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Original Article / Özgün Makale

Impact of sedation on patient satisfaction, radiation exposure, and complications in lumbar transforaminal epidural steroid injections: A retrospective cohort study

Lumbar transforaminal epidural steroid enjeksiyonlarında hasta memnuniyeti, radyasyon maruziyeti ve komplikasyonlar üzerine sedasyonun etkisi: Retrospektif kohort çalışması

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ABSTRACT

Background: This study aims to investigate whether moderate sedation (MOAA/S 3-4) affects procedural efficiency, radiation exposure, patient–physician satisfaction, and clinical outcomes during lumbar transforaminal epidural steroid injections (L-TFESI).

Patients and Methods: Between January 2021 and January 2024, a total of 201 patients with unilateral, single-root compression who underwent L-TFESI either with (Group S, n = 99) or without sedation (Group NS, n = 102) were retrospectively analyzed. In the sedation group, midazolam and fentanyl were titrated to a target Modified Observer's Assessment of Alertness/Sedation (MOAA/S) score of 3-4. The primary outcomes were cumulative radiation dose (mGy), fluoroscopy time, and procedural complications. Additional outcomes included Numeric Rating Scale-11 (NRS-11) scores (baseline, Day 4, Week 4) and Likert satisfaction scales.

Results: Of a total of 201 patients, 143 were male and 58 were female with a mean age of 47.22 ± 10.03 (range, 22 to 65) years. Both groups were comparable in terms of baseline demographics and pain scores. The sedation group had significantly lower cumulative radiation exposure (3.92 ± 0.30 mGy *vs.* 4.31 ± 0.40 mGy) and shorter fluoroscopy times (28.13 ± 2.79 sec *vs.* 33.13 ± 3.95 sec). Minor procedural complications (commonly vasovagal reactions and hypertension) were more frequent in the non-sedated group (21.6% vs. 2.0%). Group S reported lower pain scores on Day 4 (1.11 ± 1.29 *vs.* 1.88 ± 1.25), although outcomes were similar at Week 4. Patient and physician satisfaction were higher in the sedation group.

Conclusion: Moderate sedation (MOAA/S 3-4) during L-TFESI is associated with lower radiation exposure, shorter procedure times and fewer minor complications, while improving both patient satisfaction and procedural conditions. These findings suggest that sedation is a potentially useful adjunct in selected patients that may contribute to improved procedural quality in interventional pain management.

Keywords: Conscious sedation, epidural injections, intervertebral disc herniation, radiation exposure, low back pain.

ÖZ

Amaç: Bu çalışmada, lomber transforaminal epidural steroid enjeksiyonları (L-TFESI) sırasında orta düzey sedasyonun (MOAA/S 3–4) işlem etkinliği, radyasyon maruziyeti, hasta-hekim memnuniyeti ve klinik sonuçlar üzerindeki etkisi araştırıldı.

Hastalar ve Yöntemler: Ocak 2021 ile Ocak 2024 tarihleri arasında, tek taraflı tek kök basısı olan ve sedasyon ile (Grup S, n = 99) ve sedasyon olmadan (Grup NS, n = 102) olmak üzere L-TFESI uygulanan toplam 201 hasta retrospektif olarak incelendi. Sedasyon grubunda midazolam ve fentanil, Modifiye Gözlemci Uyanıklık/Sedasyon Skalası (MOAA/S) hedefi 3-4 olacak şekilde titre edildi. Primer sonuçlar kümülatif radyasyon dozu (mGy), floroskopi süresi ve prosedür komplikasyonları idi. Ek sonuçlar arasında Numerik Derecelendirme Ölçeği-11 (NRS-11) skorları (başlangıç, 4. gün, 4. hafta) ve Likert memnuniyet ölçekleri yer aldı.

