Kocatepe Tıp Dergisi
Kocatepe Medical Journal
27:383-389/ Temmuz 2026 Sayısı

ARAŞTIRMA YAZISI / RESEARCH ARTICLE

LOMBER DİSK HERNİASYONLU HASTALARDA DRG-PULSED RADYOFREKANS, STEROİD VE KOMBİNE TEDAVİLERİN OSWESTRY ÖZÜRLÜLÜK İNDEKSİ ÜZERİNE ETKİLERİNİN KARŞILAŞTIRILMASI

COMPARATIVE EFFECTS OF DRG-PULSED RADIOFREQUENCY, STEROID, AND COMBINED THERAPIES ON OSWESTRY DISABILITY INDEX IN PATIENTS WITH LUMBAR DISC HERNIATION

Basri PÜR[1], Mehmet DEMİR[2], Salih KAYA[1], Bilal KARABAK[1], Sinan YILAR[3], Ramazan YILDIZ[4]

[1]Erzurum Şehir Hastanesi Ortopedi ve Travmatoloji Bölümü
[2]Özel Kapadokya Hastanesi Ortopedi ve Travmatoloji Bölümü
[3]Atatürk Üniversitesi Tıp Fakültesi Ortopedi ve Travmatoloji Ana Bilim Dalı
[4]Erzurum Teknik Üniversitesi Sağlık Bilimleri Fakültesi, Fizik Tedavi ve Rehabilitasyon Bölümü

ÖZET

AMAÇ: Bu çalışmada, cerrahi dışı tedavi uygulanan ekstrüde veya sekestre lomber disk hernisi bulunan hastalarda, dorsal kök ganglionuna (DRG) uygulanan darbeli radyofrekans (PRF), steroid enjeksiyonu ve her ikisinin kombinasyonunun klinik etkinliğini karşılaştırmak ve Oswestry Yetersizlik İndeksi (ODI) skorları üzerindeki fonksiyonel sonuçlarını değerlendirmek amaçlandı.

GEREÇ VE YÖNTEM: 2020–2024 yılları arasında cerrahiye aday olmayan ve konservatif tedaviye yönlendirilen toplam 90 lomber disk hernili hasta çalışmaya dahil edildi. Hastalar aldıkları tedaviye göre üç gruba ayrıldı: yalnızca DRG-PRF (Grup 1), yalnızca steroid + lokal anestezik enjeksiyonu (Grup 2) ve PRF sonrası steroid enjeksiyonu ile kombine tedavi (Grup 3). ODI skorları tedavi öncesinde, 1. ayda ve 6. ayda kaydedildi. Veriler SPSS yazılımı ile analiz edildi, $p<0.05$ anlamlı kabul edildi.

BULGULAR: Başlangıçta ODI skorları tüm gruplar arasında benzerdi ($p=0.417$). Birinci ayda tüm gruplarda anlamlı iyileşme gözlendi ($p<0.001$). Altıncı ayda ise steroid grubunda etkinin azaldığı görüldü ($p=0.063$), PRF ve özellikle PRF+steroid gruplarında ise anlamlı iyileşmenin devam ettiği saptandı (sırasıyla $p=0.002$ ve $p=0.004$). Her iki takip döneminde de en düşük ODI skorları kombine tedavi grubunda izlendi ($p<0.001$). Alt grup analizinde, iki seviyeli hernisi olan hastaların tek seviyeli hernisi olanlara kıyasla daha az iyileştiği görüldü ($p=0.041$).

SONUÇ: DRG-PRF, steroid ve kombine uygulamalar, lomber disk hernili hastalarda kısa dönem semptomatik iyileşme sağlar. Ancak kombine tedavi, orta dönemde etkinliğini sürdürerek en düşük ODI skorlarını sunmuştur. Bu bulgular, cerrahi dışı tedavi düşünülen hastalarda kombine yaklaşımın öncelikli olarak değerlendirilmesi gerektiğini düşündürmektedir.

ANAHTAR KELİMELER: Lomber disk hernisi, Radyofrekans, Dorsal kök ganglionu, Steroid enjeksiyonu, Oswestry Özürlülük İndeksi.

