

A comparison of clinical and procedural outcomes of transforaminal versus parasagittal interlaminar epidural steroid injections for radicular pain secondary to lumbar disc herniation

Lomber disk hernisine bağlı radiküler ağrıda transforaminal ve parasagittal interlaminar epidural steroid enjeksiyonlarının klinik ve işlemsel sonuçlarının karşılaştırılması

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ABSTRACT

Background: This study aims to compare the clinical and procedural outcomes of transforaminal epidural steroid injections (TFESIs) and parasagittal interlaminar epidural steroid injections (P-ILESIs) in patients with unilateral radicular pain secondary to lumbar disc herniation (LDH).

Patients and Methods: Between January 2024 and June 2025, a total of 162 patients with unilateral radicular pain caused by single-level LDH were included in this retrospective, observational cohort study. The patients were divided into the two groups based on the technique as the TFESI group (n = 82) and the P-ILESI group (n = 80). Pain, disability, sleep quality, and health-related quality of life were assessed using the Numeric Rating Scale (NRS), Oswestry Disability Index (ODI), Pittsburgh Sleep Quality Index (PSQI), and Short Form-12 (SF-12), respectively at baseline, one month, and six months. Fluoroscopy time and cumulative radiation dose were also recorded.

Results: Of the patients, 120 were male and 42 were female with a median age of 47 (range 22 to 65) years. Both techniques significantly improved pain, disability, sleep quality, and quality of life at one and six months ($p < 0.001$). The reduction in NRS from baseline was greater with TFESI at one month ($p = 0.008$), but not at six months ($p = 0.545$). The ODI scores were lower with TFESI at one month, although the magnitude of improvement from baseline did not significantly differ and no difference was observed at six months. Quality of life outcomes were comparable between the groups. The P-ILESI required longer fluoroscopy time and higher radiation exposure than TFESI ($p < 0.001$ for both). No major complications occurred, and minor adverse events were infrequent and comparable between the groups ($p = 0.764$).

Conclusion: Both TFESI and P-ILESI appear to be effective and safe approaches for the treatment of radicular pain associated with LDH. The choice of epidural approach should be individualized according to clinical and anatomical considerations, as well as operator experience.

Keywords: Epidural injections, intervertebral disc displacement, low back pain, lumbar disc herniation, radiculopathy, treatment outcome.

ÖZ

Amaç: Bu çalışmada, lomber disk hernisi (LDH) nedeniyle gelişen tek taraflı radiküler ağrısı olan hastalarda transforaminal epidural steroid enjeksiyonu (TFESI) ile parasagittal interlaminar epidural steroid enjeksiyonunun (P-ILESI) klinik ve işlemsel sonuçları karşılaştırıldı.

Hastalar ve Yöntemler: Ocak 2024 ile Haziran 2025 tarihleri arasında, tek seviyeli LDH kaynaklı tek taraflı radiküler ağrısı olan toplam 162 hasta bu retrospektif, gözlemsel kohort çalışmasına dahil edildi. Hastalar uygulanan tekniğe göre TFESI grubu (n = 82) ve P-ILESI grubu (n = 80) olmak üzere iki gruba ayrıldı. Ağrı, engellilik, uyku kalitesi ve sağlıkla ilişkili yaşam kalitesi sırasıyla Sayısal Derecelendirme Ölçeği (NRS), Oswestry Engellilik İndeksi (ODI), Pittsburgh Uyku Kalitesi İndeksi (PSQI) ve Kısa Form-12 (SF-12) kullanılarak başlangıçta, birinci ayda ve altıncı ayda değerlendirildi. Floroskopi süresi ve kümülatif radyasyon dozu da kaydedildi.

Bulgular: Hastaların 120'si erkek ve 42'si kadın olup, medyan yaş 47 (dağılım, 22-65) yıl idi. Her iki teknik de birinci ve altıncı aylarda ağrı, engellilik, uyku kalitesi ve yaşam kalitesinde anlamlı iyileşme sağladı ($p < 0.001$). Başlangıça kıyasla NRS skorundaki azalma, birinci ayda TFESI grubunda daha fazlaydı ($p = 0.008$), ancak altıncı ayda gruplar arasında anlamlı fark saptanmadı ($p = 0.545$). Birinci ayda ODI skorları TFESI grubunda daha düşük olmakla birlikte, başlangıça kıyasla iyileşme düzeyindeki fark anlamlı değildi ve altıncı ayda da gruplar arasında bu fark gözlenmedi. Yaşam kalitesi sonuçları gruplar arasında benzerdi. P-ILESI grubunda floroskopi süresi ve radyasyon maruziyeti TFESI grubuna göre daha yüksekti (her ikisi için $p < 0.001$). Ciddi komplikasyon görülmezken, minör advers olaylar seyrek olup gruplar arasında benzerdi ($p = 0.764$).

