https://doi.org/10.29309/TPMJ/2026.33.08.10522 www.theprofesional.com

ORIGINAL ARTICLE

Comparison of efficacy, accuracy, and safety between axial and sagittal approaches of ultrasound guided transforaminal epidural injection for lumbar radiculopathy: A randomized controlled trial.

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ABSTRACT… Objective: To compare the clinical efficacy, parameters of intervention, and safety of axial versus sagittal ultrasound-guided TFESIs in patients with Lumbar radiculopathy. **Study Design:** Prospective Randomized Controlled Trial. **Setting:** Department of Anaesthesia and Pain Medicine, Ghurki Trust Teaching Hospital, Lahore. **Period:** August 2025 and January 2026. **Methods:** Including 88 patients (44 in each group) diagnosed with Lumbar radiculopathy were enrolled in this trial and were randomly assigned by a lottery system to undergo either axial or sagittal US-guided TFESIs. The primary outcomes were measured at baseline, 2 weeks, 1 month, and 3 months. Secondary outcomes included procedure time and fluoroscopically confirmed accuracy and adverse effects. **Results:** Both groups demonstrated significant improvements in VAS and ODI ($p < 0.001$). The sagittal approach also had significantly reduced VAS at 2 weeks (3.8 ± 0.9 vs. 4.2 ± 1.1; $p = 0.042$) and 1 month (2.8 ± 0.8 vs. 3.1 ± 0.9; $p = 0.038$). The ODI was also significantly reduced for the sagittal approach compared with the axial approach at 2 weeks ($p < 0.001$) and 1 month ($p < 0.001$). The sagittal approach was also faster than the axial approach (10.2 ± 1.8 min vs. 15.4 ± 2.5 min; $p < 0.001$). The accuracy was comparable between the two approaches: sagittal, 95.5%, axial, 90.9%. **Conclusion:** The two US-guided approaches are safe and effective. The sagittal approach is superior in terms of procedural efficiency and short-term clinical outcomes for the lumbar TFESI.

Key words: Axial Approach, Lumbar Radiculopathy, Sagittal Approach, TFESI, Ultrasound-guided.

Article Citation: Shahid A, Farooq U, Aziz L, Dar SR, Umer A, Younis W. Comparison of efficacy, accuracy, and safety between axial and sagittal approaches of ultrasound guided transforaminal epidural injection for lumbar radiculopathy: A randomized controlled trial. Professional Med J 2026; 33(08):1417-1421. https://doi.org/10.29309/TPMJ/2026.33.08.10522

INTRODUCTION

Lumbar radiculopathy is a common condition characterized by nerve root irritation or compression, often resulting in radiating lower limb pain, paraesthesia, and muscle weakness.[1] The condition is most frequently caused by herniated intervertebral discs or degenerative spinal changes, imposing a substantial burden on quality of life and healthcare systems.[2] For patients whose symptoms persist despite conservative management, interventional procedures such as transforaminal epidural steroid injections (TFESI) are widely utilized to provide targeted anti-inflammatory effects and symptomatic relief.[2,3]

Traditionally, TFESI is performed under fluoroscopic guidance, which allows for precise skeletal visualization and contrast confirmation.[3,4] However, fluoroscopy involves extensive radiation exposure for patients and clinicians and lacks the ability to visualize soft tissue structures like nerves and blood vessels.[4,5] The rise of high-resolution ultrasonography has provided a radiation-free alternative that enables real-time visualization of needle advancement and local anaesthetic spread.[5,6] Ultrasound-guided (USG) techniques also allow for the identification of vascular structures using colour Doppler, potentially enhancing procedural safety.

Despite the benefits of ultrasound, standardizing the optimal technique remains a challenge.[6,7] Two primary sonographic views are used for lumbar TFESI: the axial (transverse) approach and the sagittal (paramedian oblique) approach.[8] The axial approach typically visualizes the "lambda sign," consisting of the transverse process and facet joint.

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Article received on:
03/02/2026
Accepted for publication:
07/04/2026

Still, it may be limited by acoustic shadowing from the iliac crest or deep anatomy, especially at lower lumbar levels.[7,9] Conversely, the sagittal approach utilizes a paramedian oblique view to visualize the intervertebral foramen as an "inverted J" sign, potentially offering a more direct trajectory and better visualization of the neuroforamen.[8,10,12]

Both methods have been validated for use in different studies, but direct head-to-head studies are limited for the L5 and S1 level.[9,10,11] The purpose of this randomized controlled trial is to compare the clinical efficacy, accuracy, and safety of the Axial and Sagittal USG-TFESI approaches for the treatment of chronic lumbar radiculopathy.