Bulgular: Toplam 201 hastanın 143 erkek ve 58 kadın olup, ortalama yaş 47.22 ± 10.03 (dağılım, 22-65) yıl idi. Her iki grup demografik özellikler ve ağrı skorları açısından benzerdi. Sedasyon grubunda kümülatif radyasyon maruziyeti anlamlı olarak daha düşük (3.92 ± 0.30 mGy'ye kıyasla 4.31 ± 0.40 mGy) ve floroskopi süresi daha kısa (28.13 ± 2.79 sn.'ye kıyasla 33.13 ± 3.95 sn.) idi. Minör prosedürel komplikasyonlar (özellikle vazovagal reaksiyonlar ve hipertansiyon) sedasyon almayan grupta daha sık görüldü (%21.6'ya kıyasla %2.0). Grup S'de 4. günde ağrı skorları daha düşükken (1.11 ± 1.29'a kıyasla 1.88 ± 1.25), 4. haftada sonuçlar benzerdi. Hasta ve hekim memnuniyeti sedasyon grubunda daha yüksekti.

Sonuç: Lomber transforaminal epidural steroid enjeksiyonları sırasında orta düzey sedasyon (MOAA/S 3-4), daha düşük radyasyon maruziyeti, daha kısa işlem süresi ve daha az minör komplikasyon ile ilişkili olup, aynı zamanda hasta memnuniyetini ve prosedürel koşulları iyileştirmektedir. Bu bulgular, sedasyonun girişimsel ağrı yönetiminde seçilmiş hastalarda prosedürel kaliteyi artırabilecek potansiyel bir yardımcı yöntem olduğunu düşündürmektedir.

Anahtar sözcükler: Bilinçli sedasyon, epidural enjeksiyonlar, intervertebral disk hernisi, radyasyon maruziyeti, bel ağrısı.

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Lumbosacral radicular pain due to disc herniation is a major cause of productivity loss and chronic disability.[1] The lifetime prevalence is high, affecting up to 43% of the population during their lifetime.[2] When conservative treatments, including medication and physical therapy, are ineffective, lumbar transforaminal epidural steroid injections (L-TFESIs) are commonly employed as an interventional treatment. These procedures are performed under fluoroscopic guidance to ensure the medication reaches the targeted nerve root accurately.[3,4] Clinical practice regarding sedation during TFESI varies widely. There is no clear consensus, and the decision often depends on the physician's preference or the patient's anxiety level.[5] Sedation can certainly improve patient comfort. While sedation improves patient comfort, it carries inherent risks, particularly when procedures are performed in prone position. From an anesthesiology perspective, maintaining airway safety while still preserving real-time patient response can be challenging, particularly in the prone position. Of particular concern is the potential loss of meaningful patient-reported symptoms. Deep sedation may obscure patient reporting of paresthesia or radicular pain during needle advancement, thereby eliminating a critical warning sign for potential neural injury.[6-8] However, beyond comfort and safety considerations, sedation may also influence procedural efficiency.

Guidelines from the American Society of Interventional Pain Physicians (ASIPP) emphasize best practices for sedation, with relatively little emphasis on procedural efficiency or radiation-related outcomes.[9] In our routine clinical practice, we observed that patient cooperation during TFESI often determines how smoothly the procedure progresses, particularly during needle advancement and contrast confirmation.

Although numerous studies have evaluated the analgesic effectiveness of L-TFESIs, relatively little attention has been paid to procedural outcomes such as fluoroscopy time and radiation exposure, particularly when the procedure is performed under moderate sedation. As patient movement can prolong procedures and increase radiation exposure, in the present study, we hypothesized that moderate sedation (MOAA/S 3-4) could improve procedural efficiency by facilitating better patient immobilization. We, therefore, aimed to investigate whether the use of moderate sedation during L-TFESI was associated with reduced fluoroscopy time and cumulative radiation exposure in routine clinical practice without an apparent increase in procedural complications.