Sonuç: Hem TFESI hem de P-ILESI'nin, LDH ile ilişkili radiküler ağrının tedavisinde etkili ve güvenli yaklaşımlar olduğu görülmektedir. Epidural yaklaşımın seçimi; klinik ve anatomik özelliklerin yanı sıra, uygulayıcının deneyimi de dikkate alınarak hastaya özgü olarak belirlenmelidir.

Anahtar sözcükler: Epidural enjeksiyonlar, intervertebral disk bozukluğu, bel ağrısı, lomber disk hernisi, radikülopati, tedavi sonucu.

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Doi: 10.5606/agri.2026.96

Received: February 27, 2026 | **Accepted:** August 26, 2026 | **Published online:** September 27, 2026

Cite this article as: Gözükızıl ST, Altun Hİ. A comparison of clinical and procedural outcomes of transforaminal versus parasagittal interlaminar epidural steroid injections for radicular pain secondary to lumbar disc herniation. Agri 2026;38(4):237-246. doi: 10.5606/agri.2026.96.

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Low back pain (LBP) is a prevalent clinical condition associated with significant socioeconomic costs globally.^[1] Lumbar disc herniation (LDH) still remains one of its most frequent structural causes, typically presenting with persistent radicular symptoms.^[2] Conservative management typically includes physical therapy, muscle relaxants, and non-steroidal anti-inflammatory drugs. A substantial number of patients fail to achieve a lasting relief.^[3] For this specific group, epidural steroid injections are often considered when conservative treatment fails.

The primary goal of these injections is to deliver local anesthetics and corticosteroids directly to the inflamed neural elements, thereby interrupting the pain-spasm cycle.^[4] Clinicians typically choose between interlaminar and transforaminal routes to achieve this. The interlaminar epidural steroid injection (ILESIs) can be executed via midline, paramedian, or parasagittal trajectories.^[5] Traditional midline approaches deliver the injectate into the posterior epidural space, relying on anterior spread to reach the ventral epidural pathology.^[6] However, fluoroscopic studies indicate that placing the needle at the extreme lateral margin known as the parasagittal approach (P-ILESIs) yields a ventral contrast spread of 89 to 100%. This compares with 31.7% reported for the midline technique and has been associated with improved pain and functional outcomes in some studies.^[7]

Beyond the needle trajectory, the two techniques differ significantly in their drug distribution patterns. Interlaminar injections routinely spread across multiple spinal segments bilaterally, which benefits patients with widespread pathology.^[8] Transforaminal epidural steroid injections (TFESIs), on the other hand, prioritize target specificity. By guiding the injectate directly into the ventral epidural space along the exiting nerve root, TFESI concentrates the therapeutic dose right at the site of disc-nerve conflict.^[9] For localized unilateral radiculopathy, this targeted delivery is widely considered a potential anatomical advantage.

Despite the solid anatomical rationale for TFESI, comparative clinical data remain controversial. Several studies have reported superior pain reduction with the transforaminal approach, while others have argued that a properly executed interlaminar injection provides comparable relief.^[10] Safety profiles further complicate the clinical decision. The transforaminal needle path runs in close proximity to the radicular medullary artery, carrying a rare but

severe risk of neurological injury.^[11] However, large population-based data have shown that serious spinal adverse events after ESI are rare, with lower event rates reported for lumbar/sacral than cervical/thoracic injections.^[12] However, the optimal technique still remains a matter of ongoing debate.

Recognizing these gaps in the literature, we aimed to compare the clinical and procedural outcomes of TFESI and P-ILESIs in patients with unilateral radicular pain secondary to LDH and to evaluate therapeutic success through pain intensity, functional recovery, sleep quality, and overall well-being. Additionally, we aimed to analyze active fluoroscopy time and cumulative radiation exposure to provide a more practical and comprehensive perspective on both techniques.

PATIENTS AND METHODS

This single-center, retrospective, observational cohort study was conducted at Prof. Dr. Cemil Taşcıoğlu City Hospital Department of Pain Medicine between January 2024 and June 2025. Medical data were retrieved from the hospital database. The study design and reporting adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. Eligible participants were adults (≥ 18 years) who underwent single-level TFESI or P-ILESIs for unilateral radicular pain (Numeric Rating Scale [NRS] score ≥ 5) secondary to LDH. The diagnosis was confirmed by both clinical examination and lumbar magnetic resonance imaging (MRI). All MRI scans were re-evaluated by an experienced musculoskeletal radiologist to confirm the level of disc herniation, the presence of corresponding nerve root compression, and eligibility according to the predefined imaging criteria. Based on the nomenclature proposed by Fardon et al.,^[13] only patients with subarticular (lateral recess) or foraminal disc herniations were included. Cases with disc protrusion, extrusion, and sequestration were eligible for inclusion when associated with unilateral radicular symptoms and corresponding radiological nerve root compression. Detailed anatomical localization of the disc herniation was not systematically recorded as a predefined study variable in the retrospective dataset. Patients with sequestered disc herniation were included, only if they had no red flag findings or absolute indications for surgical intervention, such as progressive motor deficit, cauda equina syndrome, or severe neurological deterioration, and were considered appropriate candidates for

