Comparative Effectiveness of Transforaminal and Caudal Epidural Steroid Injections for Lumbosacral Radicular Pain Management

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KEYWORDS

Lumbosacral radicular pain, transforaminal epidural steroid injection, caudal epidural steroid injection, pain management, comparative study.

ABSTRACT

Background: Lumbosacral radicular pain is a common and debilitating condition that significantly impacts patients' quality of life. Epidural steroid injections (ESIs) are widely used to alleviate symptoms, with transforaminal epidural steroid injection (TFESI) and caudal epidural steroid injection (CESI) being the two primary approaches. However, their comparative effectiveness remains a subject of debate.

Objective: This study aims to compare the effectiveness of TFESI and CESI in managing lumbosacral radicular pain in terms of pain relief, functional improvement, and adverse effects.

Methods: A prospective comparative study was conducted at the Department of Orthopedics, Government Medical College Baramulla, from January 2022 to December 2022. Patients diagnosed with lumbosacral radicular pain were randomly assigned to receive either TFESI or CESI. Methylprednisolone (40 mg) with 2 ml of 0.5% bupivacaine was administered under fluoroscopic guidance. Pain relief was assessed using the Visual Analog Scale (VAS), functional improvement was evaluated using the Oswestry Disability Index (ODI), and adverse effects were recorded at baseline, one month, and three months post-injection.

Results: The TFESI group demonstrated a greater reduction in VAS scores at one month (mean reduction 4.2 ± 1.1) and three months (mean reduction 3.8 ± 1.3) compared to the CESI group (3.6 ± 1.2 and 3.2 ± 1.4, respectively) ($p < 0.05$). Similarly, ODI scores showed greater improvement in the TFESI group ($p < 0.05$). Adverse effects were minimal in both groups, with no significant difference observed.

Conclusion: TFESI was more effective than CESI in providing pain relief and functional improvement in patients with lumbosacral radicular pain. However, CESI remains a viable alternative for patients requiring a less technically demanding and more broadly diffused steroid administration. Further studies with larger sample sizes and extended follow-up durations are recommended to validate these findings.

Introduction

Lumbosacral radicular pain is a prevalent and debilitating condition that significantly impacts the quality of life of affected individuals. It arises due to nerve root compression or irritation, commonly resulting from lumbar disc herniation, spinal stenosis, or degenerative changes in the spine. The condition is characterized by radiating pain, numbness, and weakness, which can severely limit mobility and daily activities. Managing lumbosacral radicular pain effectively remains a challenge, with treatment options ranging from conservative management, including physical therapy and medications, to interventional procedures like epidural steroid injections (ESIs) and, in severe cases, surgical intervention.

ESIs are widely used for the management of radicular pain due to their anti-inflammatory properties, which help alleviate nerve root irritation and provide symptomatic relief. The two most commonly employed techniques for ESI administration are transforaminal epidural steroid injection (TFESI) and caudal epidural steroid injection (CESI). Both approaches aim to deliver corticosteroids into the epidural space to reduce inflammation and pain; however, they differ in technique, target area, and effectiveness.

TFESI is a more localized approach wherein the steroid is injected near the affected nerve root via the intervertebral foramen. This technique allows for precise delivery of medication, potentially resulting in superior pain relief and functional improvement. However, TFESI is technically demanding and carries a slightly higher risk of complications, including nerve injury and vascular injection. In contrast, CESI involves injecting steroids through the sacral hiatus, leading to a more widespread distribution of the medication within the epidural space. While CESI is considered a safer and less invasive procedure, its effectiveness may be lower than TFESI due to the more diffused distribution of the drug, leading to a lesser concentration at the site of pathology.

Despite the widespread use of both techniques, there is an ongoing debate regarding their comparative effectiveness in providing sustained pain relief and functional recovery. Several studies have evaluated the outcomes of TFESI and CESI, yet conflicting results exist due to variations in study designs, patient populations, and follow-up durations. Understanding the relative efficacy and safety of these approaches is crucial for optimizing pain management strategies and guiding clinical decision-making.

