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ORIGINAL RESEARCH

# Predictors of the analgesic efficacy of pulsed radiofrequency treatment in patients with chronic lumbosacral radicular pain: a retrospective observational study

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**Background:** Pulsed radiofrequency (RF) targeting the adjacent dorsal root ganglion (DRG) is one treatment option for lumbosacral radicular pain. However, the analgesic efficacy of this procedure is not always guaranteed. The aim of this retrospective study was to identify the predictors of the analgesic efficacy of pulsed DRG RF treatment in patients with chronic lumbosacral radicular pain.

**Methods:** Patients who underwent pulsed DRG RF treatment from 2006 to 2017 at our clinic were enrolled. Positive response was defined as a ≥50% reduction in pain score from baseline at day 30. Patient demographics, pain-related factors, and clinical factors were evaluated using logistic regression analysis to identify the predictors of a positive response to the treatment.

**Results:** A total of 60 patients satisfied the study protocol requirements. Twenty-eight patients (46.7%) had a positive outcome. Multivariate logistic regression analysis revealed that the absence of comorbid musculoskeletal pain (OR=0.518, 95% CI=0.029–0.858, *P*=0.033) and positive response to previous epidural steroid injection (OR=3.269, 95% CI=1.046–10.215, *P*=0.042) were independent predictors of the analgesic efficacy of pulsed DRG RF treatment.

**Conclusion:** Comorbid musculoskeletal pain and previous epidural injection response appear to affect the outcome of pulsed DRG RF treatment in patients with chronic lumbosacral radicular pain.

**Keywords:** pulsed radiofrequency, dorsal root ganglion, lumbosacral radicular pain, predictors, efficacy

## Introduction

Lumbosacral radicular pain caused by a herniated lumbar disc or spinal canal stenosis is a symptom often seen in outpatient clinics. The annual prevalence of this condition in the general population varies from 9.9% to 25%, with a very high point prevalence (4.6% to 13.4%) and lifetime prevalence (1.2% to 43%).[1] Chronic lumbosacral radicular pain that persists for more than 3 months can reduce social activities and the quality of life of patients.

Although many treatment modalities have been described for radicular pain, the available evidence is insufficient to determine optimal therapy. At present, radicular pain is treated conservatively with combined pharmacological management and physiotherapy.[2] However, some patients are refractory to these conservative treatments. Even after spinal surgery for lumbosacral radicular pain, pain can persist, become aggravated, or develop in new areas.[3]

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Pulsed radiofrequency (RF) targeted to the adjacent dorsal root ganglion (DRG) has been used to treat lumbosacral radicular pain. Pulsed RF treatment has been shown to be a safe procedure since it was first reported almost 20 years ago, and no complications have been reported.[4] The analgesic effect of pulsed RF treatment is longer than that of corticosteroid epidural injection and, unlike thermal RF, is not associated with a significant destruction of neural tissue.[2] A recent study reported that pulsed RF treatment reduced central sensitization as well as peripheral sensitization in chronic pain patients.[5] Pulsed RF targeted to the adjacent DRG may be a good treatment option in patients who show a poor response to conventional therapy.

However, not all patients experience an analgesic effect when treated with pulsed RF. It is also unclear which subclass of patients shows a good response to pulsed RF and how long the analgesic effect lasts. Patients' physical condition, severity of spine pathology, previous treatment method, and spinal surgery history may affect the analgesic effect of pulsed RF. However, few studies have investigated the factors predictive of pulsed RF having an analgesic effect.

In this retrospective observational study, we analyzed patient-related factors and clinical-related factors to identify the factors that can be used as positive or negative predictors of the analgesic efficacy of pulsed RF treatment.

# Materials and methods

## Study population

This retrospective study was approved by the institutional review board (IRB) of Severance Hospital, Yonsei University Health System (IRB No. 4-2017-0616). The patient records and information were anonymized before analysis, and therefore, the requirement for written informed consent to obtain medical records was waived by the IRB. On IRB approval, we obtained the relevant data from a clinical data retrieval system at our institution and collected procedure notes in our clinic. We analyzed patient records stored in the hospital database for all patients with radiating lumbosacral pain who underwent pulsed RF adjacent to the DRG for pain control between January 2006 and June 2017.

