

Retrospective Study

e Predictors of Treatment Success After Intercostal Nerve Radiofrequency for Intercostal Neuralgia: A Retrospective Cohort Study

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Disclaimer: See pgs. E676-E677.

Conflict of interest: Each author certifies that he or she, or a member of his or her immediate family, has no commercial association (i.e., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article.

Article received: 02-25-2026
Revised article received:
04-13-2026
Accepted for publication:
04-16-2026

Free full article: www.painphysicianjournal.com

Background: Intercostal neuralgia, which is characterized by neuropathic pain along the distribution of the intercostal nerves (ICNs), can impair patients' quality of life substantially. ICN-targeted radiofrequency (RF) treatment is used increasingly in current practice; however, data on factors that predict the success of such treatments remain limited.

Objectives: This study aims to evaluate factors associated with treatment success in patients with intercostal neuralgia who underwent ICN-targeted RF treatment.

Study Design: A retrospective cohort study.

Setting: A single-center retrospective study conducted at Mersin University Faculty of Medicine Hospital.

Methods: This retrospective chart review included adults who had post-traumatic, postherpetic, or idiopathic intercostal neuralgia and underwent ultrasound-guided conventional radiofrequency ablation (CRF) or pulsed radiofrequency treatment (PRF) on their ICNs between January 1, 2018, and May 30, 2025. Pain intensity (measured on the NRS-11) was assessed at baseline and at 3 and 6 months after the procedure. The primary outcome was the 6-month treatment response (according to IMMPACT criteria: $\geq 50\%$ pain reduction or a ≥ 4 -point decrease in NRS score from its baseline counterpart). Group comparisons and multivariable logistic regression were performed to evaluate the outcomes and predictors of response.

Results: Sixty patients were included in the analysis (CRF, $n = 31$; PRF, $n = 29$). At both 3 and 6 months, mean NRS scores were significantly lower in the CRF group than in the PRF group (3 months: 2.77 ± 1.80 vs 5.83 ± 2.55 ; $P < 0.001$; 6 months: 2.81 ± 1.93 vs 6.31 ± 2.34 ; $P < 0.001$). In the multivariable model, which included age, gender, presence of allodynia, baseline NRS score, and RF modality, only RF modality was identified as an independent predictor of treatment response (OR 9.395; 95% CI 2.363-37.359; $P = 0.001$).

Limitations: The single-center setting, relatively small sample size, and retrospective study design.

Conclusions: Ultrasound-guided intercostal CRF may provide clinically meaningful analgesia for patients with refractory intercostal neuralgia. Although both modalities were associated with short-term pain improvement, CRF produced significantly more sustained pain reduction at 3 and 6 months and emerged as the sole independent predictor of treatment success.

Key words: Intercostal nerve, radiofrequency ablation, postherpetic neuralgia, intercostal neuralgia, pulsed radiofrequency treatment, radiofrequency ablation, ultrasonography, pain management.

Pain Physician 2026; 29:E671-E677

Intercostal nerves (ICNs) arise from the ventral rami of the thoracic spinal nerves and provide sensory innervation to the chest wall (1). Irritation or injury of these nerves can lead to intercostal neuralgia (2). This condition is clinically characterized by sharp, stabbing, or burning pain that follows the affected dermatomal distribution (3).

The pain that intercostal neuralgia causes is commonly aggravated by respiratory maneuvers and trunk movements—such as deep inspiration, coughing, and trunk rotation—and can markedly restrict daily activities and reduce health-related quality of life (2,4). Intercostal neuralgia may arise from a variety of etiologies, including traumatic rib fractures, thoracic surgical procedures, herpes zoster infections (postherpetic neuralgia), and thoracic radiculopathy (4). When the underlying pathophysiology remains elusive despite exhaustive investigation, the neuralgia is categorized as idiopathic (4,5).

The management of intercostal neuralgia typically follows a tiered, multimodal approach. Therapeutic strategies range from systemic pharmacotherapy and topical analgesics to advanced interventional modalities such as nerve blocks, cryoablation, and radiofrequency (RF) procedures (4). In selected refractory cases, surgical interventions, including intercostal neurectomy, may be considered (6). Among these treatment options, intercostal nerve RF (ICN-RF) procedures are used more often in clinical practice, largely because they offer a targeted treatment option with relatively minimal invasiveness (3,5,7,8). Small case series suggest that pulsed RF (PRF) treatment, when applied to the ICN, may provide pain relief lasting up to 6 months, while larger retrospective cohorts indicate that the analgesic benefit of PRF often wanes over the short to intermediate term (9,10). Conventional RF has been associated with more sustained clinical improvement in case-series reports; however, heterogeneity in technical parameters, patient selection, and follow-up duration limits the generalizability of these findings (5,8). To the best of our knowledge, no head-to-head studies at present have directly compared the clinical outcomes of intercostal PRF and conventional RF.

