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Therapeutic Effect of Computed Tomography-Guided Transforaminal Epidural Steroid Injection in Patients with Persistent Low Back Pain and Unilateral Radiculopathy due to Single-Level Lumbar Disc Prolapse: A Retrospective Cohort Study

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Abstract: ***This retrospective cohort study evaluated the efficacy and safety of computed tomography guided transforaminal epidural steroid injection in adults with persistent unilateral lumbar radiculopathy due to single level disc prolapse unresponsive to conservative therapy. Thirty patients underwent intervention and were assessed using Numeric Rating Scale and Oswestry Disability Index at baseline and follow up intervals up to three months. Significant reductions in pain and disability scores were observed with a mean pain reduction of approximately seventy percent at three months. No major complications were reported. The findings suggest that computed tomography guided transforaminal epidural steroid injection is a safe minimally invasive option for short to intermediate term symptom relief in carefully selected patients.***

Keywords: Lumbar Radiculopathy, Transforaminal Epidural Injection, Computed Tomography Guidance, Intervertebral Disc Herniation, Image Guided Intervention.

1. Introduction

Lumbar radiculopathy is a specific type of clinical presentation and experience of low back pain and it is primarily caused by prolapse of lumbar intervertebral discs [1]. According to the epidemiological research, it has been argued that between 60-80 percent of the population will complain of low back pain at some stage of their lives, with about 10-20 percent ending up becoming chronic or recurrent pain [2,3]. In the fast urbanizing world like India, sedentary lifestyles, prolonged sitting, occupational strain, obesity, and delays in seeking specialized healthcare facilities have added more pressure on the growing burden of lumbar spine disorders in the developing world [4].

Disc herniation happens as a result of annulus fibrosus degeneration and weakening and causes the nucleus pulposus to protrude or extrude into the spinal canal or neural foramina [5]. The resulting radicular pains can be explained by mechanical compression of the nerve root as well as the release of cytokines, tumor necrosis factor-alpha, phospholipase A2, prostaglandins, and nitric oxide, which are the result of herniated disc material [6]. The result of this inflammatory process is edema of the nerve roots, ischemia, and increased nociceptive sensitivity that are clinically presented as unilateral lower extremity radicular pain, paresthesia, and impairment of functions [7].

The imaging modality most suitable in the lumbar disc pathology assessment is magnetic resonance imaging (MRI) because it has a better contrast of soft tissues, multiplanar, as well as, non invasive imaging [8]. MRI can be used to precisely describe the degree of herniation of the disc, its type (bulge, protrusion, extrusion) and side, and measurement of nerve root compression, spinal canal loss and related degenerative alterations. Correlation between imaging findings and clinical symptoms is imperative in the selection of patients to undergo specific interventional procedures [9].

It is common knowledge that conservative method of treatment is the first-line management approach to lumbar radiculopathy and incorporates the use of non-steroidal anti-inflammatory drugs, muscle relaxants, physiotherapy, activity modification, and ergonomic correction [10]. Although most

of the patients have shown improvement in symptoms after 6-8 weeks, a significant number still complain of the presence of the pain after three months despite conservative treatment [11]. The long-term conservative treatment of such patients can cause chronic pain syndrome, a decrease in functional capacity, psychological distress, and deterioration of quality of life. Even though surgical repair like discectomy is recommended in few patients, it carries a greater cost, perioperative risks, postoperative morbidity, and inconsistent quality of long-term results [12].

Epidural steroid injection has also become a less invasive type of therapy modality that lies between conservative management and surgery. Epidural steroid injection is based on the nature of delivering corticosteroids to the affected nerve root to inhibit inflammatory mediators, decrease nerve root edema, and break the cycle of pain-inflammation [13]. Out of the many available epidural methods such as caudal, interlaminar and transforaminal, the transforaminal is the most anatomically accurate method because it can deliver medication to the pathology site as it locates the site in the neural foramen, which are the most precise anatomical sites [14]. This focused treatment means that larger concentration of drugs at the affected nerve root with lower volumes is achieved, thus improved clinical efficacy and less systemic effects is achieved [15].

