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Research Article

# The impact of epidural steroid injections on pain, function, and psychological outcomes in patients with chronic radicular pain: a prospective cohort study Epidural steroids in radicular pain

## *Kronik radiküler ağrılı hastalarda epidural steroid enjeksiyonlarının ağrı, fonksiyon ve psikolojik sonuçlar üzerine etkisi: Prospektif kohort çalışması Epidural steroid enjeksiyonlarının radiküler ağrıda etkisi*

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### Abstract

**Aim:** Low back pain with radiculopathy due to lumbar disc herniation is a major cause of disability. The outcomes of epidural steroid injections (ESIs), which are commonly performed when conservative therapies fail, are variable, and the effects of psychological factors, including pain catastrophizing, depression, and anxiety, on these outcomes remain underexplored. In this context, the objective of this study is to evaluate the effects of ESIs on pain severity, functional status, and psychological parameters, and to investigate the correlations between pain reduction and psychosocial outcomes over time.

**Material and Methods:** The sample of this prospective observational cohort study consisted of 50 patients with chronic radicular pain due to lumbar disc herniation who underwent ESIs and were followed up for three months. Patients' pain intensity, functional disability, psychological status, pain catastrophizing status, and quality of life were assessed at three time points, i.e., baseline, after one month, and after three months, using numeric rating scale (NRS), Oswestry disability index (ODI), hospital anxiety and depression scale (HADS), pain catastrophizing scale (PCS), and brief pain inventory (BPI), including BPI relations with others, enjoyment of life, and mood (BPI REM) and BPI walking, activity, and work (BPI WAW) subscales, respectively. Changes in outcomes were analyzed using non-parametric tests, and correlations were evaluated using Spearman's rho and heatmap analyses.

**Results:** ESIs led to significant improvements in all parameters. Patients' median NRS score decreased from 8.0 at baseline to 2.0 at both one and three months after they underwent ESI ($p<0.001$). Similarly, patients' median PCS, ODI, HADS, and BPI scores improved significantly over the study period (all $p < 0.001$). Correlation analysis revealed strong positive correlations between NRS and ODI scores ($r = 0.839$ at one month and $r = 0.746$ at three months, $p < 0.001$ for both cases), and moderate correlations between NRS and PCS and HADS scores at three months.

**Conclusion:** ESIs significantly reduced patients' pain, improved their functionality, and psychological well-being. The correlations between pain and psychological parameters highlight the interconnected nature of physical and psychosocial recovery in patients with chronic radicular pain.

**Keywords:** low back pain, radiculopathy, injections, epidural, steroids, catastrophization, treatment outcome

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## Öz

**Amaç:** Lomber disk hernisine bağlı radikülopati ile birlikte bel ağrısı önemli bir sakatlık nedenidir. Konservatif tedavilerin başarısız olduğu durumlarda yaygın olarak uygulanan epidural steroid enjeksiyonlarının (ESE) sonuçları değişkendir ve ağrı felaketleştirmesi, depresyon ve anksiyete gibi psikolojik faktörlerin bu sonuçlar üzerindeki etkileri yeterince araştırılmamıştır. Bu bağlamda, bu çalışmanın amacı ESE'lerin ağrı şiddeti, fonksiyonel durum ve psikolojik parametreler üzerindeki etkilerini değerlendirmek ve zaman içinde ağrı azalması ile psikososyal sonuçlar arasındaki ilişkileri araştırmaktır.

**Gereç ve Yöntemler:** Bu prospektif gözlemsel kohort çalışmasının örneklemi, lomber disk hernisine bağlı kronik radiküler ağrısı olan ve ESE uygulanan, üç ay boyunca takip edilen 50 hastadan oluşmaktadır. Hastaların ağrı yoğunluğu, fonksiyonel yetersizlik, psikolojik durum, ağrı felaketleştirme durumu ve yaşam kalitesi; başlangıç, birinci ay ve üçüncü ayda olmak üzere üç zaman noktasında sırasıyla numerik derecelendirme ölçeği (NRS), Oswestry disabilite indeksi (ODI), hastane anksiyete ve depresyon ölçeği (HADS), ağrı felaketleştirme ölçeği (PCS) ve kısa ağrı envanteri (BPI) ile değerlendirilmiştir. Sonuçlardaki değişiklikler non-parametrik testler kullanılarak analiz edilmiş, korelasyonlar Spearman's rho ve ısı haritası analizleri ile değerlendirilmiştir.