conservative interventional management. Patients with disc bulging without definite nerve root compression were not included in the study. Exclusion criteria were as follows: multi-level disc herniations, multi-level lumbar spinal stenosis with radiologically significant central canal narrowing (anteroposterior [AP] canal diameter < 10 mm on lumbar MRI), a history of lumbar spine surgery, severe psychiatric disorders that could interfere with pain assessment or treatment compliance, inflammatory rheumatic diseases, coagulopathy, ongoing anticoagulant therapy that could not be safely discontinued in accordance with current clinical guidelines, active local or systemic infections, and known malignancies. Patients with incomplete medical records or those who failed to complete the clinical assessment questionnaires at the one-month or six-month follow-up visits were excluded from the final analysis. Finally, a total of 162 patients were recruited. The study flowchart is shown in Figure 1. A written informed consent was obtained from each patient. The study protocol was approved by the Prof. Dr. Cemil Taşcıoğlu City Hospital Ethics Committee (Date: 03.11.2025, No: 293555347). The study was conducted in accordance with the principles of the Declaration of Helsinki.

As this was a retrospective study, treatment allocation was not randomized and reflected routine clinical practice. The attending pain physician selected either TFESI or P-ILESI based on the anatomical location of the herniation, symptom distribution, radiological findings, and procedural feasibility. In our clinical practice, TFESI is usually preferred

in patients with predominantly foraminal or focal unilateral nerve root compression on lumbar MRI, where targeted ventral epidural injectate delivery is considered particularly important. In contrast, P-ILESI is preferred in patients with subarticular (lateral recess) pathology, relatively broader epidural involvement, or anatomical conditions considered less suitable for the transforaminal approach. This anatomy-informed selection reflected the differing spatial relationships between the herniated disc, affected nerve root, and epidural space: foraminal herniations are anatomically related to the exiting nerve root, whereas subarticular herniations typically affect the traversing nerve root within the lateral recess.^[9,13] The final procedural decision is based on the combined evaluation of clinical symptoms, neurological examination findings, and radiological characteristics by the treating pain physician. In this study, a single experienced pain medicine specialist performed all injections to reduce operator-dependent variability.

Adverse events occurring during the procedures or follow-up were retrieved from operative notes and clinical charts and, then, categorized according to standard interventional pain management guidelines. Due to the retrospective study design, only clinically documented adverse events recorded in the medical records were analyzed, whereas post-procedural hyperglycemia and transient blood pressure changes were not systematically evaluated. Major complications were defined as permanent neurological deficits, spinal cord or nerve root infarction, epidural

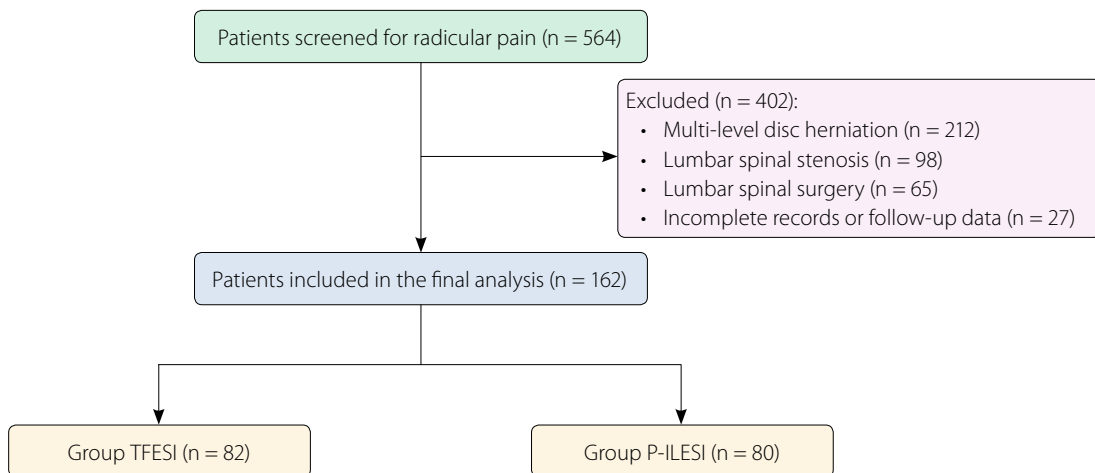


Figure 1. Study flowchart.