ABSTRACT

OBJECTIVE: This study aimed to compare the clinical efficacy of pulsed radiofrequency (PRF) applied to the dorsal root ganglion (DRG), steroid injection, and their combination in patients with extruded or sequestered lumbar disc herniation who underwent non-surgical treatment, and to evaluate their effects on functional outcomes using the Oswestry Disability Index (ODI) scores.

MATERIAL AND METHODS: Between 2020 and 2024, a total of 90 patients with lumbar disc herniation who were not considered candidates for surgery and were referred for conservative treatment were included in the study. Patients were divided into three groups according to the treatment received: DRG-PRF only (Group 1), steroid + local anesthetic injection only (Group 2), and combined treatment with PRF followed by steroid injection (Group 3). ODI scores were recorded before treatment, at the 1st and 6th months. Data were analyzed using SPSS software, with $p<0.05$ considered statistically significant.

RESULTS: At baseline, ODI scores were similar across all groups ($p=0.417$). At the 1st month, significant improvement was observed in all groups ($p<0.001$). At the 6th month, efficacy decreased in the steroid group ($p=0.063$), whereas significant improvement was maintained in the PRF and particularly in the PRF+steroid groups ($p=0.002$ and $p=0.004$, respectively). The combined therapy group had the lowest ODI scores at both follow-up periods ($p<0.001$). Subgroup analysis revealed that patients with two-level herniation improved less than those with single-level herniation ($p=0.041$).

CONCLUSIONS: DRG-PRF, steroid, and combined applications provide short-term symptomatic improvement in patients with lumbar disc herniation. However, combined therapy maintained its efficacy mid-term, offering the lowest ODI scores. These findings suggest that the combined approach should be prioritized in patients considered for non-surgical treatment.

KEYWORDS: Lumbar disc herniation, Pulsed radiofrequency, Dorsal root ganglion, Steroid injection, Oswestry Disability Index.

Geliş Tarihi / Received: 15.09.2025
Kabul Tarihi / Accepted: 22.12.2025
Yazışma Adresi / Correspondence: Uzm. Dr. Basri PÜR
Erzurum Şehir Hastanesi Ortopedi ve Travmatoloji Bölümü
E-mail: basri_pur@hotmail.com
Orcid No (Sırasıyla): 0000-0001-5849-3838, 0000-0002-3874-1379, 0000-0001-8780-2943, 0000-0003-3134-8731, 0000-0002-1268-170X, 0000-0002-8007-7854
Etik Kurul / Ethical Committee: Erzurum Sağlık Bilimleri Üniversitesi Tıp Fakültesi Bilimsel Araştırma Etik Kurulu (12.02.2025/02-29).

INTRODUCTION

Lumbar disc herniation is a common clinical condition characterized by radiculopathy due to nerve root compression, which significantly restricts individuals' daily activities and leads to loss of workforce (1). This condition, particularly among individuals engaged in physically demanding occupations, markedly reduces quality of life and may result in chronic pain and functional impairments (2). Although surgical treatment is considered in cases with severe neurological deficits or pain unresponsive to conservative management, many patients remain reluctant to undergo surgery or explicitly refuse it (3).

Among non-surgical treatment methods, minimally invasive interventions have gained prominence in recent years due to their effectiveness and low complication rates (4). These methods include local anesthetic applications targeting the dorsal nerve branches, steroid injections, and radiofrequency (RF) neuromodulation procedures (5). By aiming to reduce inflammation and modify the transmission of nerve root–related pain, these interventions provide pain control and improve patients' quality of life (6).

This study aimed to compare the effectiveness of minimally invasive interventional methods applied in patients who developed radiculopathy due to lumbar disc herniation and refused surgical treatment. The effects of local anesthetic and steroid injections targeting the dorsal nerve branches and pulsed radiofrequency procedures were evaluated in terms of pain control and functional improvement. By comparing the early (1st month) and late (6th month) clinical outcomes of these treatment modalities in three different patient groups using the Oswestry Disability Index (ODI) scores, the study sought to determine the most effective method. Specifically, extruded and sequestered types of lumbar disc herniation were selected for this study. This is because the nucleus pulposus material released from the ruptured annulus fibrosus and/or posterior longitudinal ligament in these types is known to trigger a more potent and destructive neuro-inflammatory response around the nerve root through the release of pro-inflammatory cytokines such as IL-1β and TNF-α (7). Therefore, the efficacy of anti-inflammatory and neuromodulatory treatments is more critical and pronounced in this specific subgroup. The primary hypothesis of the study is that the combined treatment of DRG-PRF and steroid injection will provide superior and more sustained functional improvement in terms of ODI scores compared to the individually applied treatments (DRG-PRF or Steroid).