In this context, we evaluated the analgesic effectiveness of intercostal RF in patients with intercostal neuralgia. We also investigated clinical and demographic factors associated with treatment response to support patient selection.

METHODS

Study Design and Patients

Ethical approval for this study was obtained from

the Mersin University Clinical Research Ethics Committee (Decision No: 2025/027; Date:12/17/2025). The study was conducted as a retrospective review of the charts of intercostal neuralgia patients who underwent intercostal CRF or PRF between January 1, 2018, and May 30, 2025. Since this was a retrospective chart-review study with anonymized data, the requirement for informed consent was waived by the ethics committee. This retrospective cohort study was designed and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement. The study was registered at ClinicalTrials.gov (Identifier: NCT07367152).

A total of 84 patients were assessed for study eligibility. Seven patients were excluded due to insufficient follow-up data, 2 due to a history of prior RF treatment at the same site, and 15 due to a history of thoracic surgery (Fig. 1). The remaining 60 patients who met the eligibility criteria were included in the final analysis.

Patients aged 18 years or older with post-traumatic, postherpetic, or idiopathic intercostal neuralgia were eligible if they had persistent neuropathic thoracic pain for at least 4 weeks and showed inadequate response or insufficient sustained benefits from conservative treatment. All patients underwent ultrasound-guided ICN CRF or PRF according to institutional practice.

Exclusion criteria were defined as the presence of active malignant invasion, spinal metastasis, or an intrathoracic mass that could account for thoracic pain; a history of surgical intervention at the corresponding thoracic dermatome level (e.g., thoracotomy or VATS); and receipt of other interventional treatments targeting the ICN during the same period, such as cryoablation or chemical neurolysis.

RF Techniques

Every procedure was performed under ultrasound guidance, with the patient in the prone or lateral decubitus position. Following sterile preparation, a high-frequency linear transducer was used to identify the target rib and intercostal space. The needle was advanced under real-time ultrasound guidance toward the inferior border of the rib. Correct positioning was confirmed with sensory stimulation reproducing concordant symptoms (Fig. 2). Given the retrospective nature of this study, treatment allocation was not randomized. The choice between CRF and PRF was based on the treating physician's clinical judgment, taking into account patient characteristics and procedural considerations. Treatment levels were chosen based

on the dermatomal levels that corresponded to the patients' symptoms. Beyond the primary target, the adjacent ICNs one level above and one level below were also treated to complete the procedure.

Group A (Intercostal CRF)

In our clinic, CRF was performed in the operating room under ultrasound guidance with minimal sedation. After sensory stimulation was used to verify correct needle positioning, thermal lesioning was delivered at 80°C for 90 seconds, following the standardized institutional practice during the study period.

Group B (Intercostal PRF)

In our clinic, PRF was delivered as a single 240-second cycle at 42°C after the needle positioning was verified to be correct with sensory stimulation. The PRF was administered under ultrasound guidance in the operating room with minimal sedation, following a standardized institutional protocol during the study period.

Data Collection

Patient demographics (age and gender), pain duration, allodynia status, and pain intensity were extracted retrospectively from medical records. Pain intensity was measured on the NRS-11 at 3 time points: before the procedure and at 3 and 6 months after treatment (0 = no pain, 10 = worst pain imaginable). Allodynia was recorded as a binary variable (present/absent) based on clinical examination.

Treatment response was defined using the IMMPACT (Initiative on Methods, Measurement, and Pain Assessment in Clinical Trials) criteria. Patients were considered responders if their NRS-11 score at 6 months showed a reduction of $\geq 50\%$ or a decrease of ≥ 4 points from baseline; all other patients were classified as nonresponders.

