patients, some of whom were lost during follow-up.

The reported success rate among the other studies lies between about 30% and 60% [18–20]. The selection criteria among studies are not homogeneous and this could partially explain the controversial reported results. A retrospective analysis of 54 patients with radicular pain due to SS, DH and FBSS who underwent one or more PRF procedures demonstrated a statistically significant reduction of the NRS score only in patients with DH and SS but not in patients with FBSS. The different results obtained in the latter category of patients, could be explained by the fact that FBSS encompass several clinical etiologies with both neuropathic and nociceptive pain components [3]. Results seem to be better when selection criteria are restricted to patients with neuropathic pain. In a prospective observational study of 65 patients with chronic L5-S1 radicular pain, clinical success (according to NRS or GPE score) was achieved 56.9%, 52.3%, and 55.4% of patients at 6 weeks, 3 months and 6 months, respectively after PRF treatment. The higher success rate reported as compared to other studies may be due to the usage of stricter inclusion criteria, with most of patients (74%) suffering from neuropathic pain, as assessed with the DN4 questionnaire. Interestingly a significant change for the DN4 was observed at 6 months [21].

A few randomized trials have compared the efficacy of PRF and TFESI. In patients with cervical or lumbar radicular pain due to disc herniation, the effectiveness of PRF was found to be not inferior to TFESI with respect to the treatment of recalcitrant pain after first TFESI [22]. A more recent trial assessed the superiority of PRF treatment over TFESI in 80 patients with chronic lumbar radicular pain [23], with a significant change of NRS scores between the two groups at 3 and 6 months after treatment. However, no differences in ODI score were observed between the two groups.

TFESI provides only short-term analgesic effect to patients with chronic LRP. It seems that adjuvant PRF allows for a more prolonged period of pain relief. In a retrospective study by Ding et al., 135 patients with lumbar radicular pain caused by HD were treated with TFESI, PRF combined with TFESI or PRF alone: patients in the first two groups had an early analgesic effect; however, groups treated with PRF alone or PRF with TFESI obtained a more prolonged period of pain relief as compared to patients treated with TFESI alone. This may be explained by the neuromodulatory effect of PRF in the spinal nerve root, which could determine a long-term effect. On the other hand, the anti-inflammatory effect of steroid injection could improve function in the patient at an early stage [24]. A randomized trial by Koh et al. reported better results, in terms of pain relief, in patients treated with PRF immediately followed by TFESI as compared to those treated with TFESI alone, at 2 and 3 months of follow-up. Results in the two groups were similar at 1 month of follow-up, thus demonstrating a trend toward superiority of the first group over time. However, no statistical difference was found between the two groups: this may be partially due to the small sample size (62 patients) and to the stricter criteria for defining successful treatment as compared to other studies [11].

The duration of pain relief does not seem to be significantly higher in patients treated with a combination of PRF and continuous RF compared to PRF alone, as assessed in a randomized prospective pilot study on a total of 76 patients that reported no difference between the two groups in terms of successful response rate and duration of pain relief (about 3 and 4 months, respectively) [25].

4. Conclusions

PRF is a minimally invasive and simple to perform procedure with compelling evidence in the management of cervical radicular pain [26]. At the same time, the application of PRF for the treatment of lumbar radicular pain is a safe intervention that has shown good results in providing intermediate-term relief of pain with no complications.
Even if the mechanism of action on the DRG has not been fully understood, it has been postulated that the electric field produced by PRF has a neuromodulatory effect. Indeed, it affects the gene expression of nerve fibers, acting selectively on the unmyelinated type C one, and increases the activity the descending antinociceptive systems [12–14,16]. The absence of a thermal damage [12], as opposed to the traditional RF, may increase the safety of the procedure.

According to the available evidence, PRF could be considered as an alternative to TFESI in patients with contraindication to steroid administration, such as uncontrolled diabetes mellitus, or when the injection of TFESI do not afford adequate duration of analgesia or in order to avoid side effects that may be associated with steroid injection, which rate lies between 0% and 9.65% [4], with some reported catastrophic complications too [27].

Another application could be the association with steroid injection, that could effectively and rapidly relieve radicular pain with a remission of symptoms that appears longer than the one obtained with only steroid injection [11,24].

PRF could be also used as an alternative to CRF, thus avoiding the side that may derive from thermal lesioning of neural fibers due to continuous administration of current [28]. CRF, however, represents a more consolidated procedure, for which we have existing guidelines, that allow to achieve established optimal parameters for a desired clinical objective.

The definition of PRF indication and contraindications requires further well-designed clinical trials with long-term follow-up. It is imperative the precise selection of patients and the definition of standardized parameters of PRF procedure, including the imaging modality for guidance, in order to make data comparable.

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Papers of special note have been highlighted as either of interest (i) or of considerable interest (≥) to readers.


- It is a randomized trial comparing TFESI+PRF and TFESI, results demonstrate a trend toward the superiority of the first groups in terms of pain relief over time. The absence of a statistically significant difference between the two groups may be due to the small cohort of patients.


22. Lee DG, Ahn SH, Lee J. Comparative effectiveness of pulsed radiofrequency and transformamial steroid injection for radicular


- In this pilot study comparing PRF+RF and PRF alone for the treatment of chronic lumbar radicular pain, no superiority of the first group was found.

