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Pulsed radiofrequency in the management of lumbar radicular pain: initial experience

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Abstract

Background Lumbar radicular pain (LRP) is one of the most encountered complaints in neurosurgical practice that pose a challenge in its management as adequate pain control, which is not always achieved.

Objective The aim of this study was to evaluate the role of pulsed radiofrequency as a minimally invasive tool in the management of lumbar radicular pain of lumbar discogenic origin.

Methods This is a prospective study that included 20 patients with lumbar radicular pain with radiological evidence of lumbar disc prolapse, who have been subjected to pulsed radiofrequency.

Results The mean preoperative visual analogue score was 71 ± 14.38 dropped to a mean of 43.5 ± 21.47 at six-month follow-up. Seventy percentage of the study population had a satisfactory outcome, which did not correlate with the age, sex, or body mass index of the patients.

Conclusions Pulsed radiofrequency is a safe and useful tool that may be used in the management of lumbar radicular pain.

Keywords Discogenic, Lumbar, Radicular, Pain, Pulsed, Radiofrequency

Background

Lumbar radicular pain (LRP) is one of the most encountered complaints in neurosurgical practice; it is characterized by a sharp, shooting, lancinating pain in one or more lumbar or sacral dermatomes. Common causes of LRP include intervertebral disc herniations, foraminal or lateral recess stenosis, and degenerative spondylolisthesis. Despite this, the exact mechanism and pathway of this neuropathic pain are not fully understood and subject to much controversy. It has been postulated that the root and the corresponding dorsal root ganglion (DRG) convey pain signal to the spinal cord in response to

inflammation and irritation from an adjacent pathological spinal segment [1–3].

The treatment of chronic lumbar radicular pain, for long, has posed a challenge to spine surgeons; as medications, per se, rarely provide adequate pain control, and thus, multimodal management through medical, physical, and occupational interventions has been utilized. Despite this, complete pain relief is rarely achieved. In refractory cases, minimally invasive procedures or surgery may be warranted [1–3].

Still after the utilization of minimally invasive procedures as epidural steroid injection (ESI), percutaneous endoscopic discectomy (interlaminar or transforaminal), continuous radiofrequency (CRF), and intra-discal nucleoplasty, some patients fail to achieve significant improvement of their complaint or quality of life and may suffer complications related to them [4–6].

The short duration of pain relief attained by use epidural steroid injection, the possible and not infrequent side effects of corticosteroid (headaches, flushing, water

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retention metabolic and endocrine changes like glucose intolerance and adrenal suppression) limit their frequent use [7–9].

Continuous radiofrequency gained popularity and has been widely used as a treatment tool for low back pain as it provides long durations of pain relief and fewer side effects than those met with ESI. While CRF is known to act through thermal ablation of the neural structures and their structural damage, several studies have shown that pulsed radiofrequency (PRF), a recent modification of CRF, acts through neuromodulation rather than causing thermal damage, when applied to the dorsal root ganglia. This lack of major damage by PRF to the neural structure led to the ongoing rise of its application in LRP and other types of neuropathic pain by both neurosurgeons and pain therapists [10, 11].

Several studies have postulated that the mechanism of neuromodulation in PRF is through selective inhibition of the unmyelinated C fibres when exposed to the electromagnetic field in the needle tip, blunting the nociceptive responses carried by these nerve fibres; the temperatures these nerve fibres are exposed to are below neuro-destructive levels, thus maintaining their structural integrity. No sensory or motor deficits were recorded in these patient series, and pain control was seen for protracted periods of time [12–16].

Aim of work

The aim of this study was to evaluate the role of pulsed radiofrequency as a minimally invasive tool in the management of lumbar radicular pain of lumbar discogenic origin.

Methods

This is a prospective study that included 20 patients with lumbar radicular pain with radiological evidence of lumbar disc prolapse, who have been subjected to pulsed radiofrequency at the neurosurgical departments of Menoufia University.

Inclusion criteria

- Single level affected.
- Patients refusing surgery.
- Patients unfit for surgery.
- Radicular pain of durations exceeding 6 months
- Absence of a progressive neurological (sensory or motor) deficit
- Failure physical and medical therapy to achieve satisfactory pain control
- Magnetic resonance imaging evidence of nerve root involvement

- Good response to preliminary nerve root block ≥ 3 month prior to recruitment

Exclusion criteria

- Patients with absolute indication of surgery.
- Paediatrics age-group (patients below 18)
- Severe back pain.
- Coagulopathy
- Those seeking 2ry gain.