Statistical Analyses

Statistical analyses were performed using IBM SPSS Statistics 20.0 (IBM Corporation). The normality of continuous variables was evaluated with the Kolmogorov-Smirnov and Shapiro-Wilk tests. Descriptive data are reported as mean $\pm$ SD for normally distributed variables, median (minimum-maximum) for non-normally distributed variables, and frequency (percentage) for categorical variables. Group comparisons were conducted using Pearson's chi-square or Fisher's exact test, as appropriate, for categorical variables, and Student's t-test or the Mann-Whitney U-test for continuous vari-

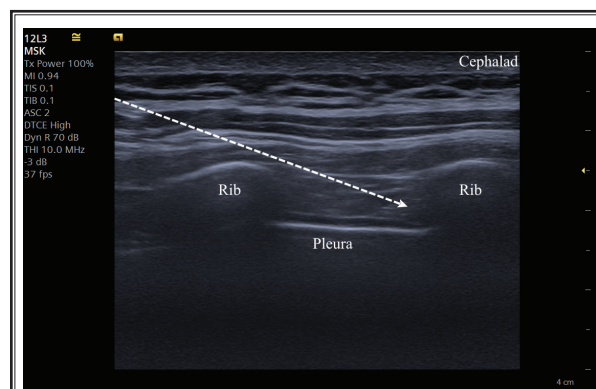
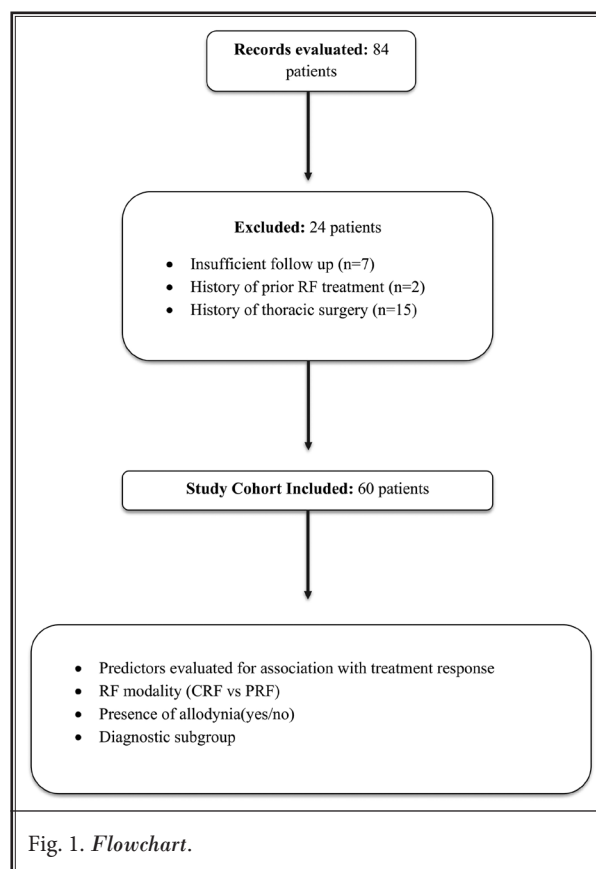


Fig. 2. Anatomical landmarks and projected needle path for ultrasound-guided ICN-RF ablation.

ables. Variables that showed significance in univariable analyses ($P < 0.05$) were included in a binary logistic regression model, using the enter method. Independent predictors of clinical response were expressed with 95% confidence intervals, and a 2-sided P value < 0.05 was considered statistically significant.

RESULTS

The study included 31 patients treated with CRF and 29 treated with PRF. Post-traumatic neuralgia was the most common etiology of the patients' intercostal neuralgia ($n = 36$, 60.0%), followed by postherpetic neuralgia ($n = 19$, 31.7%); the remaining 5 cases were classified as idiopathic ($n = 5$, 8.3%). Age ($P = 0.678$) and gender distribution ($P = 0.455$) did not differ significantly between the groups.

Comorbidity profiles, however, were similar between the groups, with comparable rates of hypertension ($P = 0.979$) and diabetes mellitus ($P = 0.979$). There were also no significant intergroup differences in pain duration or the presence of allodynia ($P = 0.106$ and $P = 0.925$, respectively) (Table 1).

Baseline (preoperative) NRS scores did not differ significantly between the CRF and PRF groups (CRF: 7.29 ± 1.29 ; PRF: 7.34 ± 1.28 ; $P = 0.849$). At follow-up, NRS scores were lower in the CRF group at both 3 months (2.77 ± 1.80 vs. 5.83 ± 2.55 ; $P < 0.001$) and 6 months (2.81 ± 1.93 vs. 6.31 ± 2.34 ; $P < 0.001$) (Table 1) (Fig. 3).