METHODS

This prospective randomized controlled trial was carried out at the Department of Anaesthesia and Pain Medicine, Ghurki Trust Teaching Hospital, Lahore, between August 2025 and January 2026. Ethical approval for the trial was obtained from the Institutional Ethical Review Board (Ref. No.2025/07/R-50), and the trial was conducted in compliance with the Declaration of Helsinki. Calculation of the sample size was done based on the expected VAS difference of 1.5 with SD 2.5. So, the required sample size for each group is 44 with 80 percent power and 5 percent significance. Therefore, the total number of patients included in this trial is 88, ranging between 18 and 65 years of both genders, with the diagnosis of L5 radiculopathy with symptoms greater than 3 months. Exclusion criteria for the trial were patients with prior spinal surgery at the level of L5-S1, severe spinal deformity, pregnant females, and coagulopathy. Patients were randomly allocated to the groups using a simple lottery system.

A total of 88 envelopes were prepared with the word 'Group A' for Axial and 'Group B' for Sagittal. These envelopes were kept in a container and drawn by a neutral research assistant who was not involved in the patients' care. This ensured equal allocation and minimized selection bias. All procedures were performed by an experienced pain physician using a high-frequency curvilinear transducer (2–5 MHz) with patients in a prone position. Axial Approach was followed in Group A. The transducer was placed transversely over the L5-S1 segment to identify the "lambda sign" (transverse process, facet joint, and vertebral body). A 22-gauge spinal needle was inserted in-plane from lateral to medial, targeting the area just ventral to the superior articular process toward the foramen. The sagittal approach was performed in Group B. The transducer was placed in a sagittal orientation over the paramedian (paraspinal) region and tilted obliquely to visualize the "inverted J" sign (the neuroforamen between L5 and S1). The needle was inserted in-plane in a cranio-caudal trajectory toward the target foramen. In both groups, once the needle tip reached the target as visualized on ultrasound, its position was validated using fluoroscopy with 1 ml of Omnipaque 240 contrast medium to confirm epidural spread. Following confirmation, a mixture of 40 mg Triamcinolone acetonide and 2 ml of 0.5% lidocaine was injected.

Primary efficacy outcomes were pain intensity by visual analogue scale (VAS, 0–10) and functional disability using Oswestry Disability Index (ODI, 0–100%) assessed at baseline, 2 weeks, 1 month, and 3 months. Secondary outcomes included procedure time in minutes (from probe contact to needle withdrawal), needle placement accuracy (fluoroscopic confirmation), patient satisfaction (5-point Likert scale at 1 week), and complications (transient paraesthesia, vascular puncture, and local infection). Data were analysed using SPSS 25.0. t-test and repeated measures ANOVA were used for longitudinal outcomes with p-value≤0.05.

RESULTS

All 88 patients completed the study. Demographic characteristics were well-balanced between groups (Table-I). The mean age was 46.2 ± 10.4 years in the axial group and 47.8 ± 9.8 years in the sagittal group. No significant differences were found in gender, BMI, or baseline VAS/ODI scores. Both groups showed significant reductions in VAS at all follow-up intervals ($p < 0.001$). However, the sagittal group achieved significantly lower VAS scores at 2 weeks (3.8 ± 0.9 vs. 4.2 ± 1.1, $p = 0.042$) and 1 month (2.8 ± 0.8 vs. 3.1 ± 0.9, $p = 0.038$) post-injection. By 3 months, the scores remained low in both groups. VAS comparison in both groups is summarised in Figure-1. Functional outcomes followed a similar pattern. The sagittal group demonstrated significantly

lower ODI scores at 2 weeks (28.1 ± 4.2 vs. 32.4 ± 5.1, p < 0.001) and 1 month (22.3 ± 3.8 vs. 25.7 ± 4.0, p < 0.001). By 3 months, functional recovery was substantial in both groups, though still slightly better in the sagittal group (18.5 ± 3.2 vs. 20.1 ± 3.5, p = 0.029). ODI comparison in both groups is demonstrated in Figure-2. The sagittal approach was significantly faster (10.2 ± 1.8 min) compared to the axial approach (15.4 ± 2.5 min, p < 0.001) (Figure-3). Accuracy rates confirmed by fluoroscopy were high: 95.5% (42/44) for the sagittal group and 90.9% (40/44) for the axial group (p = 0.640). Patient satisfaction at 1 week was significantly higher for the sagittal approach (4.6 ± 0.5 vs. 4.1 ± 0.7, p < 0.001). No major complications were reported. Transient paraesthesia occurred in 4.5% of the axial group and 2.3% of the sagittal group (p = 1.000). No vascular punctures or infections were observed.