Image guidance is vital in the accuracy of procedures and safety of the patient when performing transforaminal epidural steroid injection (TFESI). Fluoroscopy has traditionally been the most popular modality but computed tomography (CT) guidance has a number of specific benefits [16]. CT enables a better visualization of bony landmarks, neural foramina, epidural space, and vascular structures nearby, so as to be able to place the needle precisely in patients with distorted anatomy, severe degenerative changes, or postoperative changes [17]. Another benefit is CT guidance minimizes the possibility of inadvertent intravascular, intrathecal or intradiscal injection -complications that can have catastrophic neurological consequences [18].

CT-guided TFESI is a better procedure in terms of reproducibility, correct recording of needle pathway and final insertion point, and confidence in the procedure. CT guidance can be associated with comparatively increased radiation exposure as compared to fluoroscopy, but the importance of low dose regimes and low scan ranges has allayed the fears [19]. The increasingly close links between musculoskeletal and interventional radiology in pain management have placed CT-guided spinal intervention as a significant field of radiology practice [20].

Although the use of CT-guided TFESI is being increasingly used all over the globe, scarce information on the Indian subcontinent assessed its clinical efficacy in patients with lumbar disc prolapse. Majority of Indian researches have been in the form of fluoroscopy guided injections or surgery outcome or conservative management, but there are only few radiology-based outcome studies [21]. Moreover, differences in demographics of patients, lifestyle determinants, and access to healthcare highlight the necessity of the evidence that would be specific to each region to inform clinical practice. The literature on Indian radiology is there is a marked gap in literature about the systematic outcome measurement of CT-guided TFESI based on standardized pain and functional measurements.

2. Aim of the Study

The research question of this paper was to test the therapeutic effects on the use of computed tomography-guided transforaminal epidural steroid injection in individuals who experience persistent low back pain and the presence of unilateral lower extremity radicular pain of lumbar intervertebral disc prolapse refractory to at least three months of conservative management.

3. Research Question

CT-guided transforaminal epidural steroid injection of patients with unilateral lumbar radiculopathy due to single-level lumbar disc prolapse: does it result in a substantial reduction of pain as well as functional improvement?

4. Objectives

Primary Objective

Possible questions to be addressed include:

to assess the therapeutic effectiveness of computed tomography (CT) -guided transforaminal epidural steroid injection on patients with unilateral lower extremity radiculopathy and persistent low back pain who underwent at least three months of conservative therapy to no effect.

Secondary Objectives

- To determine the extent of pain relief after CT-guided transforaminal epidural steroid injection at the preset follow-up periods by use of standardized pain measurement scales.
- To determine the improvement of the functional outcome in relation to the intervention using pre-procedure and post-procedure functional outcome scores.
- To record and examine any complications or adverse events relating to the procedure involved in CT-guided transforaminal epidural steroid injection.

5. Materials and Methods

This is aimed at determining the therapeutic value of computed tomography-guided transforaminal epidural steroid injection in individuals with low back pain persistence and unilateral lumbar radiculopathy caused by a single intervertebral disc prolapse. The present study methodology was based on the thesis protocol and modified to fit a journal-based retrospective cohort study format and requirements.

5.1 Study Design

A retrospective cohort study was used in the current study. Clinical, imaging and procedural data of patients undergoing CT-guided transforaminal epidural steroid injection was previously recorded and analysed to identify the pain relief and functional outcomes after the intervention.

5.2 Study Setting

The research was conducted in the S.N. Medical College, Jodhpur, Department of Radiodiagnosis, which is the tertiary care teaching hospital with specific musculoskeletal and interventional radiology facilities.

5.3 Study Period

The research came into existence following the consent of the Institutional Ethical Committee. Data was collected retrospectively for procedures performed between Dec 2024 and August, 2025, and it involved patients who had already been undergoing the procedure within the stipulated period of the study.

5.4 Study Population

The target population of the study was patients who presented with:

- Chronic low back pain relating to unilateral lower extremity radicular symptoms, and
- Single-level lumbar intervertebral disc prolapses MRI.

Every patient who was included had received CT-guided transforaminal epidural steroid injection during his or her treatment.

5.5 Inclusion Criteria

The criteria a patient was required to meet in order to be included in the study were:

- The presence of lower back pain, which is persistent with radiculopathy on one side.
- Clinical symptoms associated with MRI evidence of single-level lumbar disc prolapse.
- Inability to respond to three months of conservative therapy, including analgesics and physiotherapy.

