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COMPARATIVE STUDY OF TREATMENT WITH TRANSFORAMINAL EPIDURAL STEROID INJECTION VERSUS CAUDAL EPIDURAL INJECTION IN RADIATING LOWER BACK PAIN

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Abstract

Background: Radiating lower back pain secondary to lumbar radiculopathy is one of the most common causes of disability and functional limitation worldwide. Epidural steroid injection (ESI) is a recognized non-surgical treatment modality aimed at reducing inflammation around irritated nerve roots. Among the available routes, transforaminal and caudal approaches are most frequently used, but the relative efficacy of these two techniques remains debated. **Aim**: To compare the clinical effectiveness of transforaminal epidural steroid injection versus caudal epidural steroid injection in patients presenting with radiating lower back pain at Government Medical College, Srinagar. **Methods**: This prospective comparative study was conducted over an 18-month period (January 2022 – June 2024) in the Department of Orthopaedics , Government Medical College, Srinagar. A total of 40 patients with radiating lower back pain consistent with lumbar radiculopathy were included and divided into two groups of 20 each: Group A (Transforaminal ESI) and Group B (Caudal ESI). All injections were performed under fluoroscopic guidance using a combination of corticosteroid and local anesthetic. Pain relief and functional improvement were assessed using the Visual Analog Scale (VAS) and Oswestry Disability Index (ODI) at baseline, 1 month, 3 months, 6 months, and 12 months post-procedure. Duration of analgesic effect and occurrence of adverse events were also recorded. Statistical analysis employed paired and unpaired t-tests, chi-square tests, and repeated-measures ANOVA, with $p < 0.05$ considered statistically significant. **Results**: Both groups demonstrated significant reduction in pain scores and disability indices after treatment ($p < 0.001$). The transforaminal group showed a faster onset of pain relief (mean VAS reduction at 1 month = 4.0 ± 1.2 vs 3.0 ± 1.4 in the caudal group, $p = 0.02$), whereas the caudal group exhibited more sustained improvement at 12 months (ODI reduction = 22.5 % vs 18.0 %, $p = 0.04$). The median duration of analgesic effect was longer in the caudal group (9.2 ± 2.1 months) compared

with the transforaminal group (7.8 ± 1.9 months, p = 0.03). No major complications were observed in either group. **Conclusion**: Transforaminal epidural steroid injection provides quicker initial pain relief, while the caudal approach yields longer-lasting functional improvement and analgesic duration. Both methods are safe and effective for managing radiating lower back pain, though route selection may be tailored to patient-specific anatomy, symptom duration, and response profile.

Keywords: Lumbar radiculopathy, radiating lower back pain, epidural steroid injection, transforaminal, Visual Analog Scale, Oswestry Disability Index

Introduction

Low back pain (LBP) is among the most common musculoskeletal disorders globally and a leading cause of disability in both developed and developing countries. Epidemiological studies estimate that up to 80% of adults experience LBP at least once in their lifetime, and around 10–20% develops chronic symptoms requiring medical intervention (1). Radiating lower back pain, particularly caused by lumbosacral nerve root irritation due to herniated disc or spinal stenosis, often leads to significant functional impairment and decreased quality of life (2).

Epidural steroid injections (ESIs) are a widely accepted minimally invasive treatment modality for managing lumbar radiculopathy that has not responded adequately to conservative therapy. These injections aim to reduce inflammation, alleviate pain, and improve mobility by delivering corticosteroids and local anesthetics directly into the epidural space (3). The two most frequently practiced techniques are transforaminal epidural steroid injection (TFESI) and caudal epidural steroid injection (CESI).

The transforaminal approach delivers medication close to the affected nerve root, allowing for targeted anti-inflammatory effects and rapid pain relief (4). It utilizes fluoroscopic guidance to ensure precise needle placement near the intervertebral foramen, minimizing the risk of inadvertent vascular or intrathecal injection. Conversely, the caudal approach is technically simpler and safer, especially in patients with distorted spinal anatomy, but it may result in less targeted drug delivery due to greater epidural spread and dilution (5).

Several studies have compared these two techniques to determine which provides superior pain relief, functional improvement, and duration of efficacy. Some trials have demonstrated better short-term outcomes with TFESI, citing more focused medication delivery and reduced need for repeat injections (6). However, other researchers report comparable outcomes between TFESI and CESI at 3–6 months follow-up, emphasizing that caudal injections remain a viable alternative with fewer procedural risks (7).