PATIENTS AND METHODS

This single-center, retrospective cohort study was conducted at Kanuni Sultan Süleyman Training and Research Hospital, Department of Pain Medicine between January 2021 and January 2024. We initially screened 991 patients presenting with low back pain (LBP). Following a review of clinical records, 790 patients were excluded primarily due to multi-level involvement, spinal stenosis, or incomplete documentation. A total of 201 patients aged between 18 and 65 years with the American Society of Anesthesiologists (ASA) Class I-III who underwent unilateral L-TFESI for single-nerve-root involvement were reviewed. Magnetic resonance imaging (MRI) scans were reviewed by a musculoskeletal radiologist with over 10 years of dedicated experience in spine imaging. Nerve root compression was graded as low (1-2) or high (3-4) based on the Pfirrmann and Ghahreman classification systems.[10,11] Exclusion criteria were as follows: prior lumbar surgery, multi-level herniation, ASA Class ≥ IV, malignancy, active infection at the injection site, bleeding disorders, psychosis, or known allergies to the study drugs. Clinical data routinely recorded at electronic health records including age, body mass index (BMI), pain duration, and procedural details (radiation dose, fluoroscopy time, and complications) were extracted from hospital records. Patients rated their pain intensity using the Numeric Rating Scale-11 (NRS-11), ranging from 0 (no pain) to 10 (worst pain). Patient and physician satisfaction were assessed using a five-point Likert scale (1: not satisfied, 5: very satisfied). These scores were routinely recorded at baseline, on postoperative Day 4, and again at the four-week follow-up. To ensure consistency, specific thresholds were used for procedural complications: hypertension was defined as a sustained systolic blood pressure increase of > 20% from baseline or exceeding 160/90 mmHg. Vasovagal reactions were identified by the acute onset of bradycardia and hypotension accompanied by autonomic symptoms such as pallor or diaphoresis. A written informed consent was obtained from each patient. The study protocol was approved by the Kanuni Sultan Süleyman Training and Research Hospital Ethics Committee (Date: 27.03.2024, No: 53). The study was conducted in accordance with the principles of the Declaration of Helsinki. The study protocol was developed in accordance with the Strengthening the

Reporting of Observational Studies in Epidemiology (STROBE) guidelines. The study was registered at ClinicalTrials.gov (NCT06539390).

Sedation protocol

Sedation was administered by an anesthesiologist with more than 10 years of clinical experience. The sedation group (Group S) received an initial intravenous bolus of 0.05 mg/kg midazolam and 1.5 μg/kg fentanyl. If the target sedation depth was not reached within 5 min, incremental boluses (0.01 mg/kg midazolam, 0.5 μg/kg fentanyl) were administered as needed. Sedation depth was monitored using the Modified Observer's Assessment of Alertness/Sedation Scale (MOAA/S), targeting a score of 3-4 (moderate sedation). A target MOAA/S score of 3-4 was selected to ensure procedural comfort while maintaining the patient's ability to provide verbal feedback in the event of nerve proximity or paresthesia, a safety requirement emphasized in current sedation guidelines.[9] The decision to use sedation was not randomized and was based on a combination of patient anxiety, clinical considerations, and shared decision-making between the physician and the patient. Information regarding the indications for sedation was retrospectively extracted from preoperative anesthesia evaluation forms and pain clinic progress notes. Although objective anxiety scales were not routinely used, the decision to administer sedation was typically documented on the basis of clinical signs of marked anxiety, a history of poor procedural cooperation, or direct patient preference.

Interventional procedure

A single pain specialist performed all procedures under standard monitoring (electrocardiogram [ECG], oxygen saturation [SpO_2], non-invasive blood pressure [NIBP], and end tidal carbon dioxide [CO_2]). Patients were placed in the prone position with