Patients that received CT guided transforaminal epidural steroid injection.

5.6 Exclusion Criteria

The patients who had any of the following conditions were excluded of the study:
Multilevel lumbar disc disease.

- Past lumbar spinal surgery.
- Spinal infection, malignancy, fracture.
- Coagulopathy or haemorrhage.
- Pregnancy
- Non-discogenic or bilateral radiculopathy pain.

5.7 Imaging Evaluation

Magnetic resonance imaging (MRI) of the lumbosacral spine was done on all patients before intervention. MRI was evaluated for:

- Level of disc prolapse
- Herniation in the form of a bulge (herniation), protrusion or extrusion.
- Side of nerve root involvement
- Volume of neural foraminal/ nerve root compression.

Clinical symptoms were matched with imaging findings so as to select the correct patient to be subjected to the targeted intervention.

5.8 CT Guided transforaminal epidural steroid injection methods

All the procedures were done by use of computed tomography under the supervision of skilled radiologists. The patients were put in a prone position in the CT table. A preliminary scout picture then followed by axial CT section was also carried out in order to be able to identify the right neural foramen at the level of the affected lumbar level.

A spinal needle was then placed through a posterolateral transforaminal approach towards the target nerve root under periodic monitoring by a CT. The detection of the right location of the needle in the neural foramen was checked on the CT pictures. Upon confirmation, a mixture of 1mL of 40mg/mL triamcinolone acetate and 3mL of 1% Lignocaine was injected slowly. Patients were followed briefly after the procedure and monitored for immediate complications. Procedures were performed using a low-dose CT protocol (90 kVp, 40mAs) to minimize radiation exposure.

5.9 Outcome Measures

The standardized assessment tools were used to evaluate clinical outcomes:

- Pain intensity: It was measured on the Numeric Rating Scale (NRS).
- Functional status was determined by the use of the Oswestry Disability Index (ODI).
- They were measured at baseline (before the procedure) and follow-up 1 weeks, 6 weeks and 3 months after the procedure.

5.10 Statistical Analysis

The data were imported into a Microsoft Excel sheet and statistical software was used in order to analyse the data. A sample size of 30 was deemed appropriate for this retrospective review of the specified timeframe, though a formal a priori power analysis was not conducted. Demographic and clinical characteristics were summarized by using descriptive statistics. Paired t-tests (or Wilcoxon signed-rank tests for non-parametric data) were used to compare pre-procedure and post-procedure pain and functional scores. A p- value below 0.05 was found statistically significant.

6. Results

6.1 Population and Demographic Characteristics of Study

The study involved 30 patients with persistent low back pain and unilateral radiculopathy that was attributed to single-level lumbar disc prolapse that had been confirmed by MRI.

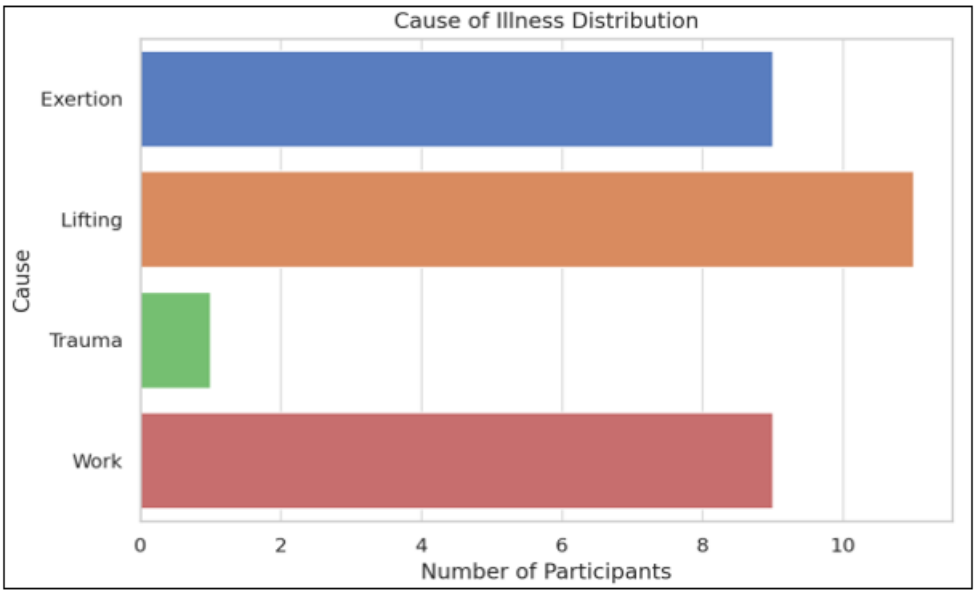
Table 1: Demographic Characteristics of the participants in the study (n = 30)