At 6 months, 27 of 60 patients (45.0%) achieved a $\geq 50\%$ reduction in their NRS scores, while 27 of 60 patients (45.0%) achieved a ≥ 4 -point reduction. Since the same patients met both thresholds, the overall re-

sponder rate according to the IMMPACT definition was also 45.0%. Responders and nonresponders did not differ significantly in gender distribution ($P = 0.714$), pain duration (responders: 9.81 ± 11.68 ; nonresponders: 10.61 ± 8.50 ; $P = 0.106$), or the prevalence of comorbidities (hypertension, $P = 0.549$; diabetes mellitus, $P = 0.795$). Mean age was higher among responders, but the difference did not reach statistical significance (responders: 67.74 ± 7.40 ; nonresponders: 59.82 ± 16.12 ; $P = 0.067$). However, the RF modality differed significantly between responders and nonresponders ($P < 0.001$). Intercostal CRF was associated more commonly with responders (21/27, 77.8%), whereas PRF had a greater association with nonresponders (23/33, 69.7%) (Table 2).

Treatment response was used as the dependent variable in the multivariable logistic regression analysis, and age, gender, RF modality, baseline NRS, and the presence or absence of allodynia were entered into the model simultaneously. The overall model was statistically significant (omnibus $\chi^2 = 24.135$, $P < 0.001$), with acceptable fit on the Hosmer-Lemeshow test ($P = 0.387$). The model's explanatory power was Cox-Snell $R^2 = 0.331$ and Nagelkerke $R^2 = 0.443$, and the overall classification accuracy was 68.3%. Among the variables

examined, RF modality was independently associated with treatment response (OR = 9.395; 95% CI: 2.363-37.359; $P = 0.001$). In contrast, age, gender, allodynia, and baseline NRS score were not significantly related to treatment response (Table 3).

DISCUSSION

In this retrospective study, we evaluated the effects of 2 kinds of ICN-RF treatment on pain scores in patients with intercostal neuralgia. We also assessed factors associated with treatment success. Both RF techniques were associated with short-term pain relief; however, at the 3- and 6-month follow-up visits, treatment success was higher in the CRF group than in the PRF group.

Targeting the ICNs is a common approach in the management of thoracic and anterior chest wall pain. Intercostal nerve blocks (ICNBs) can provide temporary yet clinically

Table 1. Baseline demographics and clinical characteristics of study patients ($n = 60$).

	All Patients ($n = 60$)	CRF ($n = 31$)	PRF ($n = 29$)	<i>P</i>
Age (years), mean $\pm$ SD (min-max)	63.38 $\pm$ 13.45 66.0 (19-81)	65.48 $\pm$ 7.88 66.0 (51-81)	61.14 $\pm$ 17.45 68.0 (19-81)	0.678
Gender, n (%)				0.455
Female	26 (43.3)	12 (38.7)	14 (48.3)	
Male	34 (56.7)	19 (61.3)	15 (51.7)	
Coexisting Conditions, n (%)				
Hypertension	27 (45.0)	14 (45.2)	13 (44.8)	0.979
Diabetes	12 (20.0)	4 (12.9)	8 (27.6)	0.155
Post-traumatic neuralgia, n (%)	36 (60.0)	20 (64.5)	16 (55.2)	0.919
Postherpetic neuralgia, n (%)	19 (31.7)	10 (32.3)	9 (31.0)	0.919
Pain duration (months)	10.25 $\pm$ 9.97	9.13 $\pm$ 10.99	11.45 $\pm$ 8.79	0.106
Allodynia present, n (%)	23 (38.3)	14 (45.2)	9 (31.0)	0.261
NRS scores, mean $\pm$ SD (min-max)				
Pre-operative	7.32 $\pm$ 1.28 7.00 (4-9)	7.29 $\pm$ 1.29 7.00 (4-9)	7.34 $\pm$ 1.28 7.00 (5-9)	0.849
3 months later	4.25 $\pm$ 2.66 4.00 (1-9)	2.77 $\pm$ 1.80 2.00 (1-6)	5.83 $\pm$ 2.55 7.00 (1-9)	< 0.001
6 months later	4.47 $\pm$ 2.78 4.00 (1-9)	2.81 $\pm$ 1.93 2.00 (1-7)	6.31 $\pm$ 2.34 7.00 (2-9)	< 0.001

NRS: Numeric Rating Scale.