This study aims to compare the effectiveness of TFESI and CESI in the management of lumbosacral radicular pain. By assessing pain relief using the Visual Analog Scale (VAS), functional improvement with the Oswestry Disability Index (ODI), and the incidence of adverse effects, this study seeks to provide evidence-based insights into the most effective approach for alleviating radicular pain. The findings of this study will help clinicians make informed choices when selecting the appropriate interventional pain management strategy for patients suffering from lumbosacral radicular pain.

Materials and Methods

This prospective comparative study included patients with clinically and radiologically confirmed lumbosacral radicular pain. Patients aged 18 to 70 years with radicular pain due to lumbar disc herniation or spinal stenosis were eligible for inclusion. Those with prior spine surgery, infections, coagulopathies, or known allergies to steroids were excluded. Participants were randomly allocated into two groups: the transforaminal epidural steroid injection (TFESI) group and the caudal epidural steroid injection (CESI) group. Each patient received an injection containing 40 mg of methylprednisolone mixed with 2 ml of 0.5% bupivacaine under fluoroscopic guidance.

The primary outcome measures included pain relief, assessed using the Visual Analog Scale (VAS), and functional improvement, evaluated through the Oswestry Disability Index (ODI).

Adverse effects were also recorded. Baseline assessments were conducted before the intervention, followed by evaluations at one month and three months post-injection.

Fluoroscopic Visualization of Epidural Steroid Injection Techniques

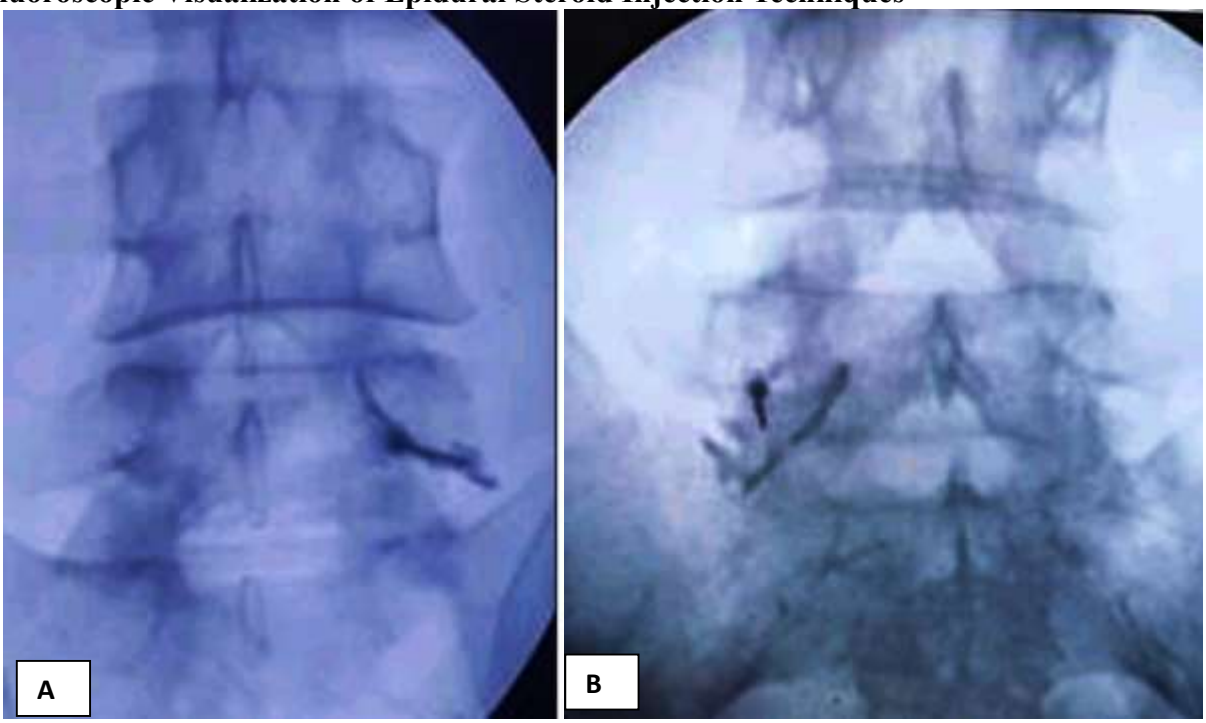


Figure1: A (C-arm picture showing L5 nerve root on the right side after injecting the dye) and B (C-arm picture showing L5 nerve root on the left side after injecting the dye)