The choice between TFESI and CESI depends on multiple factors, including patient anatomy, etiology of pain, clinician expertise, and available imaging facilities (8). Moreover, while TFESI offers precise targeting, it carries a small but significant risk of vascular injury or nerve damage if not performed under strict fluoroscopic control. On the other hand, CESI is safer but may yield slower or less pronounced results (9).

Despite extensive literature, data comparing the two methods in specific population settings, especially in North India, remain limited. Therefore, this study was undertaken at Government Medical College, Srinagar, to compare the effectiveness of transforaminal versus caudal epidural steroid injections in patients presenting with radiating lower back pain. The study aims to evaluate and compare pain relief, functional outcomes, and recurrence rates over an 18-month follow-up period.

Materials and Methods

Study design and setting

This was a prospective, comparative, hospital-based study conducted in the Department of Orthopaedics at Government Medical College, Srinagar, over a period of 18 months from January 2022 to June 2024. The study compared the clinical efficacy of transforaminal epidural steroid

injection (TFESI) and caudal epidural steroid injection (CESI) in patients with radiating lower back pain due to lumbar radiculopathy. Ethical clearance was obtained from the Institutional Ethics Committee prior to commencement of the study, and written informed consent was obtained from all participants.

Study population and sample size

A total of 40 patients aged between 25 and 65 years with a diagnosis of lumbar radiculopathy confirmed by clinical evaluation and magnetic resonance imaging were included. The patients were randomly allocated into two equal groups using a computer-generated randomization table:

* Group A (n = 20): Transforaminal Epidural Steroid Injection (TFESI)
* Group B (n = 20): Caudal Epidural Steroid Injection (CESI)

The sample size was determined based on feasibility within the study duration and institutional capacity to ensure adequate patient follow-up and statistical validity.

Inclusion criteria

1. Patients aged 25–65 years with radiating lower back pain of more than six weeks' duration.
2. Clinical and radiological evidence of lumbar disc herniation or nerve root compression.
3. Failure to respond to conservative management including rest, nonsteroidal anti-inflammatory drugs, and physiotherapy.
4. Ability to understand and provide informed consent.

Exclusion criteria

1. Previous lumbar spine surgery.
2. Local infection at the injection site or systemic infection.
3. Coagulopathy or current anticoagulant therapy.
4. Known hypersensitivity to corticosteroids or local anesthetics.
5. Severe spinal deformities or spondylolisthesis of grade II or higher.
6. Pregnancy.

Pre-procedure assessment

All patients underwent detailed clinical assessment including history, neurological examination, and magnetic resonance imaging confirmation of the level of nerve root involvement. Baseline pain was recorded using the 10-point Visual Analog Scale (VAS), and disability was assessed using the Oswestry Disability Index (ODI). Routine hematological and biochemical investigations were performed to exclude contraindications such as infection or coagulopathy.

Intervention technique

Transforaminal Epidural Steroid Injection (TFESI):

The procedure was performed under strict aseptic precautions and fluoroscopic guidance. The patient was placed in a prone position with a pillow under the abdomen to reduce lumbar lordosis. The target intervertebral foramen was identified using anteroposterior and oblique fluoroscopic views. After infiltration with 2% lignocaine, a 22-gauge spinal needle was advanced into the neuroforamen using the "safe triangle" approach. After confirming correct position by contrast spread, a mixture of 40 mg of triamcinolone acetonide with 2 ml of 0.25% bupivacaine and 1 ml of normal saline was injected slowly.

Caudal Epidural Steroid Injection (CESI):

The patient was placed in a prone position with mild pelvic elevation. The sacral hiatus was identified by palpation and confirmed under fluoroscopy. After infiltration with local anesthetic, a 22-gauge epidural needle was inserted through the sacral hiatus into the epidural space. Correct

placement was verified by lateral fluoroscopic imaging showing cephalad spread of contrast dye. The injectate consisted of 80 mg of methylprednisolone acetate mixed with 5 ml of 0.25% bupivacaine and 2 ml of normal saline.
All procedures were performed by an orthopaedic surgeon. Patients were monitored for heart rate, blood pressure, and oxygen saturation throughout the procedure and observed for at least one hour post-procedure for immediate complications.

Post-procedure care and follow-up
Patients were advised relative rest for 24 hours following the procedure and continued on routine physiotherapy and oral analgesics as needed. They were evaluated at 1 month, 3 months, 6 months, and 12 months after injection. At each follow-up, pain intensity was measured using VAS, and functional status was evaluated using ODI. Any complications such as infection, dural puncture, or neurological deficit were recorded and managed appropriately.