We included patients aged >20 years who experienced lumbosacral radicular pain for more than 3 months, and those who had clinical data for at least 1 month of follow-up after pulsed RF. Exclusion criteria were as follows: cancer patients and patients who received pulsed RF adjacent to the DRG for other causes such as postherpetic neuralgia. In addition, patients with insufficient medical records or who were lost to follow-up less than a month after the procedure were excluded.

## Patient demographics and pretreatment clinical data measures

We analyzed patient characteristics, pain-related factors, and clinical factors by electronic medical record chart review. Patient characteristics included age, gender, body mass index (BMI), and comorbid medical conditions such as hypertension, diabetes mellitus, coronary artery occlusive disease, and osteoporosis. Baseline numeric rating scale (NRS), duration of pain, and location of pain were identified as pain-related factors. We also analyzed clinical factors such as comorbid musculoskeletal pain, sleep disturbance due to pain, previous spinal surgery history, and magnetic resonance image (MRI) findings. MRI findings were classified as herniated intervertebral disc (HIVD), spinal stenosis, and compression fracture. Presence of foraminal or central stenosis and grade of central stenosis were analyzed in patients with spinal stenosis.

In addition, we analyzed previous epidural steroid injection (ESI) therapy performed in our pain clinic before applying pulsed RF. Targeted block level, trial number, and block effect were analyzed. If pain score decreased to more than 50% of the baseline NRS score, we considered the patient to have had a positive response to ESI.

## Pulsed RF procedure

We targeted pulsed RF to the adjacent DRG using a standard technique described previously.[6] Most patients were treated in an operating room in an ambulatory setting. The patient was placed in a prone position with a pillow under the lower abdomen, and a sterile drape was placed over the lumbar region. Fluoroscopic guidance (Siemens Arcadis Varic; Siemens Aktiengesellschaft, Frankfurt, Germany) was used to direct the pulsed RF to the target-level neuroforamen. After the skin was infiltrated using 1% lidocaine, an RF needle (22 G, 10 cm, curved, with a 10 mm active tip) was inserted into the neuroforamen. The tip of the needle was placed in the dorsal-cranial quadrant of the intervertebral foramen on the lateral image, and the tip was positioned between one-third and halfway to the pedicle column on the anteroposterior (AP) image. Final advancement was verified using fluoroscopic lateral and AP views (Figure 1). At the targeted position, the stylet of the RF needle was removed and the RF probe was inserted. The final definite position of the RF probe required sensory stimulation (50 Hz), which created paresthesia corresponding to the existing distribution of the

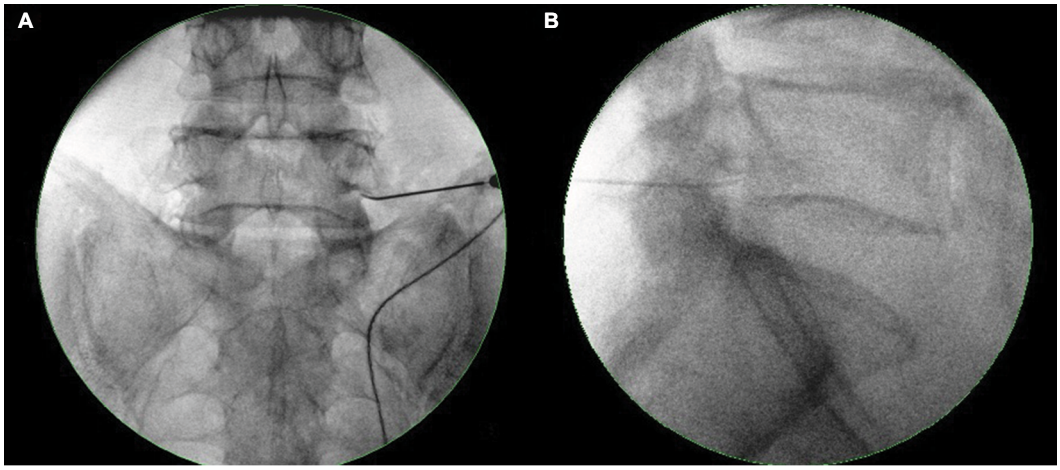


**Figure 1** (**A**) Radiofrequency needle positioning on the anteroposterior view. The tip was positioned between one-third of the way and halfway to the pedicle column. (**B**) The tip of the radiofrequency needle was placed in the dorsal-cranial quadrant of the intervertebral foramen on the lateral projection.

patient's radicular pain. After sensory (50 Hz) and motor (2 Hz) stimulation, pulsed RF was performed at 42°C for 120 seconds twice. During stimulation and lesioning, impedances were checked to ensure a complete electrical circuit and ranged from 200 to 400 ohm. After RF lesioning, we confirmed the epidural space by examining the spread pattern of contrast media. We then injected 0.5% lidocaine with 5 mg dexamethasone and removed the cannula. We monitored the patient's vital signs and neurologic complications in the recovery room for ~30 minutes.