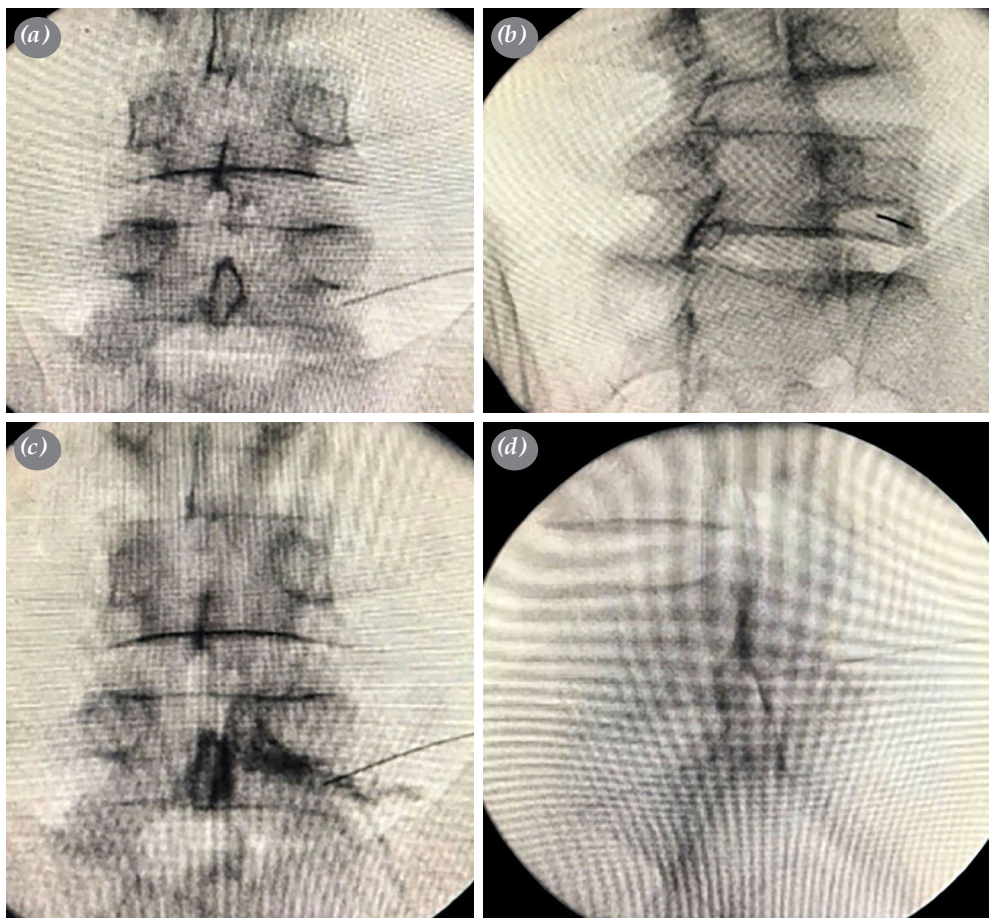

Figure 1. Fluoroscopic views of a lumbar transforaminal epidural steroid injection. **(a)** Anterior-posterior (AP) fluoroscopic image of the needle. **(b)** Oblique fluoroscopic view of the needle. **(c)** Post-contrast medium injection AP view. **(d)** Post-contrast medium injection lateral view

abdominal bolstering to flatten the lumbar lordosis. After sterile preparation and identifying the target level using C-arm fluoroscopy in the anteroposterior (AP) view, the foramen was visualized. A 22-gauge, 9-cm spinal needle was advanced using a subpedicular approach. Needle positioning was confirmed in both AP and lateral views. After observing the spread of 1 mL of contrast medium without vascular or intrathecal uptake, we injected a mixture of 40 mg triamcinolone acetonide, 2 mL 2% lidocaine, and 1 mL saline (Figure 1). All procedures were performed using the same Zenition 70 C-arm fluoroscopy system (Philips Healthcare, Best, The Netherlands) with standardized pulse-mode settings. Radiation exposure was minimized using pulse-mode fluoroscopy and in accordance with the ALARA (as low as reasonably achievable) principle. All patients were observed for at least 4 h following the procedure before discharge.

Statistical analysis

Statistical analysis was performed using the IBM SPSS Statistics for Windows version 27.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were expressed in mean and standard deviation (SD) for continuous variables and in number and frequency for categorical variables. The normality of data distribution for continuous variables was evaluated using the Kolmogorov-Smirnov test, Shapiro-Wilk test, and visual inspection of histograms. For the comparison of continuous variables between the sedation and non-sedation groups (such as age, BMI, radiation dose, fluoroscopy time, NRS-11, and Likert satisfaction scores), the Independent samples t-test was used for normally distributed data, whereas the Mann-Whitney U test was applied for non-normally distributed data. Categorical variables were compared using the Pearson chi-square test or Fisher exact test, depending on the expected cell frequencies. A two-sided p value of <0.05 was considered statistically significant.