Variable	Value
Age (years)	30.7 ± 8.2 (Mean ± SD)
Gender	Male: 15 (50%), Female: 15 (50%)
Residence	Urban: 16 (53.3%), Rural: 14 (46.7%)
Education	Secondary: 12 (40%), Graduate: 18 (60%)
Occupation	Laborer: 10 (33.3%), Housewife: 8 (26.7%), Others: 12 (40%)

6.2 Clinical Characteristics of Baseline

Table 2: Baseline Clinical Profile

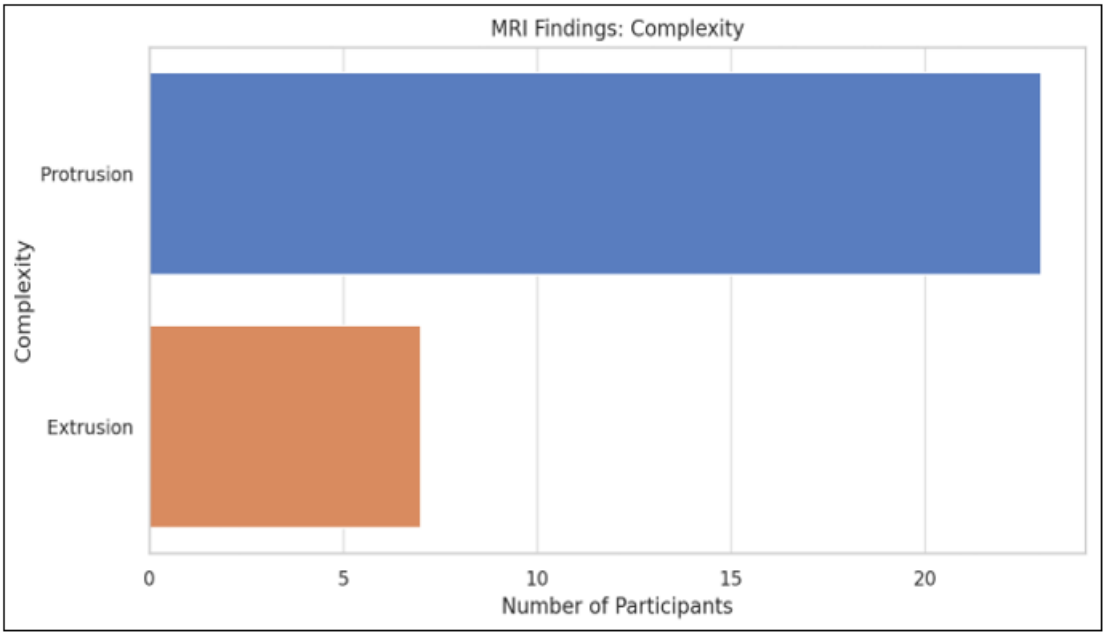
Variable	Value
Duration of symptoms (months)	7.2 ± 4.1
Etiology	Lifting: 11 (36.7%), Exertion: 8 (26.7%), Trauma: 6 (20%), Idiopathic: 5 (16.6%)
Comorbidities	None: 30 (100%)



6.3 Baseline MRI Findings

Table 3: Lumbar Disc Prolapse MRI Characteristics.