Patients were awake and placed in the prone position throughout the procedure, backs were sterilized, and c-arm fluoroscopic guidance was performed in lateral, antro-posterior and 30 degrees oblique views to visualize and localize the intervertebral foramen of interest. After local anaesthetic infiltration, a 10- or 15-cm-long 22-gauge radiofrequency needle with an active 1-cm tip was inserted. In the first cases, one to three millilitres of non-ionized contrast was injected epidurally to delineate the roots. The proximity of the needle to the DRG is determined by appropriate sensory stimulation with 50 Hz, at more than 0.4 V (avoids intra-ganglionic placement), and less than or equal to 0.6 V; motor stimulation at 2 Hz with threshold 1.5–2 times greater than sensory threshold to avoid placement near the anterior nerve root, and then, another needle was inserted in the same manner when L4 and L5 roots were targeted for bipolar PRF, were as for S1 root a single needle was introduced through the first sacral foramen for monopolar PRF. After confirmation of proper positioning of the needles, 1 ml of physiological saline was injected to allow for current transmission and lowering impedance, after which two therapeutic 120-s cycles of pulsed radiofrequency are performed with temperature not exceeding 42 degrees Celsius (Figs. 1, 2, 3).

Post-procedure evaluation

All patients were assessed at 2 weeks, 3 and 6 months post-operatively (PO). The visual analogue score (VAS score) for pain was used to measure pain intensity, the scale where, “no pain” (score of 0) and “worst imaginable pain” (score of 100, the 100-mm scale was applied to avoid subconscious clustering of scores around a preferred numeric value. The score was recorded before and immediately after the procedure and finally at sixth-month follow-up [17].

At the final assessment, the global perceived effect (GPE) on a 7-point Likert scale was used to assess the degree of patient satisfaction, where a GPE score of 4 or less was considered unsatisfactory as symptoms were unchanged or worse, satisfactory if a GPE score of 5 or

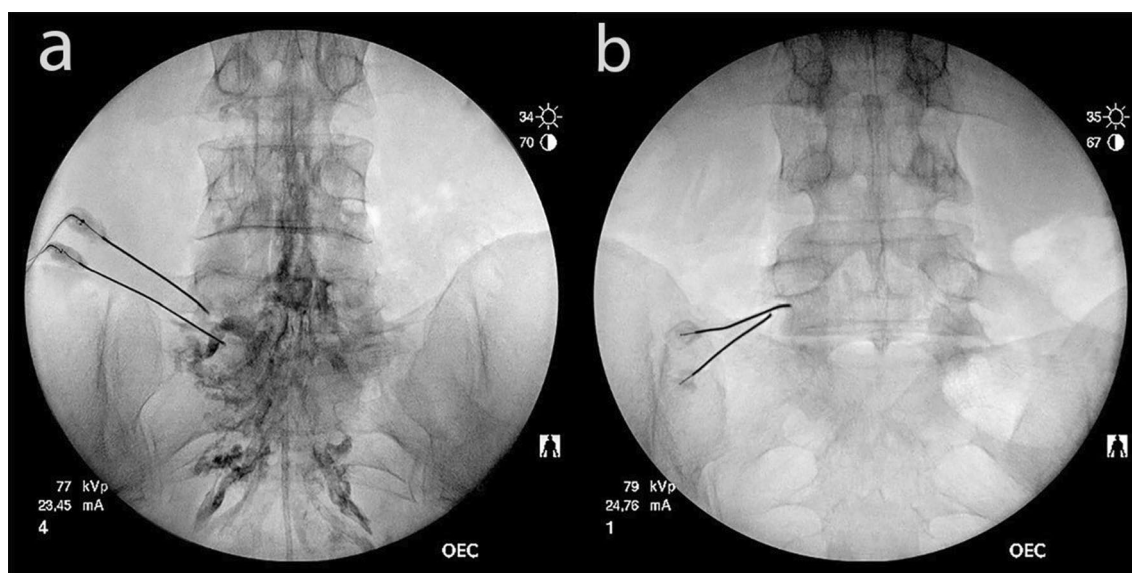


Fig. 1 **a** Bipolar PRF cannulas inserted above and below the contrast delineated L5 root. **b** Bipolar PRF cannulas inserted above and below the L5 root without contrast delineation

more was achieved, where the symptoms were improved, or the patient recovered (Table 1).