TFESI, transforaminal epidural steroid injection; P-ILESI, parasagittal interlaminar epidural steroid injections.

hematoma or abscess, meningitis, anaphylactic shock, or any condition necessitating hospital admission. Minor adverse events were defined as transient, self-limited events that did not require hospitalization or result in permanent neurological deficit. For the final analysis, the patients were stratified into the TFESI and P-ILESI cohorts based on the technique received as the TFESI group ($n = 82$) and the P-ILESI group ($n = 80$).

Procedures

All procedures were performed under strict aseptic conditions with patients in the prone position on a radiolucent table. Real-time imaging guidance was provided by a GE OEC Elite CFD C-arm fluoroscopy system (GE HealthCare, Salt Lake City, UT, USA). Upon identifying the target vertebral level, local anesthesia was infiltrated into the skin and subcutaneous tissues.

Parasagittal interlaminar technique

For the parasagittal interlaminar approach, an 18-gauge, 9-cm Tuohy needle was utilized. Following an initial AP view, the fluoroscope was tilted craniocaudally to maximize the visualization of the target interlaminar window. The optimal lateral entry point was identified, and the needle was advanced in a posterior-to-anterior direction, maintaining a parasagittal trajectory lateral to the

midline. The epidural space was identified using the classic loss-of-resistance technique. To optimize drug delivery toward the symptomatic pathology, the Tuohy needle bevel was oriented laterally (Figure 2).

Transforaminal technique

In the transforaminal group, a 22-gauge, 9-cm Quincke-tip needle was employed. After obtaining an AP view and squaring off the vertebral endplates with a slight craniocaudal tilt, the C-arm was rotated obliquely (approximately 15 to 30 degrees) to visualize the classic "Scotty dog" anatomy. The needle was navigated toward the posterosuperior aspect of the intervertebral foramen, targeting the superior-anterior portion of the neural foramen (supraneural/subpedicular approach). Final needle placement was verified: the tip had to reside within the neural foramen on the lateral projection while aligning with the pedicle margin on the AP view (Figure 2).

In both techniques, 1 mL of nonionic contrast medium (iohexol 300 mg I/mL, Omnipaque®, GE HealthCare, Cork, Ireland) was injected under live fluoroscopy before administering any medication. This mandatory step confirmed appropriate epidural spread and excluded inadvertent intravascular or intrathecal uptake. Upon confirmation of the desired contrast distribution, the therapeutic solution was administered. The TFESI group received a total

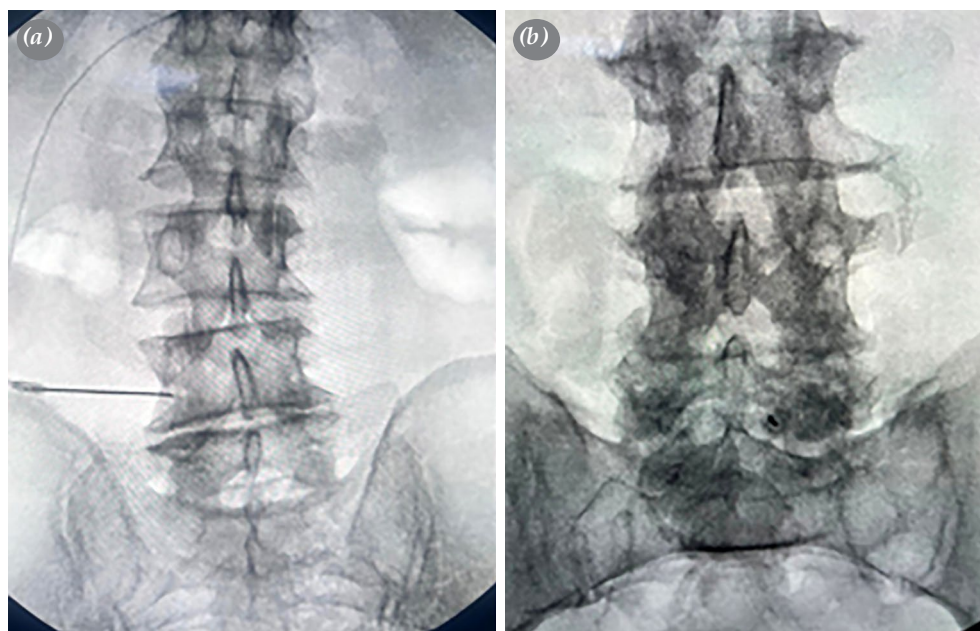


Figure 2. Fluoroscopic image of (a) TFESI and (b) P-ILESI procedure demonstrating needle positioning.