**Bulgular:** ESE'ler tüm parametrelerde anlamlı iyileşmelere yol açmıştır. Hastaların medyan NRS skoru başlangıçta 8,0'den ESE sonrası birinci ve üçüncü ayda 2,0'ye düşmüştür ($p<0,001$). Benzer şekilde, hastaların medyan PCS, ODI, HADS ve BPI skorları çalışma süresi boyunca anlamlı olarak iyileşmiştir (tümü için $p<0,001$). Korelasyon analizi, NRS ve ODI skorları arasında güçlü pozitif korelasyonlar (birinci ayda $r=0,839$ ve üçüncü ayda $r=0,746$, her ikisi için $p<0,001$) ve üçüncü ayda NRS ile PCS ve HADS skorları arasında orta düzeyde korelasyonlar ortaya koymuştur.

**Sonuç:** ESE'ler hastaların ağrısını anlamlı olarak azaltmış, fonksiyonellik ve psikolojik iyilik hallerini iyileştirmiştir. Ağrı ve psikolojik parametreler arasındaki korelasyonlar, kronik radiküler ağrılı hastalarda fiziksel ve psikososyal iyileşmenin birbiriyle bağlantılı doğasını vurgulamaktadır.

**Anahtar kelimeler:** bel ağrısı; radikülopati; enjeksiyonlar; epidural; steroidler; felaketleştirme; tedavi sonucu

## Introduction

Low back pain with radiculopathy due to lumbar disc herniation is among the leading causes of disability worldwide [1]. Epidural steroid injections (ESIs) are one of the most commonly used outpatient interventions, with high safety and efficacy in patients unresponsive to conservative treatments such as oral medications, manual therapy, or exercise therapy [1-4]. However, the success rates of ESIs reported in the literature vary widely, likely due to differences in the designs and outcomes of studies measuring these outcomes, the expertise of practitioners performing the procedures, and the characteristics of the populations studied [1,5], highlighting the importance of predicting in which patients ESIs may lead to favorable outcomes.

Several studies have demonstrated that both clinical and psychological factors can influence the outcomes of interventional procedures for chronic radicular pain [1,6,7]. Chronic low back pain has a complex and bidirectional relationship with psychosocial factors [8]. Although psychiatric comorbidities such as depression and anxiety have been linked to lower success rates of interventional pain procedures [1,7,8], it remains unclear which patients are most likely to benefit from these procedures. In particular, the effects of psychological factors present in patients before interventional pain procedures, such as pain catastrophizing, depression, and anxiety, on the success of these procedures remain underexplored.

Several studies have demonstrated a strong relationship between physical disability and mental health, especially anxiety and depression, in patients with lumbar disc herniation [9]. Treatment approaches for this patient population increasingly focus on psychiatric comorbidities [8].

Pain catastrophizing, defined as a combination of feelings of helplessness, magnification of pain-related threats, and difficulty suppressing pain-related thoughts, is highly prevalent among patients with chronic low back pain [9,10]. These patients often report higher pain intensity, physical impairment, depression, anxiety, and frustration, and impaired endogenous pain inhibition, experience greater impairment in performing daily activities, and resort to healthcare services more frequently [10,11]. Catastrophizing is therefore considered both a prognostic and modifying factor for the analgesic response to interventional pain procedures [10,12]. ESIs and other interventional modalities may help reduce catastrophizing

in patients with low back pain. In light of this information, we carried out this study to profile the mental health status of patients undergoing ESIs, evaluate the impact of ESIs on patients' depression, anxiety, and pain catastrophizing scores, and assess the correlations between patients' pre- and post-interventional psychological characteristics, based on the hypothesize that interventional pain procedures, specifically ESIs, may lead to significant improvements in the psychological status of patients with chronic low back pain.

## Material and Methods

### Study Design and Setting

This prospective, observational, single-center, cohort study was conducted at the Pain Clinic of the Department of Anesthesiology and Reanimation, Pamukkale University Hospital, between July 2024 and January 2025, per the ethical considerations outlined in the Helsinki Declaration and the Good Clinical Practice guidelines. The study protocol was approved by the Pamukkale University Non-Interventional Clinical Research Ethics Committee (Approval Date: 10 September 2024; Protocol Number: E-60116787-020-579328). Written informed consent was obtained from all participants before enrollment.

### Population and Sample

The study population consisted of 105 consecutive patients with chronic radicular pain due to lumbar disc herniation who were scheduled for ESI. Patients aged 18-80 years, who had radicular pain secondary to lumbar disc herniation for at least three months, who were unresponsive to conservative treatments, who had disc herniation at one or more of the L3–4, L4–5, or L5–S1 levels demonstrated by lumbar magnetic resonance imaging (MRI), who had a numeric rating scale (NRS) pain score of five or more, and who gave written consent to participate in the study were included in the study. On the other hand, patients with urgent surgical indications such as cauda equina syndrome or progressive motor deficit (n=7), a history of lumbar spine surgery (n = 4), uncontrolled cardiac arrhythmia or myocardial infarction within the last six months (n = 4), severe neurological or psychiatric disorders that affected their cognitive functions to the extent that they could not use the assessment tools applied within the scope of the study (n = 3), and those who did not consent to the study (n=7) were excluded from the study.