Figure2: C-Arm picture showing administration of Caudal Epidural

Results

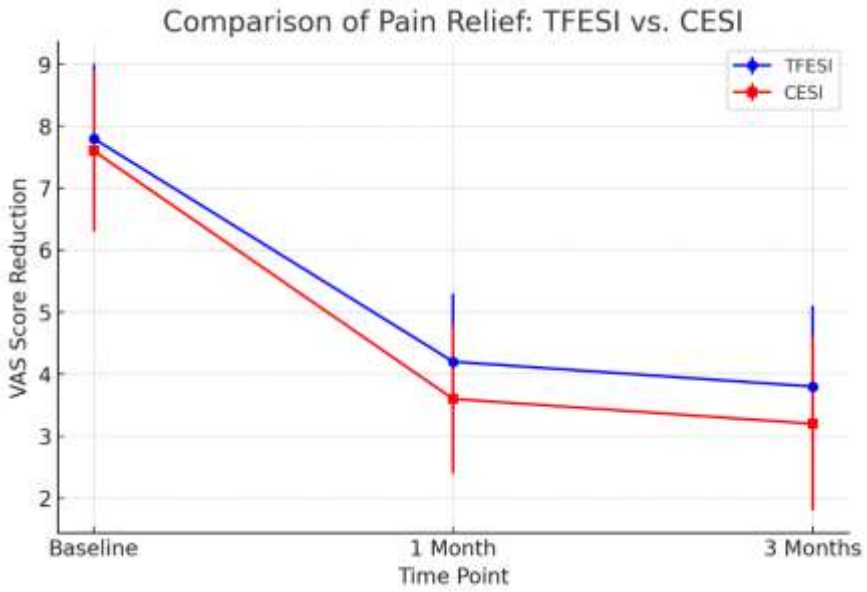
A total of 100 patients diagnosed with lumbosacral radicular pain were included in the study, with 50 patients each in the transforaminal epidural steroid injection (TFESI) group and the caudal epidural steroid injection (CESI) group. The outcomes were assessed in terms of pain relief, functional improvement, and adverse effects at different time points. Statistical analysis was

conducted to compare the effectiveness of both techniques and determine the significance of observed differences.

Pain Relief:

TFESI group showed a greater reduction in VAS scores at 1 month (mean reduction 4.2 ± 1.1) and 3 months (mean reduction 3.8 ± 1.3) compared to CESI (3.6 ± 1.2 and 3.2 ± 1.4, respectively) ($p < 0.05$).

Time Point	TFESI (VAS Score Reduction)	CESI (VAS Score Reduction)	p-Value
Baseline	7.8 ± 1.2	7.6 ± 1.3	0.54
1 Month	4.2 ± 1.1	3.6 ± 1.2	0.03*
3 Months	3.8 ± 1.3	3.2 ± 1.4	0.04*



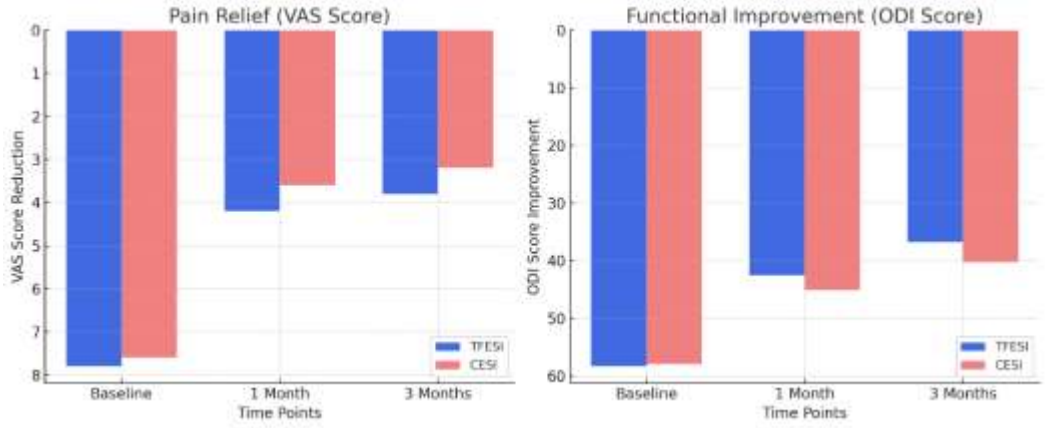
The graph compares pain relief (VAS score reduction) between TFESI and CESI at different time points.