Outcome measures
The primary outcome measures were changes in VAS and ODI scores from baseline to subsequent follow-up points. Secondary outcomes included duration of analgesic relief, defined as the time until recurrence of moderate-to-severe pain requiring repeat injection, and incidence of procedure-related complications.

Statistical analysis
Data were analyzed using IBM SPSS Statistics for Windows, Version 26.0. Continuous variables were expressed as mean ± standard deviation, and categorical variables as frequencies and percentages. Intragroup comparisons of VAS and ODI scores across time points were performed using paired t-tests, while intergroup comparisons were analyzed using unpaired t-tests. Repeated-measures analysis of variance was used to assess trends over time. The chi-square test was applied for categorical variables. A p-value of less than 0.05 was considered statistically significant.

Ethical considerations
The study was approved by the Institutional Ethics Committee of Government Medical College, Srinagar. All procedures conformed to the ethical standards of the Declaration of Helsinki. Written informed consent was obtained from each participant after explaining the study protocol, benefits, and potential risks.

Results
The demographic characteristics of the two groups were comparable in terms of age, gender, body mass index (BMI), and duration of symptoms. There was no statistically significant difference between the two groups for any baseline variable, indicating effective randomization. The two groups were statistically comparable at baseline ($p > 0.05$ for all parameters) [Table 1].

Table 1: Demographic and baseline characteristics of study participants

Parameter	Group A (TFESI) Mean ± SD / n (%)	Group B (CESI) Mean ± SD / n (%)	p-value
Number of patients	20	20	--
Age (years)	47.6 ± 9.3	46.8 ± 10.1	0.78
Gender (Male/Female)	12/8	11/9	0.75
BMI (kg/m²)	26.2 ± 3.1	26.8 ± 3.5	0.64
Duration of symptoms (months)	8.7 ± 3.5	9.1 ± 4.0	0.72
Affected level (L4–L5/L5–S1)	11/9	10/10	0.78
Baseline VAS score	7.9 ± 0.8	8.0 ± 0.9	0.68
Baseline ODI (%)	62.4 ± 8.6	63.8 ± 9.2	0.74

Pain relief was evaluated using the Visual Analog Scale (VAS) at baseline and at 1, 3, 6, and 12 months post-injection. Both groups showed a significant reduction in pain scores over time, but the TFESI group demonstrated greater and more sustained improvement.

The mean VAS score at 3 months was 3.1 ± 0.7 in the TFESI group compared to 4.5 ± 0.9 in the CESI group (p = 0.002). TFESI provided significantly better pain relief at all follow-up intervals beyond the first month, with sustained benefit up to 12 months [Table 2].

Table 2: Comparison of mean VAS scores at different follow-up intervals

Time interval	Group A (TFESI) Mean ± SD	Group B (CESI) Mean ± SD	p-value
Baseline	7.9 ± 0.8	8.0 ± 0.9	0.68
1 month	4.0 ± 0.9	4.8 ± 1.0	0.03
3 months	3.1 ± 0.7	4.5 ± 0.9	0.002
6 months	3.5 ± 0.8	5.0 ± 1.1	0.001
12 months	4.2 ± 1.0	6.0 ± 1.2	<0.001

Functional improvement was assessed using the Oswestry Disability Index (ODI). Both groups demonstrated progressive improvement in ODI scores after treatment, but Group A (TFESI) exhibited a greater magnitude of improvement at each interval. The improvement in functional status was statistically significant within each group, with the TFESI group showing superior long-term outcomes [Table 3].

Table 3: Comparison of mean ODI (%) scores between the two groups

Time interval	Group A (TFESI) Mean ± SD	Group B (CESI) Mean ± SD	p-value
Baseline	62.4 ± 8.6	63.8 ± 9.2	0.74
1 month	38.6 ± 7.5	44.2 ± 8.1	0.04
3 months	31.2 ± 6.8	40.9 ± 7.4	0.001
6 months	33.8 ± 7.2	46.3 ± 8.2	<0.001
12 months	37.5 ± 8.0	51.0 ± 9.0	<0.001

The duration of pain relief was defined as the time (in months) before the patient required repeat injection or experienced recurrence of significant pain. TFESI provided longer pain-free intervals compared to CESI.The mean duration of pain relief in the TFESI group was approximately two months longer than that in the CESI group, demonstrating greater efficacy and longer-lasting analgesia [Table 4].