Patients were free to withdraw from the study at any time. Additionally, patients who would develop complications during the procedure or require additional interventions or medications outside the study protocol during follow-up were also planned to be excluded from the study. Accordingly, 30 of the remaining 80 patients dropped out during the study period. Twelve of these patients withdrew after agreeing to participate, nine missed one or two follow-up visits, two had their diagnosis changed, and five and two, respectively, developed comorbidities and minor complications.

In the end, the sample consisted of 50 patients who completed first- and third-month assessments (Figure 1).

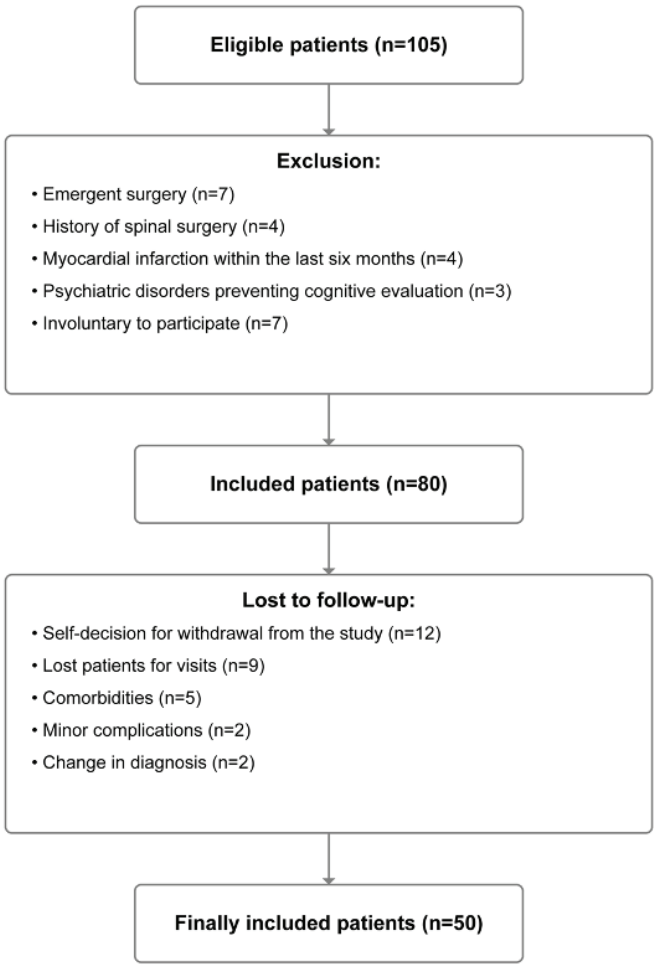


**Figure 1.** Study flowchart depicting participant enrollment, allocation, and follow-up procedures. This diagram illustrates the systematic progression of participants through each stage of the study protocol. The flowchart demonstrates initial eligibility assessment of 105 patients, subsequent exclusion criteria application resulting in 25 exclusions for specified clinical reasons, enrollment of 80 participants, and final retention of 50 patients who completed the three-month follow-up period. Numbers indicate participant counts at each stage, with detailed reasons for exclusion and loss to follow-up clearly delineated according to CONSORT guidelines for transparent reporting of clinical trials.

### ESI Protocol

All ESIs were performed in an operating room under sterile conditions under fluoroscopic guidance by experienced pain specialists. Intravenous (IV) access was established before the procedure, and standard monitoring, including electrocardiography (ECG), non-invasive blood pressure

measurement, and pulse oximetry, was employed for all patients.

The type of ESI to be performed was determined based on individual clinical findings and imaging results of the patients. Accordingly, patients with central or bilateral radicular symptoms received interlaminar lumbar ESI (n = 15), those with unilateral radicular symptoms underwent transforaminal ESI (n = 33), and those with prominent sacral involvement received caudal ESI (n = 28). Additionally, in patients with axial back pain that was aggravated with extension, a facet medial branch block (n = 20) was applied. Furthermore, some patients required more than one procedure.

The ESI injection solution, with a total volume of 4-6 mL, consisted of 80 mg methylprednisolone acetate and 0.5% bupivacaine. Patients were monitored for at least 2 hours after they underwent ESI, and those with stable vital signs were discharged.