RESULTS

Of a total of 201 patients, 143 were male and 58 were female with a mean age of 47.22 ± 10.03 (range, 22 to 65) years. Among the patients, 99 received moderate sedation (Group S), while 102 were treated without sedation (Group NS) (Figure 2). Baseline characteristics including age, BMI, and ASA scores were comparable between the two groups (p > 0.05; Table 1). Although there was a higher proportion of male patients in the sedation group (78.8% *vs.* 63.7%, p=0.018), other baseline variables such as pain duration, initial NRS-11 scores, and the grade of nerve root compression showed no statistical differences. The majority of procedures targeted the L4-L5 level (49.2%) and were performed on the right side (61.7%).

Procedural efficiency and clinical outcomes are detailed in Table 2. Sedation was associated with lower cumulative radiation doses and shorter procedure times. Specifically, Group S required a lower mean cumulative radiation dose compared to Group NS (3.92 ± 0.30 mGy *vs.* 4.31 ± 0.40 mGy, p<0.001).

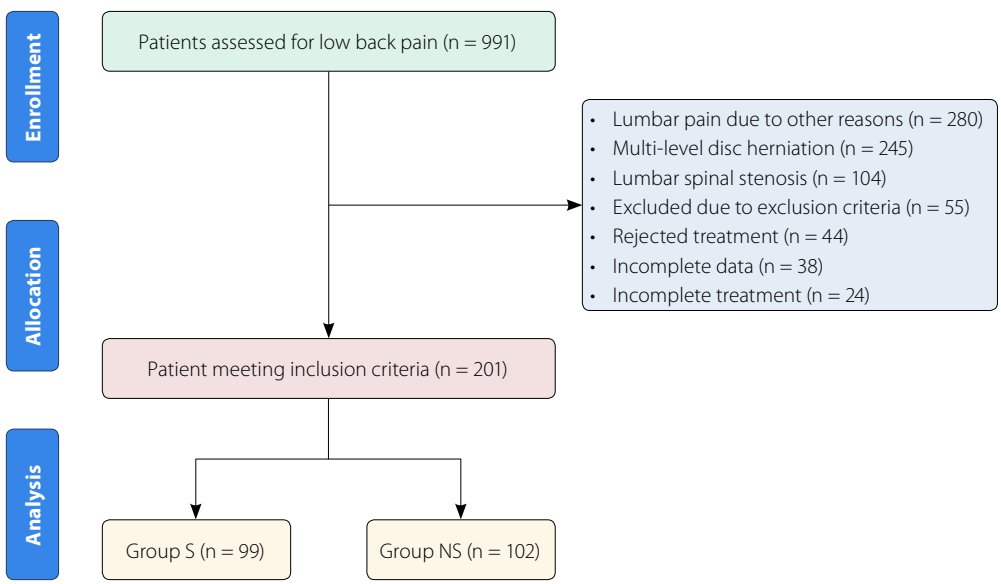

Figure 2. Study flowchart.
Group S, sedation group; Group NS, no-sedation group.

Table 1. Demographic characteristics and baseline clinical data of the patients

	Group S (n = 99)			Group NS (n = 102)			
Variables	n	%	Mean ± SD	n	%	Mean ± SD	*p*
Age (year)			46.95 ± 9.32			47.47 ± 10.70	0.722
Sex							**0.018***
Female	21	21.2		37	36.3		
Male	78	78.8		65	63.7		
Body mass index (kg/m^2)			28.51 ± 3.90			29.11 ± 3.53	0.319
ASA score							0.087
I	36	36.4		51	50.0		
II	60	60.6		46	45.1		
III	3	3.0		5	4.9		
Pain duration (year)			6.31 ± 4.59			7.36 ± 6.97	0.926
NRS-11 pre-procedure			8.27 ± 1.04			8.22 ± 0.84	0.652
Nerve root compression							0.827
Low grade (1-2)	47	47.5		50	49.0		
High grade (3-4)	52	52.5		52	51.0		
Side							0.396
Right	64	64.6		60	58.8		
Left	35	35.4		42	41.2		

Group S, sedation group; Group NS, no-sedation group; SD, standard deviation; ASA, American Society of Anesthesiologists; NRS-11, Numeric Rating Scale-11; * $p < 0.05$ indicates statistical significance.