## Posttreatment clinical data measures

We confirmed the pain score on the day of the pulsed RF procedure. Then, we analyzed pain score, the use of an additional nerve block or medication to control the remnant pain, and pulsed RF-related complications at 2, 4, and 6 weeks after the procedure.

For the purpose of this study, a positive response to pulsed RF was defined as a reduction in the pain score of more than 50% without additional analgesics for at least 1 month. All other responses were considered negative responses. In the positive response group, we identified the duration of the analgesic effect of pulsed RF. In the negative response group, we investigated the use of additional treatments to treat lumbosacral radicular pain such as spinal surgery, neuroplasty, or additional pulsed RF.

## Statistical analysis

Continuous variables are shown as means ± SD or medians (interquartile ranges), and categorical variables are shown as numbers (percentages). Demographic and clinical data were compared between the two groups (good vs. poor analgesia) using the *t*-test, Chi-square test, or Mann-Whitney *U*-test as appropriate. Significant univariate variables were included in a multivariate logistic regression analysis to identify the predictors of the analgesic efficacy of pulsed RF, and the adjusted OR and 95% CI were calculated. For multivariate logistic regression analysis, cutoff values were determined for each factor according to the best discrimination between patients with and without a good analgesic response to pulsed RF. To do that, we used the optimal values for sensitivity and specificity from a receiver operating characteristics curve analysis. All statistical analyses were performed using the Statistical Package for the Social Sciences, version 23.0 (IMB Corporation, Armonk, NY, USA). A *P*-value of less than 0.05 was considered statistically significant.

# Results

Between January 2006 and June 2017, 85 patients underwent pulsed RF adjacent to lumbosacral DRG in the pain clinic of Severance Hospital. Among them, 25 patients were excluded because of our exclusion criteria; a total of 60 patient medical records were therefore analyzed (Figure 2).

Patient baseline characteristics are listed in Table 1. Thirty-two men and 28 women were included, and their mean age was 66.6 years (range 36–91 years). The mean duration of pain was 21.68 months and the mean pain score was 7.25 by NRS.

The 60 patients were divided into two groups according to their response to pulsed RF – a good analgesia group (n=28; 46.7%) and a poor analgesia group (n=32; 53.3%). The results of univariate analysis are shown in Table 2. There were no significant differences between the two groups in basic characteristics such as age, gender, BMI, or medical