TABLE-I

Patient demographic characteristics in both groups.

Characteristic	Axial (n=44)	Sagittal (n=44)	P-Value
Age (years)	47.8 ± 9.8	46.2 ± 10.4	0.458
Gender (M/F)	22 / 22	20 / 24	0.672
BMI (kg/m²)	27.1 ± 2.9	26.5 ± 3.2	0.364
Baseline VAS	7.8 ± 0.8	7.9 ± 0.9	0.582
Baseline ODI (%)	48.6 ± 5.4	49.3 ± 5.3	0.540

FIGURE-1

Visual Analog Scale (VAS) scores in both groups over time.

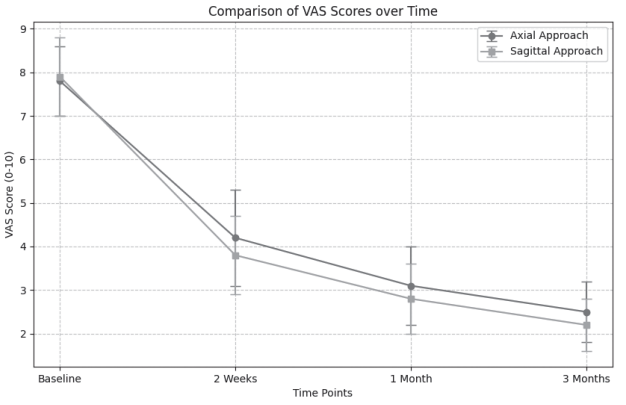


FIGURE-2

Oswestry Disability Index (ODI) scores in both groups over time.

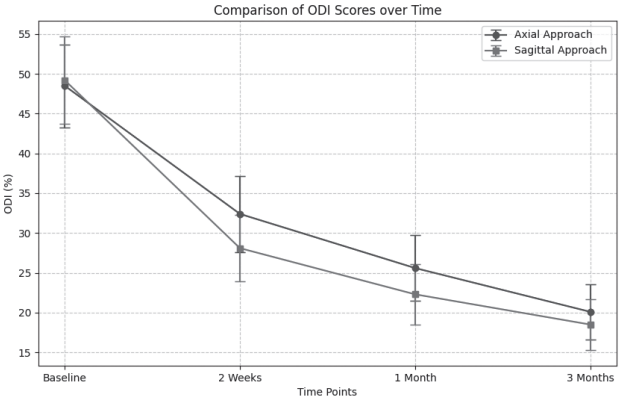
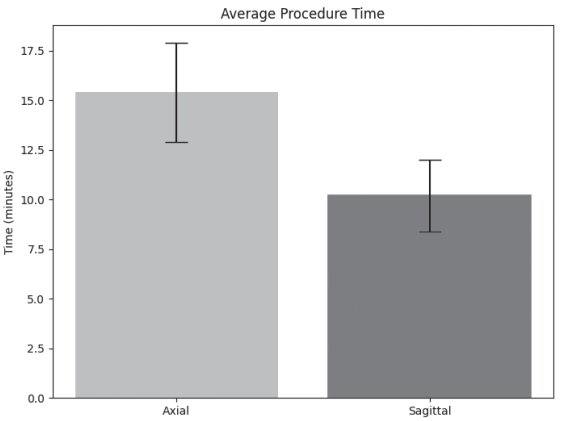


FIGURE-3

Mean procedure time (minutes) comparison in both groups.