Statistical analysis

Statistical analysis of the collected data was done using Statistical Package for Social Sciences (SPSS/version 21) software. The statistical tests used were the arithmetic mean and standard deviation. For normally distributed data, comparison between two independent populations was done using independent *t* test, while more than two populations were analysed using F-test (ANOVA), and finally, the Chi-square test was used for categorized parameters. To study the association between each two variables, Pearson correlation coefficient was used. The level of significance was 0.05.

Results

Demographic data

Table 2 summarizes the demographic criteria of the study included where 9 (45.0%) were females and 11 (55.0%) were males. The mean age of the population study was 45.45 ± 13.55 years (range 28.0–72.0). The body mass index (BMI) was calculated where eight patients (40%) were of normal body weight, six (30%) were overweight, and six (30%) were considered obese, where the BMI was considered of normal weight if 18.5 to less than 24.5, overweight if 24.5–29.9 and obese if above 30 (Table 2).

Side and level of radiculopathy

Right-sided radiculopathy was found in 12 (60%) and left in 8 (40%) of the studied patients. Three patients (15%)

had L4 radiculopathy, nine patients (45%) L5 radiculopathy and lastly eight patients (40%) had S1 radiculopathy.

VAS pre- and post-operative

Tables 3 and 4 show comparison between VAS pre- and post-operative at different periods and relation to demographic data; it demonstrated that the mean preoperative VAS was 71 ± 14.38 (range 50–95), at two weeks post-operatively was 41.75 ± 20.02 , while at three month post-operatively 43.0 ± 19.36 (range 20–85) and finally at six-month follow-up a mean of 43.5 ± 21.47 (range 20–85), i.e. this table showed statistically significant difference between pre- and post-procedural VAS throughout the follow-up.

Patient's satisfaction

According to the global effect measured, fourteen patients (70%) of the study population had a satisfactory outcome. Age groups, sex and BMI were shown not to correlate with the presence or absence of patient satisfaction. No additional post-procedural neurological deficits were reported in any of the cases, as summarized in Table 5.

Decrease in analgesics intake

In Table 6 at the end of the sixth-month post-operative follow-up all patients remained to need analgesics, but at much lower quantities and frequency in 17 (85%) of the study patients, while 3 (15%) of the patients continued at the same preoperative requirements of analgesics.