MATERIALS AND METHODS

Study Design and Patient Recruitment

This comparative study included a total of 90 patients diagnosed with radiculopathy or low back pain due to lumbar disc herniation between 2020 and 2024, who refused surgical treatment. According to a predetermined treatment protocol, patients were consecutively allocated into three equal groups (n=30 in each group):

- Group 1 (DRG-PRF): Patients who underwent pulsed radiofrequency (PRF) application to the dorsal root ganglion (DRG),
- Group 2 (Steroid): Patients who received only steroid + local anesthetic injection,
- Group 3 (Combined): Patients who received steroid + local anesthetic injection at the same level immediately after DRG-PRF in the same session.

All clinical data of the patients before and after treatment were fully accessible. The inclusion criteria were defined as being 18 years of age or older, having a diagnosis of lumbar disc herniation at only one or two levels confirmed clinically and radiologically, having no history of lumbar spine surgery, completing a minimum follow-up period of six months after treatment, and opting for non-surgical treatment methods (either refusing surgery or being directed to conservative treatment). The exclusion criteria were identified as an active systemic infection, coagulopathy or bleeding tendency due to anticoagulant therapy, diagnosis of active malignancy, a local skin infection at the injection site, and non-compliance with the defined treatment protocol or follow-up period.

Intervention Techniques

All procedures were performed under sterile conditions on the operating table with local anesthesia. Patients were discharged on the same day following the intervention. Before

the interventional procedure, anteroposterior (AP) and lateral fluoroscopic images were obtained using a C-arm scopy to identify the targeted nerve root anatomically. The needle was advanced through a transforaminal approach beneath the pedicle of the corresponding nerve root. To confirm the proper positioning of the needle tip, 2 mL of gadolinium contrast agent was injected, and its placement was verified fluoroscopically **(Figure 1)**.

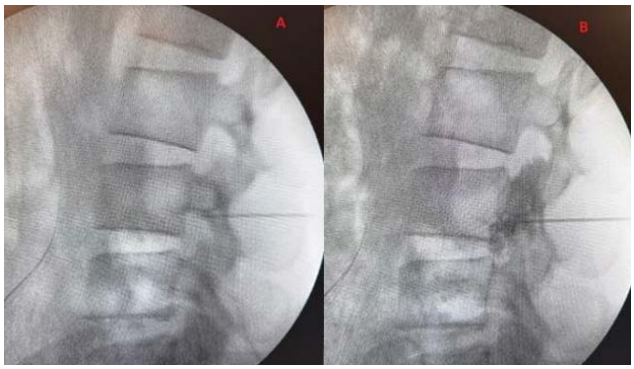

Figure 1: A: Lateral fluoroscopic image of the needle inserted into the L3–L4 disc space via the transforaminal approach.
B: The application of the contrast agent confirmed the anatomical position of the needle tip.

Nerve Stimulation and RF Parameters

To confirm that the correct nerve was targeted, sensory stimulation was first performed (50 Hz frequency, 0.1–0.5 V range), during which the overlap between the patient's primary pain complaint and the stimulation area was evaluated. Subsequently, motor stimulation was applied at a 2 Hz frequency and a 0.5–1 V voltage range, and muscle fasciculations along with limb movements were observed in the corresponding dermatome. During the procedure, the impedance value was maintained below 400 ohms. After all technical verifications, DRG-pulsed RF was applied to the targeted nerve root at 42°C for 120 seconds.

Steroid Injections

In all steroid injections, a preparation containing 7 mg/2 ml of betamethasone was used together with 2 ml of 0.5% bupivacaine as a local anesthetic. The injections were administered to the targeted foraminal region near the DRG under fluoroscopic guidance. In the combined group, steroid injection was performed at the same level immediately after DRG-pulsed RF in the same session.