TFESI, transforaminal epidural steroid injection; P-ILESI, parasagittal interlaminar epidural steroid injections.

injectate volume of 4 mL, consisting of 8 mg (2 mL) dexamethasone combined with 2 mL of 1% lidocaine (prepared by diluting 1 mL of 2% lidocaine with 1 mL of normal saline). The P-ILESI group received a total injectate volume of 6 mL, consisting of the same dexamethasone dose combined with 4 mL of 1% lidocaine (prepared by diluting 2 mL of 2% lidocaine with 2 mL of normal saline). The injectate volumes were selected according to the anatomical and technical characteristics of each epidural approach in routine clinical practice. Lower volumes were preferred in TFESI, as the injectate was delivered directly to the targeted nerve root and ventral epidural space, whereas relatively larger volumes were used in P-ILESI to facilitate broader epidural spread and adequate ventral distribution.

Outcome measures

Baseline clinical scores and demographic profiles were documented for all participants prior to the interventions. To evaluate therapeutic efficacy, follow-up assessments were conducted during scheduled outpatient clinic visits at one and six months post-injection. Pain intensity was defined as the primary outcome and was quantified using the 11-point Numeric Rating Scale (NRS).

Secondary outcomes included functional disability related to LBP assessed using the Oswestry Disability Index (ODI), sleep quality evaluated with the Pittsburgh Sleep Quality Index (PSQI), and health-related quality of life assessed using the Short Form-12 (SF-12) health survey, including the Physical Component Summary (PCS) and Mental Component Summary (MCS) scores.

To directly compare the procedural safety and feasibility of the two techniques, objective operative metrics were recorded. Total active fluoroscopy time (in sec) and the cumulative radiation dose (in mGy) were retrieved directly from the C-arm system logs. Symptom duration, defined as the time from symptom onset to intervention, was included as a clinical variable.

Statistical analysis

Statistical analysis was performed using the SPSS for Windows version 29.0 software (IBM Corp., Armonk, NY, USA). Normality of distribution of variables was checked using the Shapiro-Wilk test. Continuous data were presented in median and interquartile range (IQR) (25th-75th percentiles), while categorical data were presented in number and frequency. The Mann-Whitney U test was

used to compare continuous variables between the groups. Categorical variables were compared using the Pearson chi-square test or Fisher exact test, as appropriate. For within-group comparisons, changes between baseline and each follow-up assessment were analyzed using the Wilcoxon signed-rank test. Associations between clinical and procedural variables were assessed using the Spearman rank correlation coefficient. A two-sided p value of < 0.05 was considered statistically significant.

RESULTS

Of a total of 162 patients included in the study, 120 were male and 42 were female with a median age of 47 (range 22 to 65) years. Right-sided radiculopathy was present in 105 patients and left-sided radiculopathy in 57 patients. Baseline demographic and clinical characteristics were comparable between the two groups (Table 1).

The distribution of disc morphology was comparable between the groups. Disc protrusion was the predominant morphology in both groups, being observed in 73 patients (89.0%) in the TFESI group and 74 patients (92.5%) in the P-ILESI group. Disc extrusion was present in nine patients (11.0%) and six patients (7.5%), respectively, and no sequestered disc herniations were recorded. The distribution of disc morphology did not differ significantly between the groups ($p = 0.623$).

No major complications were observed in either group. Documented minor adverse events were infrequent and occurred in five patients (6.1%) in the TFESI group and six patients (7.5%) in the P-ILESI group, with no significant between-group difference ($p = 0.764$).

The median fluoroscopy time was significantly longer in the P-ILESI group than in the TFESI group (32.0 [29.0 to 33.0] vs. 28.0 [26.0 to 29.8] sec, $p < 0.001$). Similarly, the median cumulative radiation dose was higher in the P-ILESI group (4.1 [4.0 to 4.5] vs. 3.9 [3.7 to 4.0] mGy, $p < 0.001$).

Both treatment groups demonstrated significant improvements in pain and functional outcomes during follow-up (Table 2). NRS scores decreased significantly from baseline at both the one-month and six-month assessments in the TFESI and P-ILESI groups ($p < 0.001$ for all).

At one month, the median NRS score was 3.0 (IQR, 2.0 to 3.0) in the TFESI group and 3.0 (IQR, 3.0 to 4.0) in the P-ILESI group, with a significant between-group difference ($p < 0.001$).