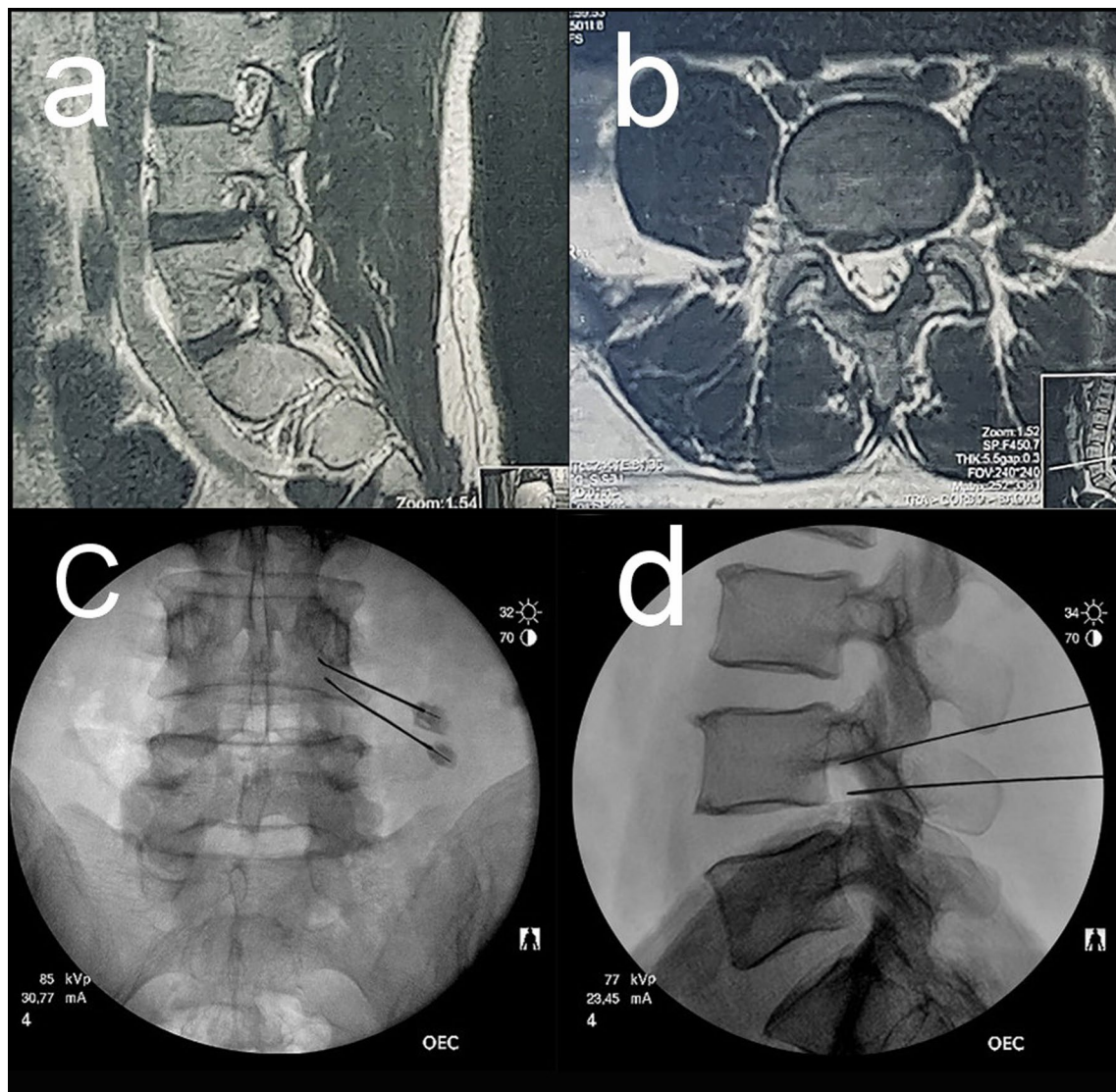


Fig. 2 A 33-year-old male suffering right L4 due to a disc compromise of the lateral recess and L4 foramen: **a** sagittal image showing right L4 foramen compromise, **b** axial image, **c** antro-posterior view of bipolar PRF cannulas inserted above and below the L4 root. **d** Lateral view of bipolar PRF cannulas inserted above and below the L4 root

Discussion

Kroll et al., Tekin et al., and Nebreda et al. compared the results of PRF and CRF of the facets in the management of chronic low back pain (LBP). Both procedures have shown an initial decrease in both VAS and ODI (Oswestry Disability Index) scores; this score reduction was maintained in both groups, but showed superiority of the CRF, due to structural sensory nerve fibre damage inhibiting transmission of nociceptive information provides the long-lasting effect of facet denervation [18–20].

The short coming of this structural damage by CRF is the possibility of neurological deficit when it is applied in patients with LRP, where the DRG is targeted rather than

the facets. The literature reports a 1% incidence of complications with CRF, including temporary neuropathic pain in the lower extremities, which might result from a lesion in a ventral branch from L3 or L4 [21].

Teixeira et al. reported that the incidence of burning sensation and hypoesthesia was observed in up to 60% and 35%, respectively, in CRF patients [12], while Geurts et al. reported post-denervation neuritis [22]. On the contrary, the safety of PRF has been reported by De and Cahana et al. [6, 23].

As previously mentioned, PRF provides pain relief through neuromodulation, and several studies have proposed various mechanisms by which the