**Data Collection**

Patients' demographic characteristics, including age, gender, body mass index (BMI), comorbidities, the type of disc herniation, and details of the procedure, were recorded using standardized case report forms. Assessments were performed at three different time points: at baseline, 1 month after the procedure, and 3 months after the procedure. Follow-up assessments were conducted face-to-face during outpatient clinic visits.

**Assessment Tools**

1. Numeric rating scale (NRS)

Patients' pain severity was assessed using the 11-point NRS, with 0 indicating "no pain at all" and 10 indicating "worst imaginable pain" [13].

2. Brief pain inventory (BPI)

The 10-point BPI, developed by Cleeland and Ryan [14] and adapted to Turkish by Dicle et al. [15], assesses pain experience, including the anatomical location of pain and pain severity (sensory dimensions of pain), and the degree to which pain affects with performing daily functions, including general activities, walking, working, relations with others, and sleep, as well as mood and enjoyment of life (reactive dimensions of pain), with 1 indicating the best and 10 the worst outcome. BPI has two subscales that address the affective and activity subdimensions: BPI relations with others, enjoyment of life, and mood (REM) subscale and BPI walking, activity, and work (WAW) subscale. We also assessed sleep dimension under the BPI REM domain based on Rajput's study [10].

3. Hospital anxiety and depression scale (HADS)

HADS was developed by Zigmond and Snaith [16]. The Turkish version of HADS was validated by Aydemir et al. [17]. HADS consists of 14 items, each scored between 0 and 3, with seven items in each of the anxiety and depression subscales. The total score that can be obtained from each HADS subscale is 21. Higher scores indicate higher degrees of anxiety and depression [18].

4. Pain catastrophizing scale (PCS) PCS was developed by Sullivan et al. [19]. The Turkish version of PCS was validated by Suren et al. [20]. The 13-item PCS, consisting of rumination, magnification, and helplessness subscales, is a self-administered tool. Each item is scored on a scale of 0 to 4, and the total score that can be obtained from the PCS ranges from 0 to 52. Higher scores indicate higher levels of catastrophizing [19].

5. Oswestry disability index (ODI)

ODI was developed by Fairbank et al. [21]. The Turkish version of ODI was validated by Yakut et al. [22]. ODI assesses functional impairment due to low back pain based on 10 daily life activities. Each item on the 6-point Likert-type ODI is scored from 0 to 5. Higher ODI scores indicate greater disability. The total ODI score, which varies between 0 and 100 and is expressed as a percentage, is found by multiplying the obtained ODI score by 2 [22].

## Statistical Analysis

The study's primary outcomes were the changes in patients' pain severity and functional status, the impact of pain on patients' quality of life, levels of catastrophizing, and psychological status, and secondary outcomes were the correlations between these variables. Jamovi project 2.6.44 (Jamovi, version 2.6.44, 2025, retrieved from https://www.jamovi.org) and JASP 0.19.3 (Jeffreys' Amazing Statistics Program, version 0.19.3, 2025, retrieved from https://jasp-stats.org) software packages were used in the statistical analyses of the collected data. The results of the statistical analyses were expressed using descriptive statistics, i.e., mean ± standard deviation values in the case of continuous variables determined to conform to the normal distribution, median with minimum and maximum values in the case of continuous variables determined to not conform to the normal distribution, and frequencies (n) and percentage (%) values in the case of categorical variables. Normal distribution characteristics of the numerical variables were analyzed using appropriate statistical tests, i.e., Kolmogorov- Smirnov and Anderson- Darling tests, in the case of large samples ($n \geq 50$), as well as visual tools, such as histograms and Q–Q plots. Friedman test, a non-parametric alternative to repeated measures analysis of variance (ANOVA) test, was used for repeated measurements of non-normally distributed variables over the study's time points. In cases where the Friedman test yielded significant differences in these variables, the Durbin–Conover test was used to conduct post-hoc pairwise comparisons in order to determine the differences across the study's time

points. Spearman's rho correlation coefficients were used to assess the relationships between the NRS, PCS, BPI, HADS, and ODI scores at each time point. Heatmap analysis was also performed to evaluate the linear relationships between the NRS, PCS, BPI, HADS, and ODI scores subscales and total scores, and the ODI at each time point and the corresponding changes. Probability (p) statistics of ≤ 0.05 were deemed to indicate statistical significance.

## Results

The mean age of the 50 patients included in the sample, 68.0% of whom were female, was 60.8 ± 13.1 years. Comorbidities were present in 72.0% of the patients, the most common of which was hypertension (42.0%), followed by diabetes mellitus (36.0%). Central disc herniation was observed in 36.0% of patients, subarticular herniation in 40.0%, and foraminal or extraforaminal herniation in 24.0% (Table 1).