Table 1. Baseline demographic and clinical characteristics of patients

Variables	TFESI (n = 82)				P-ILESI (n = 80)				p
	n	%	Median	IQR	n	%	Median	IQR	
Age (year)			46.5	39.3-54.0			48.0	39.5-56.0	0.321
BMI (kg/m ²)			28.0	26.0-32.5			29.0	26.0-32.0	0.336
Symptom duration (months)			5.0	4.0-6.0			6.0	4.0-8.0	0.084
Sex									0.528
Female	19	23.2			23	28.8			
Male	63	76.8			57	71.3			
Symptomatic side									0.908
Right	54	65.9			51	63.8			
Left	28	34.1			29	36.3			
Disc morphology									0.623
Protrusion	73	89.0			74	92.5			
Extrusion	9	11.0			6	7.5			
Sequestration	0	0			0	0			
Fluoroscopy time (sec)			28.0	26.0-29.8			32.0	29.0-33.0	< 0.001
Radiation dose (mGy)			3.9	3.7-4.0			4.1	4.0-4.5	< 0.001
Documented minor adverse events	5	6.1			6	7.5			0.764
Vasovagal reaction	5	6.1			1	1.3			
Dyspnea	0	0			2	2.5			
Transient hypertension	0	0			1	1.3			
Tachycardia	0	0			1	1.3			
Restlessness	0	0			1	1.3			

TFESI, transforaminal epidural steroid injection; P-ILESI, parasagittal interlaminar epidural steroid injections; IQR, interquartile range; BMI, body mass index.

Table 2. Numeric rating scale and ODI scores at baseline and follow-up and between-group comparisons

Outcome	Time point/comparison	TFESI		P-ILESI		p
		Median	IQR	Median	IQR	
NRS	Baseline	8.0	8.0-9.0	8.0	8.0-9.0	0.819
	1 month	3.0	2.0-3.0	3.0	3.0-4.0	< 0.001
	6 months	3.0	2.0-4.0	3.0	3.0-4.0	0.438
	Change: baseline to 1 month	5.0	5.0-6.0	5.0	4.0-6.0	0.008
	Change: baseline to 6 months	5.0	4.0-6.0	5.0	4.0-6.0	0.545
ODI	Baseline	30.0	27.0-32.0	29.5	26.0-32.0	0.795
	1 month	15.0	14.0-17.0	17.0	16.0-18.0	0.001
	6 months	17.0	14.3-18.0	17.0	16.0-18.0	0.614
	Change: baseline to 1 month	14.5	11.0-18.0	12.5	10.0-16.0	0.072
	Change: baseline to 6 months	14.0	10.3-16.0	13.0	10.0-16.0	0.621

ODI, oswestry disability index; TFESI, transforaminal epidural steroid injection; P-ILESI, parasagittal interlaminar epidural steroid injections; IQR, interquartile range; BMI, body mass index; NRS, numeric rating scale.

The reduction in NRS score from baseline was also greater in the TFESI group at this time point ($p = 0.008$). At six months, the median NRS scores were 3.0 (IQR, 2.0 to 4.0) and 3.0 (IQR, 3.0 to 4.0),

respectively, with no significant between-group difference ($p = 0.438$). Similarly, the reduction in NRS from baseline at six months did not differ significantly between the groups ($p = 0.545$).

Table 3. Sleep quality and health-related quality of life outcomes

Outcomes	Time point	TFESI		P-ILESI		<i>p</i>
		Median	IQR	Median	IQR	
PSQI	Baseline	6.0	5.0-8.0	7.0	5.8-8.0	0.761
	1 month	4.0	3.0-5.0	4.0	3.0-5.0	0.869
	6 months	4.0	3.0-5.0	4.5	3.0-5.0	0.881
SF-12 MCS	Baseline	35.0	33.0-36.0	34.5	32.0-39.3	0.936
	1 month	40.0	37.3-44.0	42.0	39.0-44.0	0.211
	6 months	40.0	36.0-44.0	40.0	36.0-44.0	0.966
SF-12 PCS	Baseline	33.5	32.0-35.0	34.0	32.0-35.3	0.893
	1 month	42.0	39.0-44.0	41.5	39.0-44.0	0.974
	6 months	41.0	35.3-44.0	43.0	38.0-44.0	0.101

TFESI, transforaminal epidural steroid injection; P-ILESI, parasagittal interlaminar epidural steroid injections; IQR, interquartile range; PSQI, Pittsburgh Sleep Quality Index; SF-12: 12-Item Short Form Health Survey; MCS, mental component summary; PCS, physical component summary.

The ODI scores also decreased significantly from baseline to both follow-up assessments in both groups ($p < 0.001$ for all). At one month, the median ODI score was 15.0 (IQR, 14.0 to 17.0) in the TFESI group and 17.0 (IQR, 16.0 to 18.0) in the P-ILESI group ($p=0.001$). However, the magnitude of improvement from baseline did not differ significantly between the groups at this time point ($p = 0.072$). At six months, the median ODI scores were 17.0 (IQR, 14.3 to 18.0) and 17.0 (IQR, 16.0 to 18.0), respectively ($p = 0.614$), and the between-group difference in change from baseline remained non-significant ($p = 0.621$).