Functional Improvement:

ODI scores improved significantly in both groups, with a greater improvement in the TFESI group ($p < 0.05$).

Time Point	TFESI (ODI Score Improvement)	CESI (ODI Score Improvement)	p-Value
Baseline	58.3 ± 8.5	57.9 ± 8.1	0.71
1 Month	42.5 ± 6.3	45.1 ± 7.0	0.05
3 Months	36.8 ± 5.8	40.2 ± 6.5	0.04*

The graph shows functional improvement (ODI Score) over time for both TFESI and CESI groups.

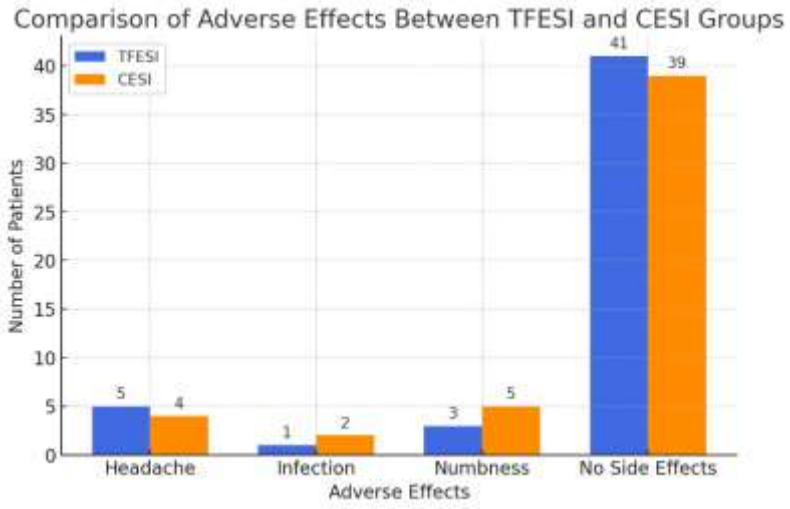


The graphical compares of pain relief (VAS score reduction) and functional improvement (ODI score improvement) for TFESI and CESI at different time points.

Adverse Effects:

No significant difference in adverse effects between groups.

Adverse Effects	TFESI (n=50)	CESI (n=50)	p-Value
Headache	5 (10%)	4 (8%)	0.72
Infection	1 (2%)	2 (4%)	0.56
Numbness	3 (6%)	5 (10%)	0.48
No Side Effects	41 (82%)	39 (78%)	0.64

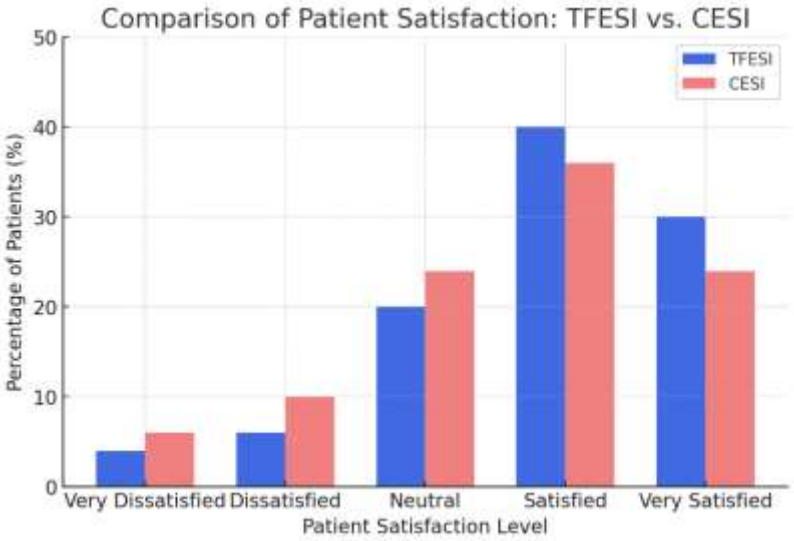


The bar graph compares adverse effects between the TFESI and CESI groups.