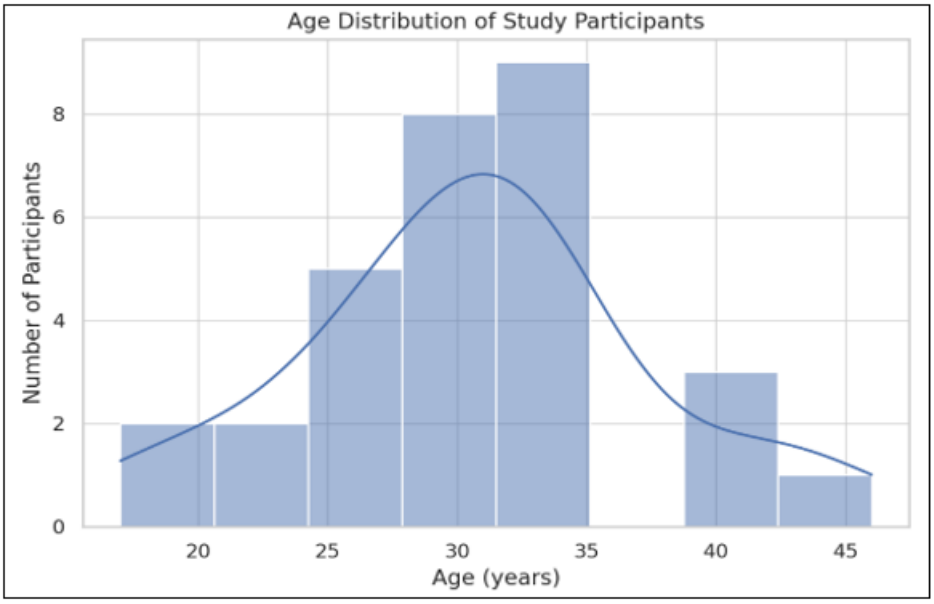
Variable	Value
Disc level	L4–L5: 21 (70%), L5–S1: 9 (30%)
Site of prolapse	Paracentral: 20 (66.7%), Foraminal: 6 (20%), Central + Paracentral: 4 (13.3%)
Morphology	Protrusion: 23 (76.6%), Extrusion: 7 (23.3%)
Size of prolapse	Small: 10 (33.3%), Medium: 14 (46.7%), Large: 6 (20%)
Nerve root relation	Abutting: 22 (73.3%), Compression: 8 (26.7%)



6.4 Age and Gender Distribution

Table 4: Age and Gender Distribution

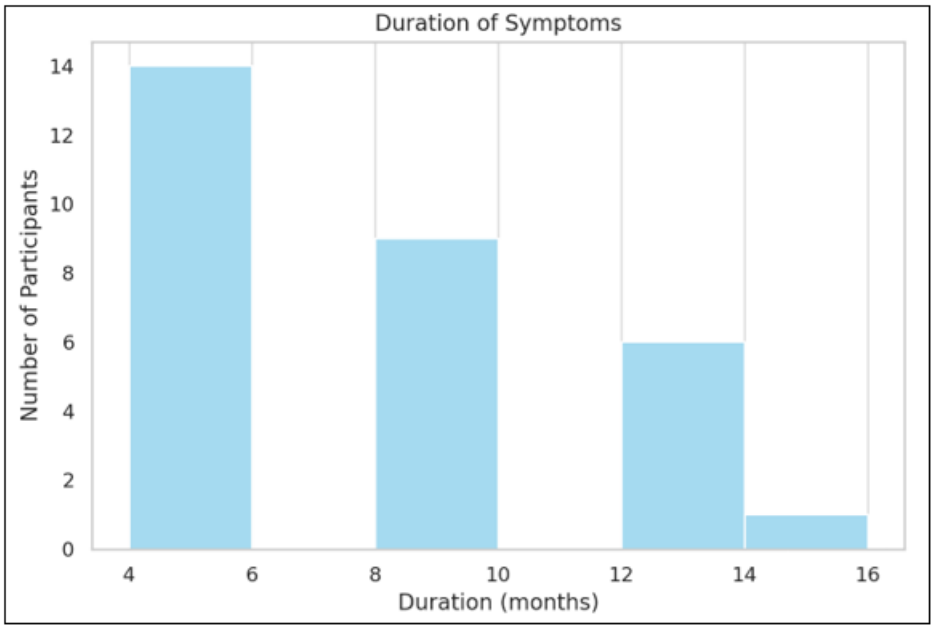
Age Group (years)	Male	Female	Total (%)
18–20	2	0	6.7
20–30	6	4	33.3
30–40	5	9	46.7
40–50	2	2	13.3