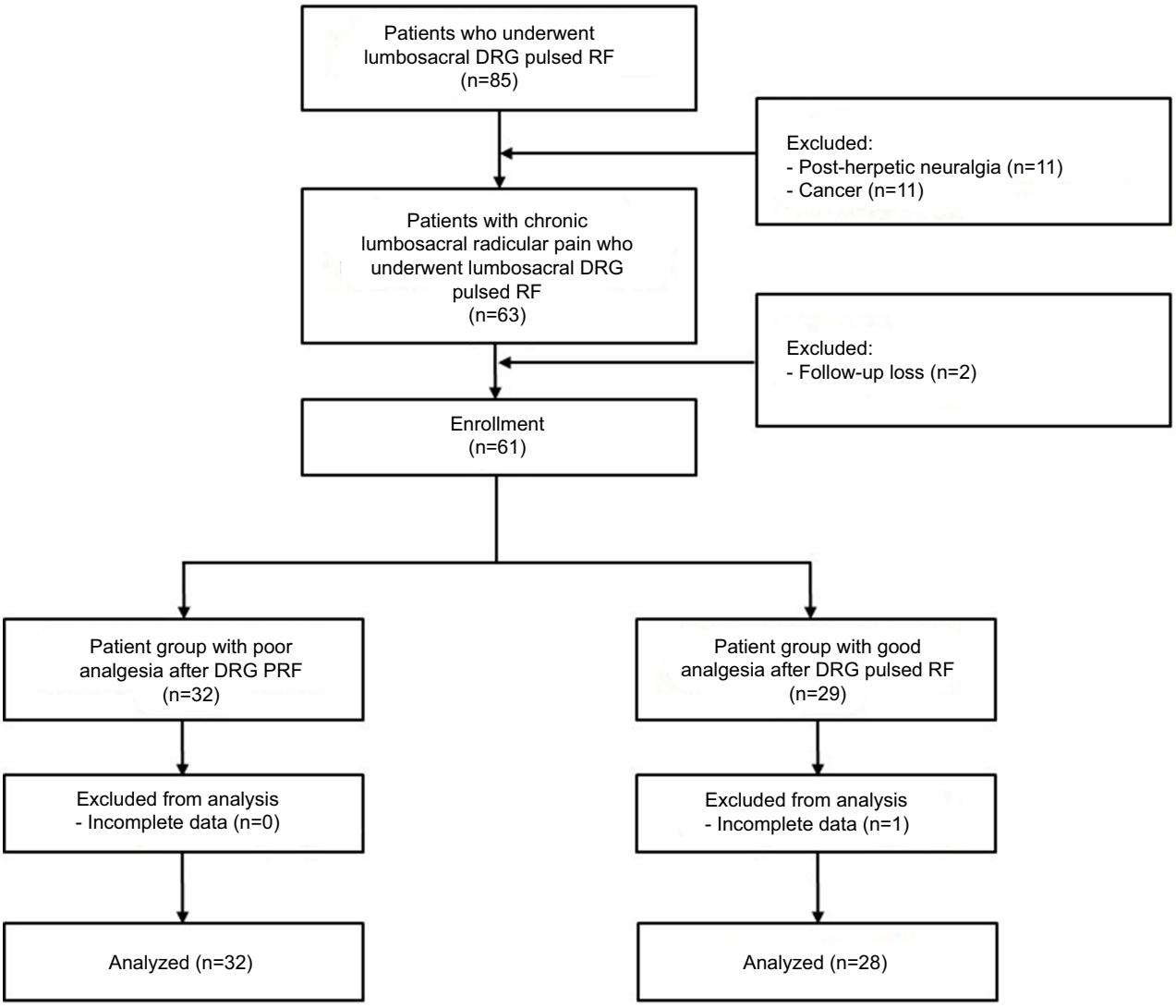


**Figure 2** Flowchart of the study.
**Abbreviations:** DRG, dorsal root ganglion; RF, radiofrequency.

comorbidities. The mean duration of pain was longer in the poor analgesia group (26.91 months) than in the good analgesia group (15.71months), but without statistical significance (*P*=0.211). Presence of foraminal stenosis, HIVD, or compression fracture on MRI did not differ between the two groups. However, more patients in the poor analgesia group had moderate or severe grade central stenosis than those in the good analgesia group (17 vs. 10, respectively), but this difference was not statistically significant (*P*=0.176). Two patients had a history of spinal surgery in the good analgesia group and 10 in the poor analgesia group, but this difference was not significant (*P*=0.146). There were more patients with comorbid musculoskeletal pain (excluding radiating leg pain and back pain) in the poor analgesia group (n=10) than in the good analgesia group (n=2; *P*=0.02). Comorbid musculoskeletal pain included knee pain (n=6), hand pain (n=3), and shoulder pain (n=2). In addition, the number of patients suffering from sleep disturbance due to pain was not significantly different between the two groups: 7 in the good analgesia group and 12 in the poor analgesia group.

In both groups, the mean trial number of previous ESIs before pulsed RF was four. There were no differences in injection target levels or sites between the two groups. Positive response to previous ESIs was defined as a reduction in pain score of more than 50% of baseline. Twenty patients in the good analgesia group had shown positive responses to previous ESIs vs. 14 patients in the poor analgesia group, which was a statistically significant difference (*P*=0.031).