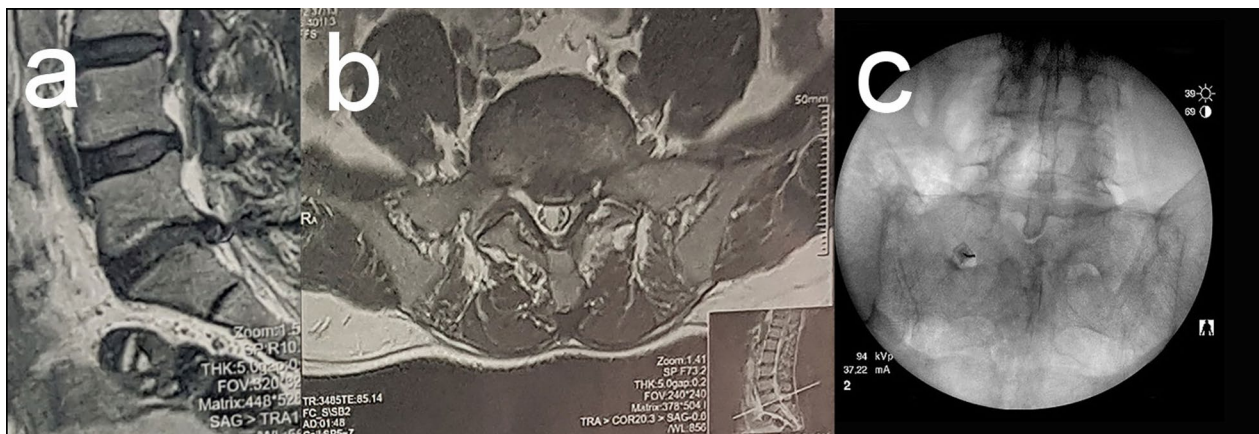


Fig. 3 A 55-year-old male blacksmith suffering persistent left S1 radiculopathy with minimal motor weakness and refusing surgery **a, b** are sagittal and axial MRI images showing the L5-S1 disc prolapse with caudal migration to the left, **c** antero-posterior view showing a PRF cannula inserted in the first sacral foramen for monopolar stimulation of S1

Table 1 The global perceived effect (GPE)

Score	% Change	Response	Satisfaction
7	≥ 75% improvement	Very good	Satisfactory
6	≥ 50% improvement	Good	
5	≥ 25% improvement	Fairly good	
4	< 25 improvement or deterioration	Same as before	Unsatisfactory
3	≥ 25% deterioration	Fairly bad	
2	≥ 50% deterioration	Bad	
1	≥ 75% deterioration	Very bad	

Table 2 Distribution of the studied group regarding demographic and basic characteristics

	Number	Percent
Age		
< 40	8	40.0
40–50	6	30.0
50 +	6	30.0
Range	28–72	
Mean ± S.D	45.45 ± 13.55	
Sex		
Male	11	55.0
Female	9	45.0
BMI		
Normal (18.5–< 24.5)	8	40.0
Overweight (24.5–29.5)	6	30.0
Obese (≥ 30)	6	30.0
Range	18.9–33.3	
Mean ± S.D	26.38 ± 4.79	
Global effect		
Satisfied	14	70.0
Unsatisfied	6	30.0

Table 3 Comparison between preoperative VAS and at different periods of follow-up

	Preoperative	2 weeks P.O	3 month P.O	6 month P.O
Range				
Mean	50–95	20–85	20–85	20–85
S.D	71.0 ± 14.38	41.75 ± 20.02	43.0 ± 19.36	43.5 ± 21.47
P value		0.001*	0.001*	0.001*

*Significant at level 0.05

Table 4 Relation between basic demographic data and VAS at the end of follow-up

	Range	Mean ± S.D	Test P value
Sex			
Male	20.0–75.0	37.73 ± 18.49	T = 1.847 0.191 N.S
Female	20.0–85.0	50.56 ± 23.78	
Age			
< 40 yrs	20.0–80.0	45.2 ± 2.36	ANOVA = 0.238 0.791 N.S
40–50 yrs	20.0–85.0	38.33 ± 25.81	
> 50 yrs	30.0–75.0	46.66 ± 18.34	
BMI			
Normal weight	20.0–85.0	50.62 ± 25.83	ANOVA = 0.909 0.422 N.S
Overweight	20.0–50.0	35.0 ± 12.64	
Obese	20.0–75.0	42.0 ± 22.07	

N.S. Not significant

electromagnetic fields were generated in PRF works in animal models. Promotion of c-FOS oncogene expression has been observed, with the formation of FOS proteins, which induce long-term depression at primary afferent synapses in the *substantia gelatinosa* of the

Table 5 Relation between basic demographic data and global effect

	Global effect				χ^2 P value
	Satisfied		Unsatisfied		
	No	%	No	%	
Sex					
Male	9	64.3	2	33.3	1.626
Female	5	35.7	4	66.7	0.202N.S
Age					
< 40 yrs	5	35.7	3	50.0	
40–50 years	5	35.7	1	16.7	0.754
> 50 years	4	28.6	2	33.3	0.686N.S
BMI					
Normal weight	5	35.7	3	50.0	
Overweight	6	42.9	0	0.0	3.929
Obese	3	21.4	3	50.0	0.140N.S

N.S. Not significant

Table 6 Distribution of the studied cases according to analgesics intake

Analgesics intake	No	%
Not	3	15.0
Decreased	17	85.0

dorsal horn of the spinal cord, with subsequent blunting the nociceptive responses [22, 24–27].