DISCUSSION

The results of this study have shown that although both the axial and sagittal US-guided methods for TFESI are safe and effective for the treatment of L5 radiculopathy, the sagittal method is superior in procedural efficiency and short-term clinical outcomes. The significance of this study is the demonstration of the role of the method of choice in optimizing the outcomes of interventional pain management. The results of both methods showed significant improvement in the intensity of pain (VAS), which confirms the reliability of US-guided TFESI compared to the fluoroscopy method in previous studies.[1,3,11] The significantly low levels of pain intensity in the sagittal method group at 2

weeks and 1 month post-procedure may be due to the effectiveness of the paramedian oblique method in delivering the steroid mixture closer to the nerve root.[12] The longitudinal view of the anatomy provided by the sagittal method may have ensured a better placement of the steroid mixture compared to the axial method, which is limited by the facet joint and iliac crest.[8,12] The results of this study are consistent with the study by Yang et al. (2024), which showed better short-term outcomes of a novel sagittal oblique method for TFESI.[12]

The improvement in function, as indicated by the ODI scores, followed a similar pattern to the pain results. However, the sagittal group again showed a greater improvement in functional recovery in the first month. This is an important finding because the main purpose of TFESI is to restore function and return the patient to normal activities. The better results for the ODI in the sagittal group ($p < 0.001$ for 2 weeks and 1 month) are likely due to the better control of the pain, which is possible by the direct approach of the sagittal method. While most studies have concentrated on the control of pain, this study indicates that the method of sonographic approach also influences the pattern of functional recovery. However, the sagittal method is better.[9,10,13]

The time was significantly shorter in the sagittal approach (~10 min) compared to the axial approach (~15 min). This is particularly important in a clinical setting, as a shorter time is associated with minimal patient discomfort and increased clinic output. The axial approach may require several adjustments of the transducer in order to maneuver past acoustic shadows from the transverse process and iliac crest, particularly in the L5-S1 level.[6,8] The sagittal approach has simplified this by offering a better acoustic window to access the foramina, thus reducing time in optimizing images and needle redirection.[12] Yang et al. shows a significantly shorter time was achieved in the sagittal oblique approach.[12]

The accuracy rate in both groups is high; 95.5% in the sagittal approach and 90.9% in the axial approach. This shows that both sonographic techniques are accurate in targeting the L5-S1 neuroforamen. The high accuracy rate of the sagittal approach is due to the distinct visualization of the "inverted J" sign, which is a landmark for the neuroforamen.[12] Although the axial approach is accurate, a slightly high accuracy rate in the sagittal approach suggests that the sagittal oblique approach might be more intuitive for practitioners. These high accuracy rates are consistent with those obtained in previous fluoroscopic validation studies, including 90% accuracy in axial US-guided injections as reported by Hashemi et al.[14,15]

Safety remains of prime importance in spinal procedures. In the present study, both techniques have shown an excellent safety profile, with no major complications or vascular puncture. This again emphasizes the advantage of ultrasound in visualizing soft tissue and avoiding segmental vessels by the use of color Doppler, which is not possible in fluoroscopy.[11,16] Transient paraesthesia was the only minor complication noted in the present study, and there was no significant difference between the two techniques. The absence of vascular injury in the present study further emphasizes the safety of ultrasound in guiding TFESI, as emphasized by Zhao et al.[16] The continuous visualization of the needle tip in real time by both techniques is very useful in avoiding accidental injury to the surrounding structures.

The strength of the present study lies in the fact that it is a prospective randomized study with the use of fluoroscopic confirmation for every procedure. The limitation of the study is that it is performed in a single center, with a 3-month follow-up period. The experience of the operator is also important, as the ultrasound-guided procedures are operator-dependent. It is recommended that further studies be performed with longer follow-up periods, i.e., 12-24 months, to confirm the long-term durability of the present results.

CONCLUSION

This randomized controlled trial demonstrates that both axial and sagittal US-guided TFESI are effective and safe for treating L5 radiculopathy. However, the sagittal (paramedian oblique) approach is superior in terms of procedural efficiency, offering significantly shorter procedure times and higher patient satisfaction. Furthermore, the sagittal approach

provides enhanced short-term pain relief and functional recovery compared to the axial approach. Therefore, clinicians should consider adopting the sagittal oblique view as the preferred sonographic approach for L5 transforaminal injections.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