**Table 1** Baseline characteristics of the study subjects

| Variable | N=60 |
|---|---|
| **Patient characteristics** | |
| Age, years | 66.6±11.55 (36–91) |
| Gender, M/F | 32 (53.3%)/28 (46.7%) |
| Body mass index, kg/m$^2$ | 24.74±3.08 (18–31) |
| Comorbid medical disease | |
| Hypertension | 34 (56.7%) |
| Diabetes mellitus | 19 (31.7%) |
| CAOD | 7 (11.7%) |
| Osteopenia/osteoporosis | 15 (25%)/10 (16.7%) |
| **Pain-related data** | |
| Pain duration, months | 21.68±34.37 (3–144) |
| 3–5 | 24 (40%) |
| 6–11 | 8 (13.3%) |
| ≥12 | 28 (46.7%) |
| Pain score, NRS | 7.25±1.5 (4–9) |
| **MRI findings** | |
| Foraminal stenosis | 40 (66.7%) |
| Central stenosis | |
| Mild/moderate/severe | 14 (23.3%)/15 (25%)/ 12 (20%) |
| Herniated intervertebral disc | 26 (43.3%) |
| Compression fracture | 5 (8.3%) |
| **Spinal surgery history** | 23 (38.3%) |
| **Comorbid musculoskeletal pain** | 12 (20%) |
| **Sleep disturbance** | 19 (31.7%) |
| **Pre-RF treatment data** | |
| Epidural steroid injection | |
| Right/left/both | 21 (35%)/22 (36.7%)/ 17 (28.3%) |
| Number of trials | 4.22±2.98 (1–17) |
| Opioid usage | 14 (23.3%) |

**Note:** Values are presented as mean ± SD (range), median (interquartile range), or number of patients (%).
**Abbreviations:** CAOD, coronary artery occlusive disease; NRS, numeric rating scale; MRI, magnetic resonance image; RF, radiofrequency.

Before applying pulsed RF, seven patients in each group were prescribed opioids such as Ultracet, morphine, or a fentanyl patch.

Multivariate logistic regression analysis revealed that comorbid musculoskeletal pain and a positive response to previous ESIs were independent predictors of the analgesic efficacy of pulsed RF (Table 3). Presence of comorbid musculoskeletal pain had an OR of 0.518 with a 95% CI of 0.029–0.858 ($P$=0.033). The OR of a positive response to previous ESIs was 3.269 (95% CI 1.046–10.215, $P$=0.042).

In the good analgesia group, 10 patients had a persistent analgesic effect (greater than 1 year), while in 18 patients, the effect persisted for less than a year. In the poor analgesic group, six patients underwent spinal surgery and three underwent neuroplasty to treat the remaining pain after pulsed RF. There were no significant complications related to pulsed RF.

## Discussion

In this retrospective observational study, multivariate logistic regression analysis revealed that the absence of comorbid musculoskeletal pain and positive response to previous ESI are independent predictors of the analgesic efficacy of pulsed RF treatment.

In the current study, comorbid musculoskeletal pain other than low back pain (LBP) was revealed to be, among various factors, prognostic of a poor outcome after pulsed RF in patients with chronic lumbosacral radicular pain. Twelve cases had other musculoskeletal pain in addition to lumbosacral radicular pain. The most common musculoskeletal pain was osteoarthritis (OA)-induced knee pain (six cases) and hand pain and shoulder pain. According to Nordstoga et al.,[7] musculoskeletal pain has a strong and independent influence on the long-term prognosis of chronic LBP. They reported that poor self-rated health, psychological symptoms, and pain-related disability might further reduce the probability of recovery from chronic LBP. Rundell et al.[8] reported that comorbid knee or hip OA in older adults with new back pain is associated with modestly worse long-term disability and health-related quality of life. The initial single site of chronic pain may cause central sensitization, thereby increasing the risk of experiencing pain in other body regions. Collectively, our results suggest that patients with comorbid multiple pain sites are highly likely to experience a poor clinical outcome following pulsed RF treatment. They should be reassessed for the origin and nature of the pain, and the associated musculoskeletal pain managed appropriately. In addition, it may be useful to classify patients as suffering from lumbosacral radicular pain alone or lumbosacral radicular pain plus other pain to improve clinical decision-making.

Generally, diagnostic block with a local anesthetic and steroid is applied to a suspected DRG before performing pulsed RF. When pain is reduced, the DRG is identified as a pathological cause and pulsed RF is performed.[1] However, in clinical practice, patients with chronic lumbosacral radicular pain are often refractory to conservative treatments such as ESI. In this case, pulsed RF can be tried as an alternative treatment option even if there is no treatment effect from ESI. Also, the analgesic effect of ESI was short-lived in some of our patients. To control pain in such patients, repeated steroid injections are needed and its systemic complications must be carefully considered. Pulsed RF can be performed in these patients to increase the duration of analgesia, as a next-line treatment option. The positive predictive value of pre-RF ESI for predicting those patients in whom pulsed RF had an analgesic effect was 58.8%, while the negative predictive