Outcome Measure

To evaluate treatment effectiveness, the Oswestry Disability Index (ODI) was used (8). The ODI is a validated assessment tool comprising 10 items that assess functional limitations associated with low back pain. Each item is related to daily living activities such as pain, personal care, lifting, walking, sitting, standing, social life, and traveling. Each question is scored on a scale from 0 (no limitation) to 5 (completely disabling). The total score reflects the patient's level of functional impairment as a percentage.

Ethical Committee

This study was approved by the Scientific Research Ethics Committee of Erzurum Faculty of Medicine, Health Sciences University, on February 12, 2025 (Decision No: 2025/02-29). The ethical principles of the Declaration of Helsinki were followed in conducting the study. Written informed consent was obtained from all participants before the procedure. Patients' personal data were protected per the principle of confidentiality and used solely for scientific purposes.

Statistical Analysis

The data obtained from the study were analyzed using IBM SPSS Statistics software (SPSS version 22, SPSS Inc., Chicago, IL, USA). The normality of distribution for continuous variables was assessed with the Kolmogorov-Smirnov test. Data with normal distribution were presented as mean ± standard deviation, while non-normally distributed data were expressed as median (minimum–maximum). Categorical variables were presented as frequencies and percentages (%). For comparisons of demographic data and baseline ODI scores between groups, one-way analysis of variance (One-Way ANOVA) was used for normally distributed variables, and the Kruskal-Wallis test was applied for non-normally distributed variables. For within-group comparisons of ODI scores at baseline (day 0), 1 month, and 6 months, repeated measures ANOVA was applied for normally distributed data, while the Friedman test was used for non-normally distributed data. When necessary, pairwise comparisons were performed using Bonferroni-adjusted post-hoc analysis. The Chi-square test was used to compa-

re categorical variables. A p-value of < 0.05 was considered statistically significant for all tests.

RESULTS

A total of 90 patients were included in the study and equally divided into three groups: the group treated with radiofrequency (RF) alone (n=30), the group receiving steroid injection alone (n=30), and the group treated with both RF and steroid (n=30). The mean baseline Oswestry Disability Index (ODI) scores of all patients were similar, and no statistically significant difference was found between the groups (RF: 59.3 ± 5.2, Steroid: 57.1 ± 6.1, RF+Steroid: 58.5 ± 4.9; p=0.417) **(Table 1)**.

Table 1: Baseline demographic and clinical characteristics of the three treatment groups.

Variable	Group 1 (DRG-PRF)	Group 2 (Steroid)	Group 3 (RF + Steroid)	p-value
Age (mean ± SD)	49.2 ± 8.1	50.1 ± 7.9	48.6 ± 9.3	> 0.05
Female / Male	17 / 13	16 / 14	18 / 12	> 0.05
One-level / Two-level herniation	20 / 10	18 / 12	19 / 11	> 0.05
Baseline ODI (mean ± SD)	59.3 ± 5.2	57.1 ± 6.1	58.5 ± 4.9	0.417

DRG-PRF: Dorsal Root Ganglion-Pulsed Radiofrequency, ODI: Oswestry Disability Index, SD: standard deviation.

Within-Group Comparisons

In all three groups, a significant reduction in ODI scores was observed at the end of the first month compared to baseline (RF: p < 0.001; Steroid: p < 0.001; RF+Steroid: p < 0.001). However, when the 6-month results were evaluated, no statistically significant change was detected in the steroid group compared to baseline (p = 0.063) **(Table 2 and Figure 2)**.

Table 2: Within-Group Changes in ODI Scores (p-values).