meaningful pain relief. In routine practice, these blocks are often incorporated into a stepwise treatment strategy and may be repeated in appropriate patients before the regimen progresses to more durable interventions such as RF (11). Although ICNBs are used widely for both diagnostic and therapeutic purposes, evidence regarding the use of ICN-RF procedures for intercostal neuralgia remains quite limited. The current evidence leans heavily on small case reports and retrospective studies rather than large controlled trials. In a 6-patient series, Fiala et al documented that the individuals experienced substantial analgesia after they received CRF, with an average pain reduction of approximately 81% (5). Similarly, in a retrospective comparative cohort of 80 patients who developed thoracic neuralgia after undergoing surgery for lung cancer, those who received ultrasound-guided intercostal PRF demonstrated significantly lower pain scores and lesser analgesic requirements than did the controls, and no procedure-related adverse events were reported (7). However, the available data on intercostal PRF suggest that its clinical benefit is most apparent in the short term, with a tendency for the effect to attenuate over longer follow-up. Makharita et al (12) noted a clear reduction in pain beginning in the second week after intercostal PRF, and yet they also reported that pain began to rise again gradually after approximately the tenth week. In a study of patients with thoracic postherpetic neuralgia, PRF that targeted either the ICN or the dorsal root ganglion (DRG) was reported to improve pain and quality-of-life measures; notably, DRG-targeted PRF was associated with superior outcomes to those of ICN-targeted PRF over a 2-12-week follow-up period, and analgesic efficacy appeared to decline between weeks 2 and 12 (13). Similarly, our data suggest that the analgesic benefit of ICN-directed PRF may attenuate over time, as we observed reduced efficacy at the 3- and 6-month follow-up visits, particularly when the patients who received PRF were compared to those who had received CRF.

The clinical outcomes in our study that favored CRF at the 3- and 6-month follow-up visits may reflect fundamental differences in how the 2 modalities work. Conventional RF produces a neurodestructive lesion in the target tissue by generating high temperatures (60-80°C). In contrast, PRF is applied with the

aim of keeping tissue temperature below 42°C. Accordingly, PRF is generally regarded as a neuromodulatory technique, in which high-voltage electric fields are thought to drive analgesia rather than direct neuronal injury (14). While PRF has the advantage of preserving tissue integrity, our results suggest that the neuromodulatory analgesia of PRF may have a shorter period of clinical durability than the pain relief achieved with CRF. In support of this interpretation, comparative studies in

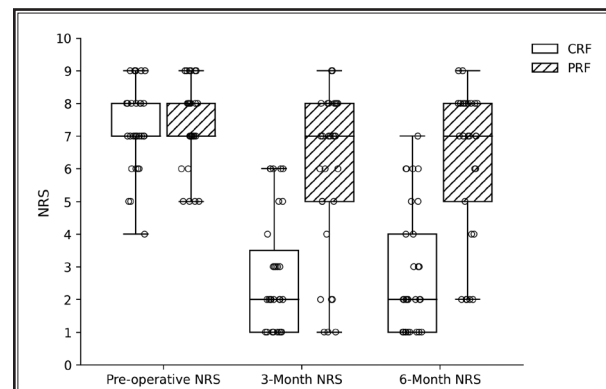


Fig. 3. NRS scores over time after intercostal RF: CRF versus PRF.

Table 2. Comparison of baseline clinical and demographic characteristics between the responder and nonresponder groups.

Variables	Responders	Nonresponders	P
Age	67.74 ± 7.40	59.82 ± 16.12	0.067
Gender, n (%)			0.714
Female	11 (40.7)	15 (45.5)	
Male	16 (59.3)	18 (54.5)	
Pain duration (months)	9.81 ± 11.68	10.61 ± 8.50	0.106
Post-traumatic neuralgia, n (%)	17 (63.0)	19 (57.6)	0.672
Postherpetic neuralgia, n (%)	9 (33.3)	10 (30.3)	0.510
Coexisting conditions, n (%)			
Hypertension	11 (40.7)	16 (48.5)	0.549
Diabetes	5 (18.5)	7 (21.2)	0.795
Baseline NRS score	7.52 ± 1.25	7.15 ± 1.30	0.266
3-month NRS	1.78 ± 0.75	6.27 ± 1.80	< 0.001
6-month NRS score	1.78 ± 0.80	6.73 ± 1.48	< 0.001
RF Modality (%)			< 0.001
CRF	21 (77.8)	10 (30.3)	
PRF	6 (22.2)	23 (69.7)	

CRF: conventional radiofrequency ablation; PRF: pulsed radiofrequency; NRS: Numeric Rating Scale.