**Table 2** Comparison of patient characteristics and pre-RF data between study groups

| Variable | Good analgesia (n=28) | Poor analgesia (n=32) | *P*-value |
|---|---|---|---|
| **Patient characteristics** | | | |
| Age, years | 66.82±11.93 (41–84) | 66.41±11.39 (36–91) | 0.89 |
| <65 | 8 (28.6%) | 12 (37.5%) | 0.46 |
| ≥65 | 20 (71.4%) | 20 (62.5%) | |
| Gender, M/F | 14 (50%)/14 (50%) | 18 (56.2%)/14 (43.8%) | 0.63 |
| Body mass index, kg/m$^2$ | 24.62±2.95 | 24.43±3.22 | 0.82 |
| <25 | 14 (50%) | 20 (62.5%) | 0.33 |
| ≥25 | 14 (50%) | 12 (37.5%) | |
| Medical comorbidities | | | |
| Yes | 21 (75%) | 18 (56.2%) | 0.13 |
| No | 7 (25%) | 14 (43.8%) | |
| Osteoporosis | | | |
| Osteopenia and osteoporosis | 12 (42.9%) | 13 (40.6%) | 0.86 |
| Normal | 16 (57.1%) | 19 (59.4%) | |
| **Pain-related data** | | | |
| Pain duration, months | 15.71±28.47 | 26.91±38.5 | 0.21 |
| <6 | 16 (57.1%) | 12 (37.5%) | 0.13 |
| ≥6 | 12 (42.9%) | 20 (62.5%) | |
| Pain score, NRS | 7.32±1.47 | 7.19±1.55 | 0.73 |
| NRS <7 | 9 (32.1%) | 9 (28.1%) | 0.74 |
| NRS ≥7 | 19 (67.9%) | 23 (71.9%) | |
| MRI findings | | | |
| Foraminal stenosis | | | 0.86 |
| Yes/no | 19 (67.9%)/9 (32.1%) | 21 (65.6%)/11 (34.4%) | |
| Grade of central stenosis | | | |
| Moderate and severe | 10 (35.7%) | 21 (65.6%) | 0.18 |
| Normal and mild | 18 (64.3%) | 11 (34.4%) | |
| Herniated intervertebral disc | | | |
| Yes/no | 15 (54.5%)/13 (46.5%) | 11 (34.4%)/21 (65.6%) | 0.13 |
| Compression fracture | | | |
| Yes/no | 2 (7.1%)/26 (92.9%) | 3 (9.4%)/29 (90.6%) | >0.999 |
| Spinal surgery history | | | |
| Yes | 8 (28.6%) | 15 (46.9%) | 0.15 |
| No | 20 (71.4%) | 17 (53.1%) | |
| Comorbid musculoskeletal pain | | | |
| Yes/no | 2 (7.1%)/26 (92.9%) | 10 (31.2%)/22 (68.8%) | 0.02 |
| Sleep disturbance | | | |
| Yes/no | 7 (25%)/21 (75%) | 12 (37.5%)/20 (62.5%) | 0.30 |
| **Pre-RF treatment-related data** | | | |
| Epidural steroid injections | | | |
| Right/left/both | 12 (42.9)/10 (35.7)/6 (21.4) | 9 (28.1)/12 (37.5)/11 (34.4) | 0.40 |
| Single/multilevel | 11 (39.3%)/17 (60.7%) | 17 (53.1%)/15 (46.9%) | 0.28 |
| Number of trials | 4.07±2.814 | 4.34±3.158 | 0.73 |
| Effects | | | |
| Yes/no | 20 (71.4%)/8 (28.6%) | 14 (43.8%)/18 (56.3%) | 0.03 |
| Opioid usage | | | |
| Yes/no | 7 (25%)/21 (75%) | 7 (21.9%)/25 (78.1%) | 0.78 |

**Note:** Values are presented as mean ± SD (range), median (interquartile range), or number of patients (%).
**Abbreviations:** RF, radiofrequency; NRS, numeric rating scale; MRI, magnetic resonance image.

value was 69.2%. Multiple regression analysis showed that those patients who had a positive response to pre-RF ESI also had good response to pulsed RF. In other words, pulsed RF was effective for the patients who showed effectiveness with previous ESI.