**Table 1.** Demographic and clinical characteristics of patients with chronic radicular pain due to lumbar disc herniation.

| Variable | Overall (n=50) |
|---|---|
| Age (years) | 60.8 ± 13.1 |
| Sex | |
| Female | 34 (68.0) |
| Male | 16 (32.0) |
| Body mass index (kg/m$^2$) | 28.7 ± 4.0 |
| Comorbidity, present | 36 (72.0) |
| Type of comorbidity | |
| Hypertension, present | 21 (42.0) |
| Diabetes mellitus, present | 18 (36.0) |
| COPD, present | 5 (10.0) |
| Coronary artery disease, present | 2 (4.0) |
| Chronic renal failure, present | 3 (6.0) |
| Hyperlipidemia, present | 9 (18.0) |
| Type of lumbar disc herniation | |
| Central | 18 (36.0) |
| Subarticular | 20 (40.0) |
| Foraminal/extraforaminal | 12 (24.0) |
| Type of ESI | |
| Caudal | 28 (56.0) |
| Lumbar/interlaminar | 15 (30.0) |
| Transforaminal | 33 (66.0) |
| Facet medial branch block | 20 (40.0) |

Abbrev.: COPD = chronic obstructive pulmonary disease; ESI = epidural steroid injection.
Data are presented as mean ± standard deviation for continuous variables or n (%) for categorical variables. Some patients received more than one type of epidural steroid injection.

At baseline, the median worst pain score on the BPI was 8.0 (range, 3.0-10.0), whereas median least pain, average pain, and current pain scores were 4.5 (range, 1.0-8.0), 5.0 (range, 1.0-9.0), and 5.0 (range, 0.0-8.0), respectively. The mean pain severity and interference scores were 5.4 (Table 2).

**Table 2.** Pre-interventional pain severity and interference characteristics assessed by the Brief Pain Inventory.

| Pain characteristics | Overall (n=50) |
|---|---|
| Worst pain | 8.0 [3.0–10.0] |
| Least pain | 4.5 [1.0–8.0] |
| Average pain | 5.0 [1.0–9.0] |
| Current pain | 5.0 [0.0–8.0] |
| Mean severity | 5.4 [1.7–8.5] |
| Mean interference | 5.4 [3.0–7.0] |
| Affective items | |
| Relations with other people | 5.0 [1.0–6.0] |
| Enjoyment of life | 5.0 [1.0–8.0] |
| Mood | 6.0 [1.0–8.0] |
| Activity items | |
| Walking | 6.0 [2.0–9.0] |
| General activity | 6.0 [2.0–10.0] |
| Work | 5.0 [1.0–8.0] |
| Others | |
| Sleep | 5.0 [1.0–8.0] |

Data are presented as median [minimum–maximum]. All scores range from 0 (no pain/no interference) to 10 (worst possible pain/complete interference). Mean severity score represents the average of worst, least, average, and current pain scores. Mean interference score represents the average of all seven interference items.

Significant decreases were observed in all study's outcomes following the ESI procedure (Table 3). The median NRS score decreased significantly from 8.0 (range, 5.0–10.0) at baseline to 2.0 (range, 0.0–7.0) at one month after the procedure and remained at 2.0 (range, 0.0–10.0) at three months after the procedure ($p < 0.001$ for both cases). The median PCS score improved significantly from 22.5 (range, 8.0–51.0) at baseline to 15.0 (range, 8.0–40.0) at one month after the procedure and 16.5 (range, 6.0–49.0) at three months after the procedure ($p < 0.001$ for both cases). Similarly, ODI, HADS, BPI interference, REM, and WAW subscale scores all significantly decreased during the follow-up period (Table 3).

The Spearman correlation heat map revealed correlations at varying strengths between pain, psychological, and functional outcomes across time points (Figure 2).

Correlation analysis revealed a strong positive relationship between NRS and ODI scores at both one-month ($r = 0.839$, $p < 0.001$) and three-month ($r = 0.746$, $p < 0.001$) after the procedure. NRS pain scores were significantly correlated with PCS ($r = 0.434$, $p = 0.002$), HADS depression subscale ($r = 0.306$, $p = 0.031$), HADS total ($r = 0.377$, $p = 0.007$), and BPI REM subscale ($r = 0.092$, $p = 0.527$) and BPI WAW subscale ($r = 0.833$, $p < 0.001$) scores at three months after the procedure. No significant correlations were found between NRS pain and psychological parameters at baseline ($p > 0.05$) (Table 4).