Table 3. *Multivariable logistic regression analysis for predictive factors associated with successful response after treatment.*

Variables	Univariate		Multivariate	
	OR (95% CI)	P	OR (95% CI)	P
Allodynia	5.403 (1.738-16.791)	0.004	4.089 (0.945- 17.696)	0.060
Age	1.061 (1.003- 1.121)	0.038	1.053 (0.965- 1.151)	0.247
RF CRF (ref.) PRF	8.050 (2.493 – 25.997)	0.001	9.395 (2.363- 37.359)	0.001
Male (ref.) Female	0.825 (0.295-2.309)	0.714	1.318 (0.348-4.998)	0.685
Pre-operative NRS	1.262 (0.834-1.911)	0.270	1.048 (0.616- 1.784)	0.862

CRF: conventional radiofrequency ablation; PRF: pulsed radiofrequency; NRS: Numeric Rating Scale. Cox-Snell R²: 0.331; Nagelkerke R²: 0.443; Accuracy: 68.3%

pain syndromes outside the intercostal region have reported more favorable outcomes with thermal RF than with PRF. For example, in a prospective, randomized, double-blind trial involving patients with trigeminal neuralgia, significant improvements in VAS scores and patient satisfaction were observed only in the thermal RF group, whereas the PRF group demonstrated a limited response and, by the third month, a recurrence of the initial pain (15). Along similar lines, randomized studies in lumbar facet arthropathy have shown that the statistically significant benefit observed at 6-12 months of follow-up was seen mainly in the thermal RF group (16). Although these studies involve different target sites, the comparative findings nevertheless support the hypothesis that thermal, lesion-producing RF may be associated with more durable analgesia in certain clinical settings.

In our study, multivariable analysis showed that the only factor independently associated with treatment response was the RF modality used. Age, gender, baseline NRS score, and the presence of allodynia were not independently related to response ($P = 0.247$, $P = 0.685$, $P = 0.862$, and $P = 0.060$, respectively). Presently, robust evidence delineating predictors of long-term efficacy for interventional management of intercostal neuralgia remains limited. However, in a large retrospective cohort of patients with thoracic postherpetic neuralgia who underwent DRG-targeted RF thermocoagulation, disease duration, the presence of complications, higher baseline pain severity, and RF electrode type were reported to be associated with recurrence (17). While direct comparison is constrained by heterogeneity in study populations, anatomical targets, and clinical endpoints (response versus recurrence), these findings support the view that the specific RF technique applied may be a major driver of clinical outcomes.

Ultrasound-guided intercostal RF procedures are generally well tolerated; however, patients commonly report procedural pain, particularly during conventional (thermal) RF. Although uncommon, pneumothorax has been described in the literature as a clinically important complication of ICN-targeted interventions. Shanti et al reported an incidence of pneumothorax of 1.4% per blocked nerve during intercostal nerve blocks (18). In a more recent study of ultrasound-guided intercostal RF, no serious complications were observed (19).

In our cohort, no serious complications were observed. Post-procedurally, only 4 patients reported dysesthesia, which was transient and mild.

Limitations

This study has several limitations. Firstly, its retrospective design limits causal inference and may be subject to selection bias. Secondly, the sample size was relatively small, which might have reduced the power to detect associations with some variables. Thirdly, treatment allocation was not randomized, and unmeasured confounders may have influenced the choice of RF modality. Finally, the follow-up was limited to 6 months, and longer-term outcomes could not be evaluated.

CONCLUSIONS

In patients with refractory intercostal neuralgia, intercostal RF treatment provides meaningful pain relief. While both CRF and PRF were effective in the short term, CRF was associated with more sustained analgesia at the mid-term follow-up and emerged as the only independent predictor of treatment success. Prospective randomized studies with longer follow-up are warranted to confirm these findings.

Disclaimer

Ethical approval for this study was obtained from the Mersin University Clinical Research Ethics Committee (decision no: 2025/027; date: 12/17/2025). Since this project was a retrospective chart-review study with anonymized data, the requirement for informed consent was waived by the ethics committee. The data that support the findings of this study are available on request from the corresponding author. Due to privacy concerns and ethical restrictions, the data are not publicly available. This study was registered at ClinicalTrials.

gov with the number NCT07367152. The authors used ChatGPT (GPT-5.1, OpenAI) to assist in checking English grammar and improving the clarity of the manuscript,

and they reviewed and verified all suggestions carefully. The contributors take full responsibility for the final content.

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