Table 2. Comparison of procedural data, complications, and clinical outcomes between groups

	Group S (n = 99)			Group NS (n = 102)			
Variables	n	%	Mean ± SD	n	%	Mean ± SD	*p*
Cumulative radiation dose (mGy)			3.92 ± 0.30			4.31 ± 0.40	**< 0.001***
Fluoroscopy time (sec)			28.13 ± 2.79			33.13 ± 3.95	**< 0.001***
Procedural complications							**< 0.001***
Absent	97	98.0		80	78.4		
Present (minor)	2	2.0		22	21.6		
Likert scale (post-procedure)							
Patient satisfaction			4.75 ± 0.53			3.36 ± 0.85	**< 0.001***
Physician satisfaction			4.93 ± 0.23			4.04 ± 0.32	**< 0.001***
NRS-11 scores (follow-up)							
4th Day			1.11 ± 1.29			1.88 ± 1.25	**< 0.001***
4th Week			1.85 ± 1.27			1.84 ± 1.50	0.583

Group S, sedation group; Group NS, no-sedation group; SD, standard deviation; NRS-11, Numeric Rating Scale-11.

Fluoroscopy times were also shorter in the sedated group (28.13 ± 2.79 sec *vs.* 33.13 ± 3.95 sec, $p < 0.001$).

Minor complications were more frequent in Group NS (21.6% *vs.* 2.0%, $p < 0.001$). Among the 22 adverse events observed in Group NS, the included were hypertension (n = 7), vasovagal reactions (n = 6), and agitation (n = 5). In contrast, only two minor complications occurred in the sedation group. No cases of respiratory depression or cardiovascular instability requiring intervention were observed in patients under moderate sedation.

Both patients and physicians reported significantly higher Likert scores in the sedation group (4.75 ± 0.53 and 4.93 ± 0.23, respectively) compared to the non-sedated group (3.36 ± 0.85 and 4.04 ± 0.32) ($p < 0.001$).

Both groups demonstrated significant pain relief following the procedure. Baseline NRS-11 scores were nearly identical (~8.2), but by the postoperative Day 4, Group S reported lower pain levels than Group NS (1.11 ± 1.29 *vs.* 1.88 ± 1.25, $p < 0.001$). However, this early advantage equilibrated by Week 4, NRS-11 scores were similar between groups ($p = 0.583$).

DISCUSSION

In the present study, we investigated whether the use of moderate sedation during L-TFESI was associated with reduced fluoroscopy time and cumulative radiation exposure in routine clinical practice without an apparent increase in procedural complications. Our study results showed that the use of moderate sedation during L-TFESI was associated with shorter fluoroscopy times and lower radiation exposure. Additionally, both patient and physician satisfaction scores were higher in the sedation group. More importantly, a lower rate of minor complications was observed in the sedated group compared to the non-sedated group. However, given the retrospective design of our study, these findings suggest an association rather than a causal effect. Of note, a retrospective design was chosen to reflect real-world clinical practice and outcomes in this study.

The demographic profile of our cohort is broadly similar with the previously reported risk factors for lumbar disc herniation (LDH), including age and BMI.[12,13] The high prevalence of L4-L5 and L5-S1 herniations we observed is also consistent with the literature.[14] While TFESI is a cornerstone of non-surgical management for these patients, the technical success of the procedure depends on precise needle placement under fluoroscopic guidance.[15]

A major concern in interventional pain management is the potential for tissue damage from repeated radiation exposure.[16] We observed that radiation doses and fluoroscopy times were significantly lower in the sedation group. While the absolute reduction per procedure appears small, even minor decreases in fluoroscopy exposure may accumulate over time for physicians performing a high procedural volume. For interventionalists performing hundreds of cases annually, a consistent 10% reduction per procedure substantially lowers the cumulative lifetime radiation risk, adhering to the ALARA principle.[16] This finding can be explained by efficiency to the reduced patient movement under sedation. A calm patient allows the physician to advance the needle with fewer adjustments and less frequent imaging, facilitating faster needle positioning and contrast spread confirmation. These findings are supported by recent studies, such as Er et al.,[17] who reported similar dose ranges for transforaminal injections.