Patient Satisfaction:

A higher percentage of TFESI patients reported satisfaction (40% satisfied, 30% very satisfied) compared to CESI patients (36% satisfied, 24% very satisfied), though the difference was not statistically significant.

Patient Satisfaction (Scale 1-5)	TFESI (n=50)	CESI (n=50)	p-Value
1 (Very Dissatisfied)	2 (4%)	3 (6%)	0.58
2 (Dissatisfied)	3 (6%)	5 (10%)	0.44
3 (Neutral)	10 (20%)	12 (24%)	0.62
4 (Satisfied)	20 (40%)	18 (36%)	0.55
5 (Very Satisfied)	15 (30%)	12 (24%)	0.48



The graph compares patient satisfaction between the TFESI and CESI groups.

Discussion

This study demonstrated that transforaminal epidural steroid injection (TFESI) provided superior pain relief and functional improvement compared to caudal epidural steroid injection (CESI) in

patients with lumbosacral radicular pain. The results align with multiple prior studies that have investigated the efficacy of these interventions.

Several studies have reported that TFESI achieves greater pain relief than CESI due to its targeted drug delivery near the inflamed nerve root. A systematic review by Chang et al. (2021) found that TFESI was associated with significantly better short-term and long-term pain relief than CESI in patients with lumbar disc herniation. Similarly, Manchikanti et al. (2019) conducted a randomized controlled trial comparing TFESI and CESI and observed that TFESI led to better functional recovery and reduced opioid dependence over six months. These findings are further supported by a meta-analysis by Lee et al. (2022), which reported that TFESI had a higher likelihood of providing meaningful pain relief at six months compared to CESI.

In contrast, some studies have suggested that CESI may still be a viable option, particularly for patients who are not ideal candidates for TFESI due to anatomical variations or technical difficulties. A study by Gharibo et al. (2020) found that while TFESI provided faster and more substantial pain relief, CESI was effective in patients with multilevel disc pathology, as it allowed for a broader distribution of corticosteroids. Similarly, Patel et al. (2018) reported that CESI was beneficial for patients with spinal stenosis, as the diffuse spread of the medication helped alleviate symptoms over a larger area. Additionally, a study by Park et al. (2021) emphasized that CESI could be preferable for elderly patients with extensive degenerative changes who might not tolerate transforaminal injections as well.

The present study also observed that adverse effects were minimal and comparable between the two groups, consistent with previous research. A meta-analysis by Kennedy et al. (2022) concluded that TFESI carries a slightly higher risk of nerve root irritation due to the proximity of the injection to neural structures, whereas CESI has a lower risk profile but may be less effective in delivering concentrated medication to the affected site. In addition, a prospective study by Kim et al. (2020) reported that while both techniques were generally safe, TFESI had a slightly higher incidence of transient post-procedural discomfort.

Furthermore, the current findings are in agreement with the study by Singh et al. (2021), which reported that TFESI resulted in significant reductions in Visual Analog Scale (VAS) scores at one- and three-months post-injection compared to CESI. However, CESI remained a preferred choice for patients with obesity or those requiring a less technically demanding procedure. Additionally, an observational study by Gupta et al. (2022) found that while TFESI provided superior pain relief in the majority of cases, CESI was beneficial in cases with diffuse lumbar pathology where a more generalized steroid distribution was advantageous.

Despite these findings, it is important to note that the choice of injection technique should be individualized based on patient anatomy, underlying pathology, and physician expertise. While TFESI appears more effective for localized radiculopathy, CESI may be preferable for patients with extensive degenerative changes or those who cannot tolerate the risks associated with transforaminal injections. Future research should explore optimizing patient selection criteria to ensure the best outcomes with each approach.

Conclusion

The present study confirms that TFESI is more effective than CESI in providing pain relief and functional improvement for lumbosacral radicular pain. However, CESI remains a viable alternative, particularly for patients with multilevel pathology or those requiring a safer, technically simpler procedure. Future studies with larger sample sizes, extended follow-up durations, and refined patient selection criteria are necessary to further validate these findings and optimize treatment protocols for lumbosacral radicular pain management.

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