The PSQI scores improved significantly from baseline to both follow-up assessments in both groups ($p < 0.001$ for all). No significant between-group differences were observed at baseline, one month, or six months ($p = 0.761$, $p = 0.869$, and $p = 0.881$, respectively).

Both groups showed significant improvements from baseline in PSQI and SF-12 PCS and MCS scores at the one-month and six-month follow-ups ($p < 0.001$ for all) (Table 3). No significant between-group differences were observed in PSQI, PCS, or MCS scores at any assessment point ($p > 0.05$ for all).

DISCUSSION

In the present study, we directly compared procedural and clinical outcomes between TFESI and P-ILESI in a well-defined patient population. Both modalities were associated with significant clinical improvement in pain and functional outcomes. Our findings showed that the two techniques mainly

differed in their early analgesic effect. The TFESI demonstrated statistically superior analgesia at one month; however, this early benefit diminished by the six-month follow-up, leaving both groups with comparable clinical success. However, the P-ILESI required longer fluoroscopy time and resulted in higher radiation exposure. Taken together, these findings suggest that, in this cohort, TFESI may provide earlier analgesic benefit, although this between-group difference was not observed at six months, while P-ILESI was associated with longer fluoroscopy time and higher radiation exposure.

In the present study, patients who underwent TFESI showed greater reduction in NRS scores at one month, although this difference was not sustained at six months. This finding is consistent with previous reports suggesting an earlier analgesic effect with the transforaminal approach.^[14,15] The earlier analgesic effect in the TFESI group may relate to targeted delivery of medication to the nerve root. This targeted distribution may contribute to earlier suppression of local inflammatory activity. In contrast, interlaminar injections rely on a broader epidural spread. Although the difference was significant at one month, it was no longer observed at six months.

Several studies have shown that interlaminar approaches are not clinically inferior to TFESI over extended follow-up periods.^[16,17] Similarly, Khojasteh et al.^[18] demonstrated comparable clinical outcomes and epidural contrast distribution patterns between parasagittal interlaminar and TFESIs in patients with lumbar radicular pain. Our six-month results are consistent with these findings.

Procedurally, while the corticosteroid dose was standardized across the study, the volume of local anesthetic differed between the techniques to reflect real-world clinical practice. Interlaminar injections inherently require larger volumes to achieve adequate epidural spread, whereas transforaminal injections rely on lower volumes to target a more focal ventral epidural region. This volume difference may influence immediate injectate dispersion patterns and short-term clinical responses; however, the identical dexamethasone dose provided a comparable core anti-inflammatory effect between the groups. Although the injectate volume differed between the two techniques, clinical outcomes should not be interpreted solely according to injectate volume or the extent of anterior epidural spread. The therapeutic response to epidural steroid injections is influenced by multiple factors, including needle position, epidural anatomy, injectate distribution, and the pharmacological effects of corticosteroids. Therefore, the absence of superior clinical outcomes with P-ILESI at one-month follow-up is unlikely to be explained solely by insufficient anterior epidural spread, as multiple anatomical and procedural factors may also contribute to treatment response. The exclusive use of a non-particulate steroid also mitigated the risk of embolic vascular events, which is particularly important in the transforaminal approach.

Although ODI scores were lower in the TFESI group at one month, the magnitude of improvement from baseline did not differ significantly between the groups. This finding suggests that the greater early reduction in radicular pain was not accompanied by a corresponding difference in the magnitude of functional improvement between the two approaches. Overall, the degree of functional improvement appeared to be similar between the two injection approaches.

An additional difference between the techniques was observed in procedural metrics. The parasagittal interlaminar approach is generally considered technically straightforward and is often assumed to require shorter fluoroscopy time.^[19] However, active fluoroscopy time and cumulative radiation dose were higher in the P-ILESI group in our study.

In our practice, entry into the posterior epidural space was not considered sufficient for P-ILESI; additional fluoroscopic adjustments were performed to position the needle tip laterally to facilitate ventral spread. Navigating this narrow corridor between the dural sac and the lateral recess often required

repeated oblique views and careful depth control. By comparison, the “Scotty dog” landmarks used during TFESI are relatively standardized for experienced operators.