6.5 Duration of Symptoms

Table 5: TFESI Symptom Duration Before TFESI

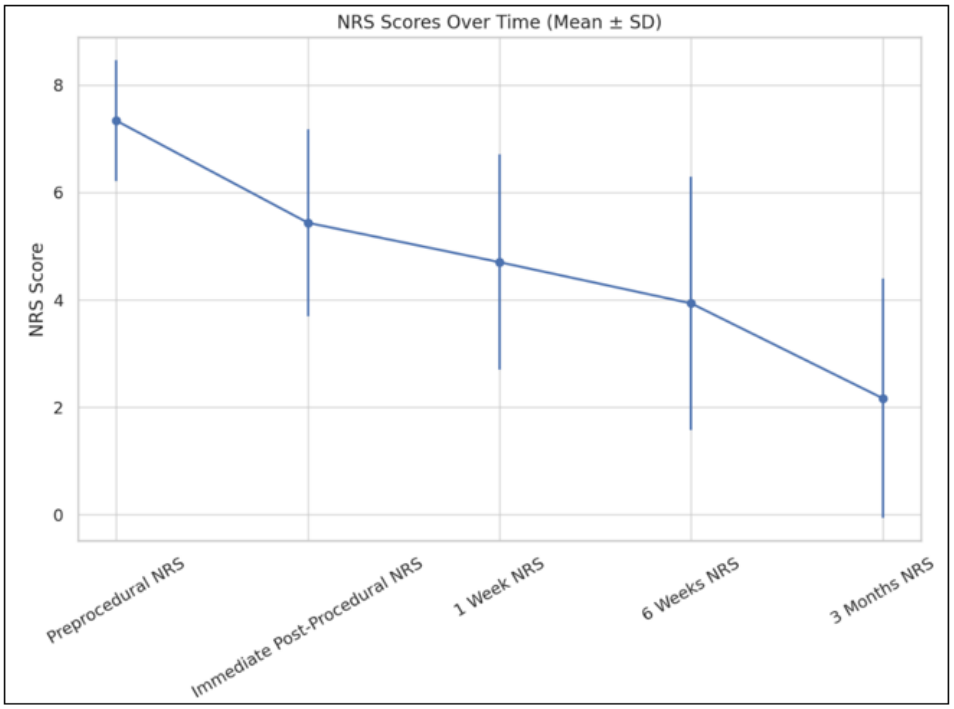
Duration	Patients (%)
< 6 months	14 (46.7%)
6–12 months	9 (30%)
> 12 months	7 (23.3%)



6.6 Main Outcome: NRS Pain Reduction

Table 6: Mean NRS Scores Over Time

Time Interval	Mean ± SD	Mean Difference	p-value
Baseline	7.33 ± 1.12	—	—
1 week	4.70 ± 2.00	2.63	<0.001
6 weeks	3.93 ± 2.36	3.4	<0.001
3 months	2.17 ± 2.23	5.17	<0.001



6.7 Dynamic Result: Oswestry Disability Index (ODI)

Table 7: Mean ODI Scores Over Time

Time Interval	Mean ± SD	Mean Difference	p-value
Baseline	26.20 ± 4.69	—	—
1 week	22.07 ± 5.59	4.13	<0.001
6 weeks	19.97 ± 6.27	6.23	<0.001
3 months	16.60 ± 6.91	9.6	<0.001

6.8 Complications and Other Interventions

a) No complications: 27 patients (90%)
b) Minor complications (n = 3):
   - Injection site soreness: 2
   - Mild headache: 1

No significant complications including infection, haemorrhage, neurological deterioration, intravascular or intrathecal injection were found.

- Repeat TFESI: It is necessary in 1 patient.
- Surgery: Necessary in 2 patients (extruded discs causing nerve root compression)
- Physiotherapy: 1 patient.

7. Discussion

Intervertebral disc prolapse-related lumbar radiculopathy has continued to be a major cause of pain and functional impairment to young and middle-aged adults. In the current research, the therapeutic effectiveness and safety of transforaminal epidural steroid injection (TFESI) were assessed in patients who had persistent unilateral radiculopathy without responding to conservative treatment. The results indicate that the pain and functional change is statistically significant and clinically meaningful, and has a good safety profile.

To evaluate the efficacy of pain management and functional outcomes, Clinical outcomes were evaluated by comparing pre-procedural and post-procedural NRS and ODI scores using appropriate statistical tests.