Groups	Baseline ODI (mean ± SD)	1st Month ODI (mean ± SD)	6th Month ODI (mean ± SD)	Baseline – 1st Month (p)	Baseline – 6th Month (p)	1st Month – 6th Month (p)
Group 1 (DRG-PRF)	48.2 ± 7.5	32.6 ± 6.8	31.4 ± 6.3	0.003	0.002	0.021
Group 2 (Steroid)	47.5 ± 8.2	39.4 ± 7.1	37.8 ± 7.2	0.007	0.063	0.038
Group 3 (RF + Steroid)	49.1 ± 7.8	34.1 ± 6.5	32.0 ± 6.1	0.005	0.004	0.033

DRG-PRF: Dorsal Root Ganglion-Pulsed Radiofrequency, ODI: Oswestry Disability Index

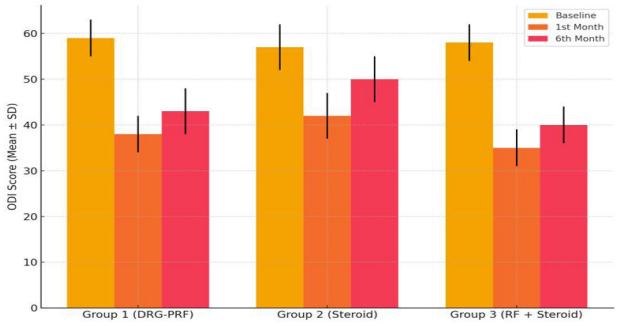

Figure 2: Within-Group Changes in ODI Scores (p-values).

Between-Group Comparisons

At the end of the first month, a significant difference was observed among the groups regarding ODI scores (p < 0.001). Post-hoc analyses revealed that the RF+Steroid group had significantly lower scores than the RF and the steroid groups. The significant difference among the groups persisted at the 6-month follow-up (p < 0.001); during this period, the RF+Steroid group demonstrated significantly lower scores compared to the steroid group, while the RF group also showed better outcomes than the steroid group **(Table 3)**.

Table 3: Post-hoc Comparisons between groups.

Comparison	Mean ODI Difference at 1st Month p-value	Mean ODI Difference at 6th Month p-value
Group 1 vs Group 2	0.027	0.015
Group 1 vs Group 3	< 0.001	0.009
Group 2 vs Group 3	< 0.001	< 0.001

Subgroup Analysis According to Herniation Level

In the subgroup analysis, no significant difference was observed at baseline in ODI scores between patients with one-level and two-level disc herniations. However, at the 6-month follow-up, the ODI scores of the two-level herniation group were significantly higher than those of the one-level group (p = 0.041) **(Table 4)**. No serious complications were observed in any of the groups. Only two patients developed transient pain at the injection site, which resolved spontaneously within 3–5 days without the need for intervention.

Table 4: Comparison of ODI Scores between Patients with One- and Two-Level Disc Herniations.

Groups	Baseline ODI Scores (mean ± SD)	1st Month ODI Scores (mean ± SD)	6th Month ODI Scores (mean ± SD)	Comparison at 6th Months (p)
One-level herniation	58.4 ± 5.3	38.2 ± 5.1	41.0 ± 5.0	0.041
Two-level herniation	58.7 ± 5.0	40.9 ± 5.4	45.6 ± 5.2	

DRG-PRF: Dorsal Root Ganglion-Pulsed Radiofrequency, ODI: Oswestry Disability Index, SD: standard deviation.

DISCUSSION

The findings of this study demonstrate that DRG-PRF, steroid injection, and combined treatment are effective non-operative options for patients who developed radiculopathy due to extruded or sequestrated lumbar disc herniation and prefer non-surgical management. All three treatment methods provided significant symptomatic improvement at the end of the first

month. However, at the six-month evaluation, clinical effectiveness was found to have declined in the steroid-only group, whereas symptomatic improvement was best maintained in the combined treatment group. These results suggest that while all methods are beneficial in the short term, combined treatment provides a more sustained clinical response in the mid-term.

In animal experiments conducted by Huang et al. (6) and Tun et al. (9), it was demonstrated that PRF modulates nociceptive transmissions from the dorsal root ganglion to the central nervous system without causing permanent tissue damage (6,9). PRF exerts its analgesic effect through this mechanism, which is reportedly more prominent in sequestrated and extruded disc herniations due to suppressing the inflammatory response. Particularly in the combined treatment group, where RF and steroids were used together, more pronounced clinical improvement was observed at both follow-up points compared to the other groups. This finding is consistent with studies suggesting that the anti-neuropathic effects of DRG-PRF and the anti-inflammatory properties of steroids may produce a synergistic effect (10-12). The results support that combined treatment strategies may be a more effective approach to enhancing functional recovery in patients who refuse surgery or are not suitable candidates for surgical intervention.