Similar to DRG RF, it is generally recommended that diagnostic block be performed first when RF is applied to a medial branch or peripheral nerve. Diagnostic medial branch blocks are considered the reference standard for diagnosing facetogenic pain and selecting patients for RF denervation.[9]

**Table 3** The results of multivariate logistic regression analysis

| Variable | Good analgesia, n (%) | OR (95% CI) | *P*-value |
|---|---|---|---|
| Comorbid musculoskeletal pain | | | |
| Yes | 2 (16.6%) | 0.518 (0.029–0.858) | 0.033 |
| No | 26 (54%) | reference | |
| Previous ESI effect | | | |
| Yes | 20 (58.8%) | 3.269 (1.046–10.215) | 0.042 |
| No | 8 (30%) | reference | |

**Abbreviation:** ESI, epidural steroid injection.

However, prediction of RF response to the diagnostic block is still controversial. Cohen et al.[10] reported that there was no statistically significant difference between the percentage pain relief obtained from single diagnostic blocks among those patients who had successful RF denervation and those individuals in whom RF treatment failed. According to Lindquist et al.,[9] there was no statistically significant difference in treatment effect between patients who previously had a corresponding diagnostic test block and those who had not. When they examined the relationship between test blocks and the effect of medial branch-pulsed RF, they found a positive predictive value of only 52% for medial branch diagnostic test blocks in patients with suspected facetogenic pain. In our study, the pre-RF ESI was performed four times on average, which is more than general diagnostic block. Therefore, our result suggests that a previous ESI response might be a prognostic factor for the analgesic efficacy of DRG RF. However, the relationship between traditional diagnostic blocks and DRG RF outcomes has not been studied yet; additional research is needed.

Pulsed RF has been performed for various types of chronic pain for the past 20 years.[11] Although the results of many randomized controlled trials, retrospective studies, and prospective studies have been reported, few studies have investigated factors predictive of the analgesic effects of pulsed RF.[12] Abejon et al.[13] evaluated the effect of pulsed RF according to the cause of chronic lumbosacral radicular pain and found that pulsed RF of the DRG was significantly more efficacious for treating pain due to a herniated disc and spinal stenosis than pain in failed back surgery syndrome (FBSS) patients. Van Boxem et al.[14] reported that positive diagnostic nerve root block and age ≥55 years were predictive factors for a successful outcome at 6 months, while disability was a negative predictor of pulsed RF outcome. Based on the previous studies, we compared various factors that could potentially affect the therapeutic outcomes of pulsed RF, but the only independent predictors were a previous positive response to ESI and absence of musculoskeletal comorbidities. Three factors showed a tendency to affect the RF results, but differences were not statistically significant. First, when pain persisted longer than 6 months, the response to pulsed RF tended to be worse. Second, the greater the severity of the central stenosis in MRI findings, the less the RF effect tended to be. On the other hand, patients with HIVD tended to have a better response to pulsed RF than those without HIVD. We think that pulsed RF basically may be more beneficial to patients with neurogenic origin pain, i.e., with radicular pain due to nerve compression following degenerative spinal stenosis or disc herniation. Nevertheless, in severe spinal stenosis, the DRG and affected spinal nerves are thought to be more mechanically compressed, and therefore, RF could be less effective. However, no prior studies have examined RF outcomes according to the degree of spine pathology such as spinal stenosis grade, and further studies are needed in this regard. Lastly, patients with a history of spinal surgery had a relatively poor response to pulsed RF. Generally, the results of RF in FBSS patients are inferior to those in non-operated patients. This might be due to the multifocal origin of the pain in patients who have undergone spinal surgery. In this case, not only DRG-origin pain but also pain in adjacent joints and muscles may contribute to the poor outcomes of DRG RF.[15]

This retrospective study had some limitations. First, the study was conducted in a single clinical setting and the sample size was small, which may have limited our ability to discover potentially significant associations. Second, the primary end point was defined as a decrease in NRS pain score after a month of pulsed RF, so our findings did not provide information on the long-term efficacy of pulsed RF. Additionally, we did not collect information related to the disability or quality of life other than pain reduction. Finally, there was no exclusion of psychological factors that may have affected the efficacy of treatment in patients with chronic pain. These limitations should be taken into consideration when interpreting the results of this study.

## Conclusion

In conclusion, the analgesic effect of pulsed RF might be poorer in patients with comorbid musculoskeletal pain than in those

without, while it may be better in those patients who showed a positive response to pre-RF ESIs vs. those who did not. Further large and controlled studies should be initiated to investigate the relevant predictors of the analgesic efficacy of pulsed RF.

## Disclosure

The authors report no conflicts of interest in this work.

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