Vigneri *et al.* hypothesized that PRF results in upregulation of activating transcription factor 3 expression seen in small and medium calibre neurons of the DRG in rats [28]. Others demonstrated an anti-inflammatory and immunomodulating effect of PRF with decreased production of pro-inflammatory cytokines [29]. Several studies detected the modulatory effect of PRF on microglial activity with activation of noradrenergic and serotonergic descending inhibitory pain pathways in the spinal dorsal horn on application of PRF of the DRG with subsequent pain control [30–32].

In the study of Lee *et al.*, thirty-eight patients were divided into two groups: in the first group, PRF was applied for 240 s, while in the second group PRF was applied for 240 s in addition to epidural steroid injection; both groups reported statistically significant improvement of their VAS score and Oswestry Disability Index and were of comparable outcome [33].

Yang *et al.* assessed the efficacy of PRF combined with transforaminal epidural steroids in disc herniation, spinal stenosis, and failed back surgery syndrome and concluded its efficacy in those distinct aetiologies [34].

De *et al.* found a statistically significant pain relief in those receiving PRF of the DRG for 180 s with transforaminal local anaesthetic (TFLA) injection compared to TFLA alone. They reported the lack of any steroid injection-related side-effects such as facial flushing, hyperglycaemia, transient headaches, myopathy, osteoporosis, or pituitary adrenal axis suppression [6].

Patients suffering chronic lumbosacral radicular pain, that was refractory to epidural steroid injection, were targeted by Jorge *et al.*, a mild but statistically significant reduction in pain interference and the verbal numerical scale, recorded in response to PRF [35].

In this study, steroids were only used as diagnostic tool rather than a therapeutic one, aiming to confirm that pathological segment was the trigger of the LRP, prior to patient enrolment for PRF of the DRG, if they had shown improvement of their complaints after nerve root block. Patients in this study demonstrated a significant improvement of their VAS throughout the follow-up, but the GPE did not achieve statistical significance. The initial lower VAS recorded in most patient at the second post-operative week may be attributed to residual effect of the preprocedural steroids another possible explanation is that the increased VAS in the latter follow-ups may be due to early partial waning of effect of PRF, an observation necessitating a detailed future study on a larger scale.

Kim *et al.* found that the analgesics effect of PRF was not altered by the position of the needle tip, whether it was just lateral to the pedicle or underneath it, but urged a larger-scale study to assess this result. They only included cases with L4 and L5 radiculopathy [36]. In this study, a point below the centre of the pedicle was targeted for at least one of the bipolar electrodes, in patients with L4 and L5 roots affected, while in patients with roots S1 a single electrode in the first sacral foramen was inserted as it was rather difficult to insert a second electrode safely, and thus, monopolar mode was applied in these cases.

Although six patients were unsatisfied by the results of the procedure, none of them developed de novo deficits nor deterioration of their pain, they reported that what was achieved did not meet their expectations as their pain and medications returned to the pre-procedural levels with minimal or no improvement.

Limitation of this study is the small size of the study population, the relatively short follow-up period, the lack of a comparative placebo group, the use of monopolar or bipolar PRF in different patients and lastly the lack of assessment of the impact of the emotional and psychological state on the outcome; all of which need to be addressed in a future study.

Conclusions

Pulsed radiofrequency is a safe and useful minimally invasive procedure, which may be used in the management of lumbar radicular pain, to reduce pain intensity and frequency of analgesic intake.

Abbreviations

LRP	Lumbar radicular pain
DRG	Dorsal root ganglion
ESI	Epidural steroid injection
PRF	Pulsed radiofrequency
CRF	Continuous radiofrequency
GPE	Global perceived effect
TFLA	Transforaminal local anaesthetic
LBP	Low back pain

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Not applicable.

Author contributions

HEAAH, SFA and AGEN done concepts. HEAAH, SFA and AGEN designed the study and did the definition of intellectual content. HEAAH, SFA and AGEN done literature search and clinical studies and experimental studies. HEAAH, SFA and AGEN were involved in data acquisition, data analysis, statistical analysis, manuscript preparation, manuscript editing, and manuscript review. HEAAH, SFA and AGEN are the guarantors.

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Availability of data and materials

Available.

Declarations

Ethics approval and consent to participate

The current study was approved by the ethics approval committee of Faculty of Medicine of Menoufia University in its monthly session, IRB approval number and date 52022/NEUS9, and each patient gave an informed consent.

Consent for publication

Each patient gave an informed consent.

Competing interests

No competing interests.

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