In a meta-analysis compiled by Manchikanti et al. (13), it was reported that the short-term analgesic effect of corticosteroid injections is well established; however, as shown in previous studies, their effectiveness on radicular pain significantly diminishes within 3–6 months when used alone. In a similar study conducted by Yildiz et al. (5), the beneficial effects of RF application were emphasized; however, it was reported that the addition of steroid injection did not significantly contribute to clinical outcomes. Other studies in the literature with similar findings also support this hypothesis (5,14). In a comparative study by Lee et al. (15), no significant difference in clinical efficacy was found between RF and steroid applications; nevertheless, it was suggested that RF may be preferred to avoid potential side effects associated with steroid use. In a prospective cohort study conducted by Gugliotta et al. (4), which compared surgical and conservative treatments in patients diagnosed with lumbar disc herniation, surgical treatment was found to provide faster and more effective symptomatic improvement in the early period; however, no significant difference between the two treatment approaches was observed in long-term follow-up. In this context, the findings of our study indicate that the RF-steroid combination should be considered, particularly in cases where non-surgical treatment options are evaluated, highlighting its noteworthy clinical applicability.

The finding from the subgroup analysis that patients with two-level disc herniations showed less functional improvement at 6 months ($p = 0.041$) compared to those with single-level herniations reflects the increased biomechanical and neurophysiological burden of the pathology. Continuous nociceptive (pain) input emanating from two separate DRGs (dorsal root ganglia) can heighten the probability and degree of central sensitization at the spinal cord level (16). Once central sensitization develops, pain is no longer solely peripheral but is maintained by persistent changes in the central nervous system. This is a critical neurophysiological mechanism explaining why the effect of peripheral interventional treatments (PRF and steroid) remains more limited in this patient group. Also, disc damage at two distinct segments compromises the overall biomechanical stability of the spine more severely than a single lesion (17). Even if successful interventional treatment reduces pain sensation, the structural inadequacy and restriction of movement arising from two levels can persist, leading to continued functional disability and higher ODI scores in patients' daily activities.

Our study has several limitations. Firstly, as stated in the methodology, patients were assigned consecutively to the three groups. This approach carries the risk of selection bias and necessitates caution when interpreting the results. Secondly, neither the patients nor the outcome assessors were blinded in this study.

Given that a subjective patient-reported scale like the Oswestry Disability Index (ODI) was used, the expectations of patients or assessors

who knew the treatment type may have introduced observer bias. Thirdly, the fact that the study was conducted at a single center limits its external validity, and findings should be generalized to different populations with caution. The limited number of patients in each group may have reduced the statistical power and restricted the generalizability of the results. Although mid-term follow-up was achieved, long-term clinical outcomes could not be obtained. Pain and functional status were assessed only using the Oswestry Disability Index (ODI). The absence of other measures, such as the Visual Analog Scale (VAS), quality of life scales (e.g., SF-36), or objective functional tests, may have limited the multidimensional evaluation of symptoms. Nevertheless, the study also has important strengths. First, a homogeneous patient population was established by including only patients with extruded and sequestrated types of lumbar disc herniation, thereby increasing the clinical relevance of the comparisons between treatment groups. Moreover, by comparing the DRG-PRF application alone with its combination with steroids, this study provided a systematic analysis of a subject where no clear consensus has yet been reached in the literature. In this respect, our study contributes to the growing body of evidence regarding the effectiveness of non-surgical treatment approaches. Future randomized, double-blind, multi-center studies are needed to overcome these limitations and more definitively establish the efficacy of the combined treatment. In patients with extruded and sequestrated lumbar disc herniation who underwent non-surgical treatment, both DRG-PRF and steroid injection provided significant symptomatic improvement at the 1-month follow-up. However, by the 6th month, this effectiveness had markedly diminished in the steroid group. In patients who received combined treatment (DRG-PRF + steroid), the lowest ODI scores were achieved in both the early and mid-term periods, and clinical success was maintained. Furthermore, cases with single-level herniation demonstrated a more favorable response than those with two-level herniations. These promising results must be verified by large-scale, randomized controlled trials; however, our current data suggest that combined therapy should be considered as a priority or primary option in clinical practice.