The use of sedation in epidural procedures remains a subject of ongoing debate. Sencan et al.[18] previously reported that sedation was safe for single-level TFESI and increased satisfaction scores. Our study adds to existing evidence by suggesting in a larger cohort of 201 patients that an association was observed between sedation and a lower incidence of minor complications. The significantly higher rate of minor complications in our non-sedated group (21.6%), with vasovagal reactions and hypertension being the most frequently observed, may reflect the physiological stress of the intervention in a fully awake patient. The sedated group also reported less nausea. While opioids can typically induce nausea, the lower incidence observed in our sedation group suggests that attenuation of pain- and anxiety-related vasovagal responses may be associated with improved patient stability.

Some authors, such as Diehn et al.,[19] argue that routine sedation is unnecessary for preventing vasovagal episodes or ensuring patient satisfaction. However, our results appear to support sedation for both metrics. An important consideration may be the depth of sedation. Many reported risks, such as hypoxic brain injury or masked nerve damage, are associated with deep sedation where patient feedback is lost.[20,21] Targeting a MOAA/S score of 3-4 allowed for continuous verbal communication, ensuring that patients could report sudden paresthesia while maintaining sufficient immobility for safe needle placement.

Regarding pain relief, both groups showed significant improvement. However, the sedation group reported lower NRS-11 scores on postoperative Day 4. One possible explanation for the lower early pain scores may be improved procedural comfort in the sedation group. However, this observation should be interpreted cautiously, as our study was not designed to evaluate mechanisms related to pain modulation. By the four-week follow-up, this disparity resolved, likely as the long-term anti-inflammatory effects of the corticosteroid took precedence in both groups. A significant consideration in our study is the potential for confounding by indication, as the decision to administer sedation was non-randomized. Patients with higher baseline anxiety or lower pain tolerance may have been more likely to receive sedation.

Since sedation was not randomized, baseline psychological factors such as anxiety may have influenced procedural conditions. Sedation may have reduced the impact of these factors and facilitated patient cooperation. However, this interpretation remains hypothetical and should be confirmed by prospective studies. Future randomized trials are warranted to decouple these psychological variables from procedural outcomes.

Nonetheless, this study has several limitations, most notably its retrospective design and the lack of randomization. Decisions regarding sedation were guided by clinical judgment and patient preference, a process that may have introduced selection bias. Although baseline pain scores and most clinical characteristics were comparable between groups, the unequal gender distribution should be taken into account when interpreting the findings. In addition, the absence of a standardized sedation protocol across patients limits the generalizability of our conclusions. Although all procedures in our study were performed using a single standardized fluoroscopy device, absolute radiation exposure values may differ when extrapolated to other centers using different equipment. Physician satisfaction scores should also be interpreted with caution, as they reflect the subjective assessment of a single, non-blinded operator and were therefore considered secondary outcomes. Finally, the study is subject to potential confounding by indication, as patients selected for sedation were more likely to have higher baseline anxiety. While this limitation is inherent to retrospective analyses, it may also suggest that moderate sedation helped optimize procedural conditions even in a clinically more challenging patient population.

In conclusion, L-TFESI is a commonly used interventional option for LBP associated with LDH, regardless of the use of sedation. In the present study, the use of moderate sedation during L-TFESI was associated with higher patient and physician satisfaction, lower radiation exposure, and fewer minor procedural complications. These results indicate that sedation may be beneficial in selected patients rather than for routine use, particularly in individuals with high procedural anxiety. When appropriate monitoring and anesthesiology support are available, moderate sedation appears to be a feasible adjunct to optimize procedural conditions. Further prospective, randomized studies are needed to help further clarify standardized sedation strategies in interventional pain practice.

Author Contributions

H.İ.A., G.A.: Idea/concept, control/supervision, analysis and/or interpretation, writing the article; H.İ.A., S.T.G., F.A.E., G.A., A.S.Ş.: Design, literature review, critical review; H.İ.A., S.T.G., F.A.E., A.S.Ş.: Data collection and/or processing.

Conflict of Interest

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

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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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