**Table 3.** Longitudinal changes in pain severity, functional disability, quality of life, psychological status, and pain catastrophizing following epidural steroid injection.

| Variable | Baseline | One month follow-up | Change from baseline | p | Three month follow-up | Change from baseline | p |
|---|---|---|---|---|---|---|---|
| Numerical rating scale pain score | 8.0 [5.0–10.0] | 2.0 [0.0–7.0] | -6.0 [-2.0–(-10.0)] | <0.001 | 2.0 [0.0–10.0] | -6.0 [-1.0–(-10.0)] | <0.001 |
| Relations-Enjoyment-Mood-Sleep (REM) score | 5.0 [1.5–6.8] | 4.0 [1.5–6.2] | -1.0 [0.5–(-3.0)] | <0.001 | 4.0 [1.2–6.5] | -1.0 [0.5–(-3.5)] | <0.001 |
| Walking-Activity-Work (WAW) score | 5.7 [3.3–8.0] | 2.5 [1.0–6.3] | -3.2 [-0.3–(-5.0)] | <0.001 | 3.0 [1.0–9.0] | -2.7 [0.0–(-5.0)] | <0.001 |
| Mean interference score | 5.4 [3.0–7.0] | 3.3[1.4–8.2] | -2.1 [0.9–(-4.0)] | <0.001 | 3.6 [1.4–7.0] | -1.8 [0.0–(-4.0)] | <0.001 |
| HADS anxiety subscale | 5.5 [0.0–11.0] | 2.0 [0.0–8.0] | -3.5 [0.0–(-8.0)] | <0.001 | 3.0 [0.0–11.0] | -2.5 [0.0–(-7.0)] | <0.001 |
| HADS depression subscale | 10.0 [1.0–17.0] | 5.0 [1.0–13.0] | -5.0 [0.0–(-10.0)] | <0.001 | 6.0 [1.0–14.0] | -4.0 [0.0–(-9.0)] | <0.001 |
| HADS total score | 15.0 [1.0–25.0] | 9.0 [1.0–19.0] | -6.0 [0.0–(-15.0)] | <0.001 | 10.0 [1.0–23.0] | -5.0 [0.0–(-12.0)] | <0.001 |
| Pain catastrophizing scale | 22.5 [8.0–51.0] | 15.0 [8.0–40.0] | -7.5 [0.0–(-20.0)] | <0.001 | 16.5 [6.0–49.0] | -6.0 [2.0–(-18.0)] | <0.001 |
| Oswestry disability index | 47.0 [22.0–82.0] | 22.0 [20.0–72.0] | -25.0 [-2.0–(-40.0)] | <0.001 | 25.0 [20.0–82.0] | -22.0 [0.0–(-38.0)] | <0.001 |

Abbrev.: HADS = Hospital Anxiety and Depression Scale; REM = Relations-Enjoyment-Mood-Sleep composite score from the Brief Pain Inventory; WAW = Walking-Activity-Work composite score from the Brief Pain Inventory.
Data are presented as median [minimum–maximum]. Statistical comparisons were performed using the Friedman test with Durbin-Conover post-hoc analysis. Bold p-values indicate statistical significance (p≤0.05). Negative values in change columns represent improvement (reduction in scores).

**Table 4.** Correlation analysis between pain intensity and functional, psychological, and quality-of-life parameters across follow-up.time points.

| Variable | Baseline | | One-month follow-up | | Three-month follow-up | |
|---|---|---|---|---|---|---|
| | r | p | r | p | r | p |
| Relations-Enjoyment-Mood-Sleep (REM) score | 0.184 | 0.200 | 0.283 | 0.047 | 0.092 | 0.527 |
| Walking-Activity-Work (WAW) score | 0.266 | 0.061 | 0.475 | <0.001 | 0.833 | <0.001 |
| Mean interference score | 0.220 | 0.125 | 0.439 | 0.001 | 0.685 | <0.001 |
| HADS anxiety subscale | -0.095 | 0.513 | 0.003 | 0.984 | 0.279 | 0.050 |
| HADS depression subscale | 0.031 | 0.829 | 0.105 | 0.468 | 0.306 | 0.031 |
| HADS total score | -0.047 | 0.748 | 0.082 | 0.572 | 0.377 | 0.007 |
| Pain catastrophizing scale | 0.088 | 0.543 | 0.094 | 0.517 | 0.434 | 0.002 |
| Oswestry disability index | 0.105 | 0.469 | 0.839 | <0.001 | 0.746 | <0.001 |

Abbrev.: HADS = Hospital Anxiety and Depression Scale; REM = Relations-Enjoyment-Mood-Sleep composite score from the Brief Pain Inventory; WAW = Walking-Activity-Work composite score from the Brief Pain Inventory
.Spearman's rank correlation coefficient (r) was used for all analyses. Bold p-values indicate statistical significance (p≤0.05). Positive correlations indicate that higher pain scores are associated with greater impairment or distress.