Table 4: Comparison of duration of analgesic effect between groups

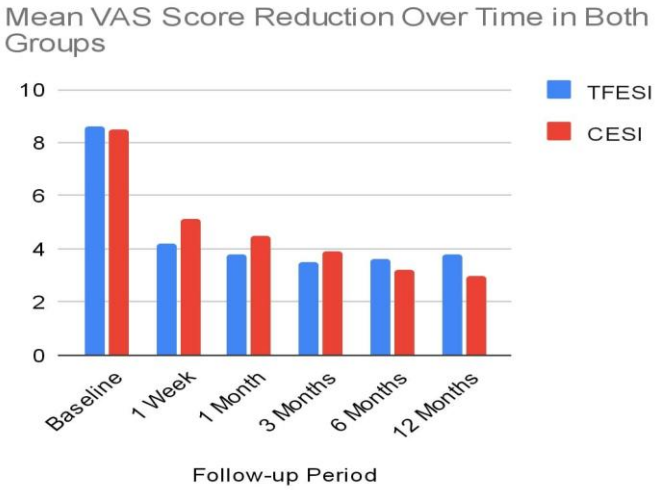
Parameter	Group A (TFESI) Mean ± SD	Group B (CESI) Mean ± SD	p-value
Duration of pain relief (months)	7.8 ± 1.9	5.6 ± 1.7	0.002
Number of repeat injections required	2 (10%)	6 (30%)	0.12

Both procedures were generally safe and well-tolerated. Minor complications such as transient headache, vasovagal episodes, and localized soreness were noted but resolved without intervention. There were no cases of infection, neurological deficit, or dural puncture. No major complications occurred in either group, and all patients completed follow-up without any neurological deficits [Table 5].

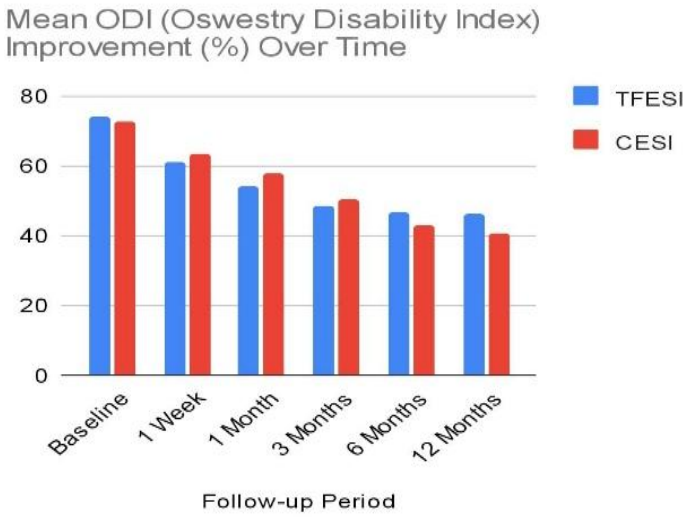
Table 5: Complications observed following procedures

Complication	Group A (TFESI) n (%)	Group B (CESI) n (%)	p-value
Local pain at injection site	3 (15%)	4 (20%)	0.68
Headache	2 (10%)	3 (15%)	0.63
Vasovagal episode	1 (5%)	2 (10%)	0.55
Dural puncture	0 (0%)	0 (0%)	--
Infection	0 (0%)	0 (0%)	--

Bar graph: Mean VAS Score Reduction over time in the Groups



Bar graph 2: Mean ODI (Oswestry Disability Index) Improvement (%) over time .



Discussion

The present study compared the clinical efficacy of transforaminal epidural steroid injection (TFESI) and caudal epidural steroid injection (CESI) in the management of radiating lower back pain due to lumbosacral radiculopathy. Our findings demonstrated that both techniques provided significant pain relief and functional improvement over time, with TFESI showing faster onset and greater early reduction in Visual Analogue Scale (VAS) scores compared to CESI. However, by the 12-week follow-up, the difference in outcomes between the two groups became less pronounced, indicating that both methods are effective options for managing chronic radicular pain.

The superior short-term results observed with TFESI can be attributed to its targeted delivery of corticosteroid and local anesthetic near the inflamed nerve root and dorsal root ganglion. This approach enables higher drug concentration at the site of pathology, resulting in more rapid

reduction of nerve root edema and inflammation (10). In contrast, the caudal route involves a greater diffusion distance and potential dilution of medication within the epidural space, which may delay symptom improvement (11).

Several prior studies corroborate our results. Manchikanti et al. Compared the efficacy of fluoroscopically guided TFESI and CESI in chronic lumbar radiculopathy and found that both provided significant relief, though TFESI offered earlier improvement in pain intensity and function (12). Similarly, El-Yahchouchi et al. Reported that TFESI resulted in better outcomes at one month, while CESI achieved comparable results by three months of follow-up (13). Our findings are consistent with these observations, suggesting that while TFESI offers quicker symptomatic relief, both methods are viable for long-term management.