SOURCE OF FUNDING

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

REFERENCES

1. Hofmeister M, Dowsett LE, Lorenzetti DL, Clement F. **Ultrasound- versus fluoroscopy-guided injections in the lower back for the management of pain: A systematic review.** Eur Radiol. 2019 Jul; 29(7):3401-09.
2. Manchikanti L, Abdi S, Atluri S, Benyamin RM, Boswell MV, Buenaventura RM, et al. **An update of comprehensive evidence-based guidelines for interventional techniques in chronic spinal pain. Part II: guidance and recommendations.** Pain Physician. 2013; 16(2 Suppl):S49-283.
3. Michelle Chi, Allen S. Chen. **Ultrasound for lumbar spinal procedures.** Physical Medicine and Rehabilitation Clinics of North America. 2018; 29(1):49-60.
4. Krol A. **SP34 Ultrasound-guided spinal procedures – advantages and limitations.** Regional Anesthesia & Pain Medicine. 2022; 47:A37-A40.
5. Vydyanathan A, Agrawal P, Donia K, Wahezi SE, Koushik SS, Slinchenkova K, et al. **Feasibility of ultrasound-guided lumbar transforaminal epidural steroid injections for management of lumbar radicular back pain.** J Pain Res. 2025; 18:759-67.
6. Yang G, Liu J, Ma L, Cai Z, Meng C, Qi S, et al. **Ultrasound-guided Versus Fluoroscopy-controlled lumbar transforaminal epidural injections: A prospective randomized clinical trial.** Clin J Pain. 2016 Feb; 32(2):103-8.
7. Kimura R, Yamamoto N, Watanabe J, Ono Y, Hongo M, Miyakoshi N. **Comparative efficacy of ultrasound guidance and fluoroscopy or computed tomography guidance in spinal nerve injections: A systematic review and meta-analysis.** European Spine Journal. 2023 Dec; 32(12):4101-10.
8. Chi M, Chen AS. **Ultrasound for lumbar spinal procedures.** Phys Med Rehabil Clin N Am. 2018 Feb; 29(1):49-60.
9. Hurdle MF. **Ultrasound-Guided spinal procedures for pain: A review.** Phys Med Rehabil Clin N Am. 2016 Aug; 27(3):673-86.
10. Kim YH, Park HJ, Moon DE. **Ultrasound-guided pararadicular injection in the lumbar spine: A comparative study of the paramedian sagittal and paramedian sagittal oblique approaches.** Pain Pract. 2015; 15:693-700.
11. Tay M, Sian SCSH, Eow CZ, Ho KLK, Ong JH, Sirisena D. **Ultrasound-Guided lumbar spine injection for axial and radicular pain: A single institution early experience.** Asian Spine J. 2021 Apr; 15(2):216-23.
12. Yang H, Wang H, Lu J, Hu L. **A novel simplified sonographic approach with fluoroscopy-controlled L5 transforaminal epidural injections in patients with high iliac crest: A retrospective study.** JA Clinical Reports. 2024 Jul 20; 10(1):43.
13. Li H, Kang Y, Jin L, Ma D, Liu Y, Wang Y. **Feasibility of ultrasound-guided lumbar epidural access using paramedian transverse scanning with the needle in-plane: A comparison with paramedian sagittal scanning.** Journal of Anesthesia. 2020 Feb; 34(1):29-35.
14. Emami SA, Sanatkar M, Espahbodi E, Pestehei SK. **Ultrasound and nerve stimulator guidance lumbar transforaminal epidural block for the treatment of patients with lumbosacral radicular pain.** Scientific Reports. 2022 Apr 8; 12(1):5954.
15. Hashemi M, Dadkhah P, Taheri M, Haji Seyed Abootorabi SM, Naderi-Nabi B. **Ultrasound-Guided lumbar transforaminal epidural injections; A single center fluoroscopic validation study.** Bull Emerg Trauma. 2019 Jul; 7(3):251-55.
16. Zhao W, Guo G, Wang Q, Yang L. **Ultrasound-guided transforaminal epidural injection with fluoroscopy confirmation for the treatment of unilateral lumbar radiculopathy: A randomized controlled non-inferiority study.** Clinical Neurology and Neurosurgery. 2023; 231.107849.

AUTHORSHIP AND CONTRIBUTION DECLARATION	
1	**Adeel Shahid:** Conceptualization of study.
2	**Umer Farooq:** Literature review.
3	**Leena Aziz:** Supervisor of study.
4	**Shahid Rasool Dar:** Critical revision.
5	**Adnan Umer:** Data collection.
6	**Waseem Younis:** Critical revisions.