In the current study, the higher radiation exposure observed in the P-ILESI group likely reflects the additional positioning steps required rather than technical difficulty. Although the absolute difference in fluoroscopy time was small, this difference may become relevant in high-volume clinical practice. Reduced radiation exposure may provide an additional practical advantage of the TFESI technique, particularly for interventional pain physicians and patients undergoing repeated fluoroscopy-guided procedures, given the cumulative nature of radiation exposure over time. Therefore, efforts to reduce radiation exposure should be maintained in accordance with “As Low As Reasonably Achievable” (ALARA) principles.^[20] This finding may partly reflect the procedural technique and operator experience in our cohort, as fluoroscopic exposure has varied across comparative studies. Ultrasound-guided epidural injections may represent a potential alternative for reducing fluoroscopy-related radiation exposure. Ultrasound guidance provides real-time soft tissue visualization without ionizing radiation and has been increasingly investigated in interventional pain practice. However, lumbar transforaminal and parasagittal epidural procedures still remain technically challenging under ultrasound guidance due to limited visualization of deep spinal structures and foraminal anatomy, particularly in patients with obesity or in the presence of advanced degenerative changes. Therefore, fluoroscopy currently remains the most widely accepted and standardized imaging modality for these procedures in routine clinical practice.

No major complications were observed in this cohort; however, the complication profiles of the two techniques should be considered. Review of the literature reveals vascular risks associated with TFESI due to its proximity to radicular arteries, including the artery of Adamkiewicz.^[21] Although meta-analyses have reported no significant difference in overall complication rates between transforaminal and interlaminar approaches,^[22] the types of complications may differ. Transforaminal injections carry a rare, but serious risk of spinal cord infarction related to inadvertent intra-arterial injection. Complications associated with P-ILESI, such as dural puncture or subdural spread, are usually self-limited

and manageable with conservative treatment. Given the comparable clinical outcomes observed in this study, P-ILESI may be considered an alternative approach in selected patients, particularly when vascular risk is a concern.

Of note, there is a limited number of studies directly comparing transforaminal and parasagittal interlaminar epidural techniques in patients with unilateral single-level LDH. We believe that the present study provides additional contribution to the existing literature by evaluating both clinical outcomes and procedural parameters, including fluoroscopy time and radiation exposure. In addition to pain and functional scores, sleep quality and quality of life measures were also assessed to provide a broader view of treatment response in routine clinical practice.

Nonetheless, there are certain limitations to this study that should be acknowledged. First, the study has a single-center, retrospective design. Second, an a priori sample size calculation or power analysis was not performed, which may limit the interpretation of the statistical power of the study. Third, without randomization, the choice of epidural technique relied on clinical judgment and anatomical considerations, which may have introduced selection bias. Additionally, differences in total injectate volumes inherent to the anatomical and technical characteristics of these procedures in routine clinical practice may have influenced injectate dispersion patterns and short-term clinical responses. Although baseline demographic and clinical characteristics were well matched between the cohorts, unmeasured confounding variables cannot be entirely excluded. In addition, patient comorbidities were not systematically collected as predefined study variables due to the retrospective study design and, therefore, could not be included in the analysis. Moreover, all procedures were performed by a single experienced pain medicine specialist, which may limit the generalizability of the findings to broader clinical settings. Also, detailed analyses according to the exact anatomical localization of disc herniation could not be performed, as this information was not systematically recorded as a study variable in the retrospective database. Therefore, the potential influence of specific anatomical locations on the choice and clinical response to TFESI or P-ILESI could not be assessed. Further prospective, randomized-controlled trials with predefined power analyses are warranted to confirm these findings.

In conclusion, both TFESI and P-ILESI were effective in the treatment of radicular pain associated with LDH and TFESI provided greater early pain reduction, although this difference was not sustained at six months. Regarding procedural metrics, P-ILESI was associated with longer fluoroscopy time and higher radiation exposure in our cohort, although these parameters may vary depending on anatomical factors and procedural technique. In addition, both procedures showed favorable safety profiles, with no major complications. In the light of these findings, in clinical practice, the choice of epidural approach should be individualized, taking into account symptom severity, anatomical considerations, and operator experience. Further studies are needed to further elucidate the clinical and procedural effectiveness and safety of these approaches.

Author Contributions

S.T.G., H.I.A.: Conceptualization, methodology, writing-review & editing; S.T.G.: Investigation, data curation, writing-original draft; H.I.A.: Formal analysis, validation, visualization.

Conflict of Interest

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support for the research and/or authorship of this article.

Data Sharing Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

AI Disclosure

The authors declare that artificial intelligence (AI) tools were not used, or were used solely for language editing, and had no role in data analysis, interpretation, or the formulation of conclusions. All scientific content, data interpretation, and conclusions are the sole responsibility of the authors. The authors further confirm that AI tools were not used to generate, fabricate, or 'hallucinate' references, and that all references have been carefully verified for accuracy.

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