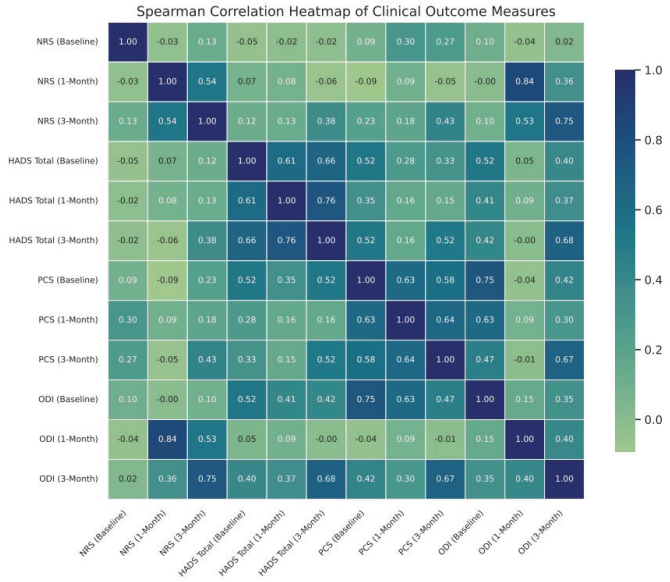


**Figure 2.** Spearman correlation heatmap illustrating the relationships between pain severity, functional disability, psychological parameters, and quality-of-life measures across the three-month study period. This visualization presents a comprehensive correlation matrix examining the associations among numerical rating scale (NRS) pain scores, Hospital Anxiety and Depression Scale (HADS) total scores, Pain Catastrophizing Scale (PCS) scores, and Oswestry Disability Index (ODI) values at baseline, one-month, and three-month time points. The color gradient represents correlation strength, with warm tones (orange to red spectrum) indicating negative correlations and cool tones (green to blue spectrum) representing positive correlations. Correlation coefficients are interpreted as follows: 0.2–0.4 indicates weak association, 0.4–0.6 indicates moderate association, and values exceeding 0.6 indicate strong association. The diagonal elements represent perfect self-correlation (r = 1.0). This heatmap reveals temporal patterns in the relationships between physical and psychological outcomes following epidural steroid injection therapy. Abbreviations: BPI, Brief Pain Inventory; HADS, Hospital Anxiety and Depression Scale; NRS, Numerical Rating Scale; ODI, Oswestry Disability Index; PCS, Pain Catastrophizing Scale; REM, Relations-Enjoyment-Mood-Sleep composite score; WAW, Walking-Activity-Work composite score.

## Discussion

ESIs led to significant and sustained improvements in pain severity, functional status, and psychological well-being in patients with chronic radicular pain due to lumbar disc herniation. Correlation analysis revealed a strong positive relationship between NRS pain scores and functional disability, assessed by ODI, at both one- and three-month post-procedure. The decrease observed by the third month after the ESI procedure was moderately correlated with psychological factors, including HADS depression subscale and PCS scores. Quality-of-life measures, particularly BPI WAW subscale scores, were strongly correlated with pain intensity. The correlations observed at the third month after the procedure were generally stronger than those observed at the first month after the procedure. Overall, these findings underline the interrelationship between pain, function, and psychological health in the recovery process and support the hypothesis that pain management with interventional procedures contributes not only to symptomatic relief but also to broader functional and psychological recovery.

Our cohort was characterized by a high baseline pain burden, with median NRS pain scores of 8.0, and by notable psychological distress and functional limitations, as evidenced by elevated PCS, ODI, and HADS scores. The marked decrease in pain and psychosocial outcomes by the first month after the procedure and the sustainment of these improvements through the three-month follow-up period highlight the early and sustained benefits of ESIs. Furthermore, the strong correlation between pain reduction and improvements in both functional status and quality-of-life outcomes underscores the multifaceted clinical impact of ESI intervention.