REFERENCES

1. Kreiner DS, Hwang SW, Easa JE, et al. An evidence-based clinical guideline for the diagnosis and treatment of lumbar disc herniation with radiculopathy. The Spine Journal. 2014;14(1):180-91.

2. Ranc P-A, Rudel A, Bentellis I, Prestat A, et al. Patient-Reported Outcomes and Return to Work after CT-Guided Percutaneous Lumbar Discectomy: A Prospective Study. Journal of Vascular and Interventional Radiology. 2024;35(3):390-7.

3. Kim J, Hur JW, Lee J-B, Park JY. Surgery versus nerve blocks for lumbar disc herniation: quantitative analysis of radiological factors as a predictor for successful outcomes. Journal of Korean Neurosurgical Society. 2016;59(5):478.

4. Gugliotta M, da Costa BR, Dabis E, et al. Surgical versus conservative treatment for lumbar disc herniation: a prospective cohort study. BMJ open. 2016;6(12):e012938.

5. Yildiz G, Goksu H, Akcaboy EY, et al. Does transforaminal epidural steroid injection added to dorsal root ganglion pulsed radiofrequency treatment increase efficacy? Turkish Journal of Physical Medicine and Rehabilitation. 2024;70(3):390.

6. Ren-Yu Huang M, Liao C-C, MS W-TL, et al. Rapid and delayed effects of pulsed radiofrequency on neuropathic pain: electrophysiological, molecular, and behavioral evidence supporting long-term depression. Pain Physician. 2017;20:269-83.

7. Jacobsen HE, Khan AN, Levine ME, et al. Severity of intervertebral disc herniation regulates cytokine and chemokine levels in patients with chronic radicular back pain. Osteoarthritis and cartilage. 2020;28(10):1341-50.

8. Fairbank JC, Pynsent PB. The Oswestry disability index. Spine. 2000;25(22):2940-53.

9. Tun K, Cemil B, Gurcay AG, et al. Ultrastructural evaluation of pulsed radiofrequency and conventional radiofrequency lesions in rat sciatic nerve. Surgical neurology. 2009;72(5):496-500.

10. Ding Y, Li H, Zhu Y, et.al. Transforaminal epidural steroid injection combined with pulsed radio frequency on spinal nerve root for the treatment of lumbar disc herniation. Journal of pain research. 2018:1531-9.

11. Yan Q, Zhong X, Li J, et al. Modified transforaminal epidural steroid injection combined with pulsed radiofrequency: an effective treatment measure for lumbar radiculopathy. Frontiers in Surgery. 2025;12:1566661.

12. Van Boxem K, Huntoon M, Van Zundert J, et al. Pulsed radiofrequency: a review of the basic science as applied to the pathophysiology of radicular pain. Regional Anesthesia & Pain Medicine. 2014;39(2):149-59.

13. Manchikanti L, Buenaventura RM, Manchikanti KN, et al. Effectiveness of therapeutic lumbar transforaminal epidural steroid injections in managing lumbar spinal pain. Database of Abstracts of Reviews of Effects (DARE): Quality-assessed Reviews [Internet]. 2012.

14. Leoni MLG, Micheli F, Abbott DM, et al. Transforaminal steroid injection after dorsal root ganglion pulsed radiofrequency (drg-prf): impact on pain intensity and disability. Pain and Therapy. 2024;13(5):1271-85.

15. Lee DG, Ahn S-H, Lee J. Comparative effectivenesses of pulsed radiofrequency and transforaminal steroid injection for radicular pain due to disc herniation: a prospective randomized trial. Journal of Korean Medical Science. 2016;31(8):1324-30.

16. Nijs J, Leysen L, Vanlauwe J, et al. Treatment of central sensitization in patients with chronic pain: time for change? Expert opinion on pharmacotherapy. 2019;20(16):1961-70.

17. Levy HA, Potes MDA, Nassr AN, et al. Biomechanical analysis of lumbar decompression technique and the effect on spinal instability: a narrative review. AME Medical Journal. 2024;9:1-22.