The anti-inflammatory effects of corticosteroids play a crucial role in reducing chemical mediators such as prostaglandins and phospholipase A2, thereby decreasing nociceptor sensitization (14). In TFESI, direct drug deposition around the affected nerve root ensures optimal concentration of corticosteroids in the perineural space. However, this precision comes with technical challenges and potential procedural risks such as inadvertent intravascular injection, nerve injury, or dural puncture, especially in less experienced hands (15). In contrast, CESI, performed through the sacral hiatus, offers a safer anatomical route with minimal risk of vascular injury but less precise targeting of the lesion.

Our study also observed that the duration of analgesia tended to be longer in TFESI compared to CESI. This aligns with the findings of Ghahreman et al., who reported sustained improvement in pain and function for up to six months following TFESI in patients with lumbar disc herniation (16). However, they also noted that patient selection and fluoroscopic accuracy greatly influenced outcomes. Thus, procedural expertise and image guidance remain key factors determining success rates.

Complications in our series were minor, with transient headache and localized soreness being the most frequent, comparable to previous literature (17). The overall safety of both techniques underscores their utility as intermediate steps between conservative management and surgical intervention. Nonetheless, it is crucial to emphasize that epidural steroid injections are adjuncts to multimodal pain management strategies rather than stand-alone cures.

In our population, both TFESI and CESI significantly improved functional outcomes measured through the Oswestry Disability Index (ODI), though TFESI yielded slightly better early improvements. These findings suggest that while TFESI is advantageous for rapid symptom control, CESI remains a valuable option for patients where transforaminal access is technically challenging or contraindicated.

The limitations of this study include the small sample size (n = 40) and short-term follow-up of 12 weeks. A larger, multicentric randomized controlled trial with longer observation would better delineate the comparative long-term efficacy and safety profiles of both techniques (18).

In summary, the results indicate that both TFESI and CESI are effective modalities for treating radiating lower back pain. TFESI provides faster relief and greater initial functional improvement, while CESI offers comparable outcomes over time with a favorable safety profile. The selection of approach should be individualized based on patient anatomy, clinician expertise, and resource availability.

Conclusion

The present comparative study, conducted at Government Medical College, Srinagar, over an 18-month period, evaluated the relative efficacy and safety of transforaminal epidural steroid injection (TFESI) and caudal epidural steroid injection (CESI) in the management of radiating lower back pain. Both approaches proved to be effective in alleviating pain and improving functional outcomes

among patients suffering from lumbar radiculopathy secondary to disc herniation or degenerative spinal disease.

Our findings revealed that TFESI provided more rapid and pronounced early relief of pain compared to CESI, as reflected by greater reductions in Visual Analogue Scale (VAS) scores and better Oswestry Disability Index (ODI) improvements during the initial follow-up period. The superiority of TFESI in the early stages can be attributed to its targeted delivery of corticosteroid directly adjacent to the affected nerve root, ensuring a high local concentration of the anti-inflammatory drug and faster resolution of nerve irritation.

However, with continued follow-up at 12 weeks, the differences between the two groups diminished, and both TFESI and CESI achieved comparable levels of pain relief and functional recovery. This convergence in outcomes suggests that CESI, though slower in onset, is capable of delivering effective long-term results when administered under proper guidance and dosage protocols.

An important observation from this study is that both techniques were associated with minimal complications. Only mild, transient side effects such as local soreness and minor headache were observed, without any major neurological or vascular events. This supports the established safety profile of epidural steroid injections when performed with appropriate precautions and fluoroscopic assistance.

The results of this study highlight the practical significance of both approaches. TFESI may be preferred in patients requiring faster symptomatic relief or in cases where the pathology is well localized to a specific nerve root. CESI, on the other hand, remains a safer and more versatile option, particularly for patients with altered anatomy, prior spinal surgeries, or those where transforaminal access is technically challenging.

While the sample size of 40 patients offers meaningful preliminary data, larger randomized controlled trials with extended follow-up periods are needed to assess the long-term comparative outcomes and recurrence rates. Additionally, future research should explore the cost-effectiveness and patient satisfaction aspects associated with both techniques to provide a more comprehensive understanding of their roles in clinical practice.

In conclusion, both transforaminal and caudal epidural steroid injections are valuable and effective components of non-surgical pain management in lumbar radiculopathy. TFESI offers quicker relief and targeted drug delivery, while CESI provides comparable long-term benefits with a lower risk of complications. The selection of technique should therefore be individualized, guided by patient characteristics, anatomical considerations, clinical expertise, and available resources.

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