The relationship between interventional pain outcomes and the psychological states of patients with chronic low back pain is multidimensional and complex [9,23]. As noted by Linton and Shaw [24], psychological factors influence pain perception and treatment response through intricate mechanisms. The improvements we observed in patients' pain scores and functional outcomes are consistent with literature data supporting the efficacy of ESI in treating lumbar radiculopathy [25,26]. Although many studies have examined psychological factors as predictors of treatment response, there is no consensus yet regarding the interplay between patient characteristics and the benefits of ESI [2,10,27]. Turner et al. [2] reported that baseline characteristics, including sociodemographics, severity of spinal canal stenosis, and psychological factors, were not robust predictors of the benefits to be obtained from ESI. Rajput et al. [10] identified baseline PCS and the BPI REM subscale scores as the most important predictors of PCS changes following ESI. Nevertheless, the change in PCS score between pre- and post-procedure was not significant. In comparison, we focused on the effects of the ESI procedure on patients' psychological outcomes to address the need referred to in the literature to elucidate the bidirectional relationship between psychosocial factors and ESI treatment response [10,28].

We assessed the psychological improvements in patients in our cohort based on the biopsychosocial model of chronic pain proposed by Gatchel et al. [29], which highlights the influence of cognitive, emotional, and social factors on the pain experience. Nevertheless, relevant findings in the literature are conflicting, likely due to methodological heterogeneity featuring the use of aggregate data and reliance on administrative coding, which may be prone to inaccuracies or misclassification. Jindal et al. [7]

reported no significant difference in the mean changes in VAS and ODI between distressed and non-distressed patients after they underwent ESI for chronic low back pain. Similarly, other studies found no significant relationship between depression or anxiety and clinically meaningful elevations in pain scores [8,18]. In contrast, we found significant decreases in our patients' depression and anxiety scores, mirroring the findings of strong correlations between depression, chronic pain, and disability scores in patients with low back pain in primary care settings reported in other studies [30,31]. Another study found that patients with higher baseline pain, depression, and obesity were more likely to experience poor outcomes after interventions for low back pain [5]. Taken together, these conflicting findings suggest that the predictive role of psychological distress in determining ESI success remains uncertain.

The significant decrease we found in patients' PCS scores is among the most prominent findings of our study. Catastrophizing, assessed by PCS, is a key factor known to adversely affect treatment outcomes in chronic pain patients. Cancer patients with severe pain reportedly have higher catastrophizing levels and worse pain interference, depression, anxiety, and self-efficacy scores despite using higher opioid doses [11]. These findings indicate a positive correlation between opioid dose, anxiety, and catastrophizing. The improvement in our patients' catastrophizing levels after they underwent an ESI procedure suggests that interventional procedures may influence both peripheral pain mechanisms and central pain processing. Stensland et al. [1] reported that high negative affect (anxiety and depression) and lower cognitive resilience were associated with less pain improvement following ESI.

The relationships between pain severity, PCS, and BPI subscale scores remain controversial. Rajput et al. [10] reported a weak correlation between pain severity and PCS scores, as in our study. They also found the BPI REM subscale score, reflecting the affective subdimension of pain, to be correlated with the PCS score. The directional relationship between patient functionality and catastrophizing remains unclear and warrants further investigation.

The dynamic changes identified in our correlation analyses are particularly noteworthy. Although we did not detect any significant relationships between pain intensity and psychological parameters at baseline, we found significant correlations between NRS scores and PCS, HADS anxiety, and depression subscale scores three months after the ESI procedure. These time-dependent correlations may indicate that the links between pain, mood, and coping strategies become more apparent as pain relief is sustained, reflecting the complex interplay of biopsychosocial factors during recovery.

This study had several limitations. First, its single-center design and relatively small sample size limit the generalizability of its findings. Secondly, lack of a control group prevents attributing the observed improvements solely to ESI, as placebo effects or natural recovery cannot be excluded. Thirdly, although we comprehensively assessed pain, psychological, and functional outcomes, the three-month follow-up period was not long enough to provide information on the impact of ESI in the long term. Finally, the use of patient-reported outcome measures may be subject to recall or response biases, and the lack of imaging follow-up limits the ability to correlate clinical outcomes with structural changes.

In conclusion, ESI has led to marked improvements in pain, function, and psychological well-being in patients with chronic radicular pain due to lumbar disc herniation over a three-month follow-up period. The correlations observed between pain severity, functional status, and psychological parameters underscore the interconnected nature of these outcomes and highlight the importance of addressing both physical and psychological components in pain management. Further controlled studies with larger cohorts and longer follow-up are needed to corroborate these findings and evaluate their long-term sustainability.

## Ethics approval

Ethical approval was obtained from the Pamukkale University Non-Interventional Clinical Research Ethics Committee (Approval Date: 10 September 2024; Protocol Number: E-60116787-020-579328).

## Conflicts of Interest Statement

The authors declare they have no conflicts of interest.

## Financial Disclosure

The authors declared that this study has received no financial support.

## Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version

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