The major outcome measure showed that pain scores significantly dropped and remained low with the mean NRS of 7.33 changing to 4.70 at 1 week and 2.17 at 3 months. It is a 70.5 percent decrease in the intensity of pain, which suggests a short-term and medium-term effectiveness of CT-guided TFESI.

The trend in pain reduction was reflected in functional outcomes which were measured through Oswestry Disability Index (ODI). Even though the initial improvement was minimal at three months, there was a progressive and clinically significant functional recovery that was seen after three months with a 36.6% decrease in the mean ODI score. This slow yet protracted recovery is an indication that analgesics come before functional recovery, which is in line with the normal sequence of recovery after the resolution of nerve root inflammations.

The extent and trend of pain relief that was shown in this study are similar to past published Indian and global studies that have tested TFESI to lumbar radiculopathy. Some studies have reported considerable NRS/VAS improvements of 50-75% in 3 months especially those with disc protrusion and a shorter duration of symptoms [22,23].

Indian research has also shown that TFESI is effective in short to intermediate term analgesia particularly in single-level disc disease and no serious neurological loss [21]. These findings are corroborated in the present study in an Indian tertiary care radiology environment, which deals with the relative dearth of geographically specific CT-guided TFESI information.

There are a number of unique benefits of CT guidance as compared to blind or fluoroscopic methods. The direct visualization of the neural foramen, exiting nerve root, and needle pathway increases the accuracy of the procedure and reduces the chances of accidental intravascular or intrathecal injection.

The fact that there were no significant complications in the current study and that there was low occurrence of minor and self-limiting events have supported safety of CT-guided TFESI. Further, CT enables precise drug placement in even anatomically difficult levels like L45 without any effect on clinical outcome, which is demonstrated by similar outcome in disc levels.

The focus of the study population consisted of young adults and working-age adults, with most of them being affected by the socioeconomic burden of lumbar radiculopathy. The resulting functional improvement corresponded to pain reduction which decreased the disability and possibly postponed or even prevented the need to have surgery in most patients.

A small percentage of patients needed re-injection or surgical care, mainly the one with extruded discs, nerve root compression, and increased duration of the symptom, indicating the effectiveness of TFESI in the form of an intermediate treatment between conservative therapy and surgery.

The positive results can be explained by several factors. The specificity of deposition of corticosteroid into the nerve root inflammation site has probably led to the effective inhibition of inflammatory mediators and perineural edema difficult to achieve randomly. Patients with disc protrusion showed superior response than in patients with extrusion perhaps because of decreased mechanical compression and increased dominance of inflammation.

Subgroup analyses indicated a positive tendency in younger patients and the ones with shorter symptom duration, but not all of the differences were statistically significant. These results point to the possibility of early intervention and less progressed disc pathology to promote therapeutic outcome.

8. Limitations

The current research is limited to some degree. First, the retrospective cohort design does not allow to determine causal relationship and can be prone to selection and information biasing. Second, the sample size (n = 30) is rather small, which limits the generalizability of the results and minimizes the statistical power of subgroup analyses. Third, due to the short follow-up period (three months), it is impossible to evaluate the conditions of long-term pain treatment, rates of recurrence, and functional outcomes of CT-guided transforaminal epidural steroid injection. Lastly, treatment efficacy cannot be directly compared due to the lack of a control or comparison group, i.e., conservatively treated patients or receiving fluoroscopy-guided injections. These

limitations should be overcome in future prospective controlled studies with larger cohorts and extended follow-up.

9. Conclusion

CT-guided transforaminal epidural steroid injection is a viable, minimally invasive treatment modality for patients with persistent low back pain and unilateral radiculopathy related to single-level lumbar disc prolapse who fail to respond to conservative therapy. The procedure led to a significant short-term decrease in pain scores and a clinically significant change in functional disability at the three-month follow-up.

CT guidance allows for the accurate positioning of the needle and specific delivery of drugs, which contributes to a high safety profile with few complications. The results substantiate the use of CT-guided TFESI as a useful image-guided procedure in radiology, providing a successful intermediate treatment that can decrease disability in properly chosen patients. However, larger prospective controlled studies with extended follow-up are required to confirm long-term efficacy.

10. Future Scope / Recommendations

Further research agenda needs to be on prospective, randomized controlled trials with a view of establishing greater therapeutic efficacy of CT-guided transforaminal epidural steroid injections and reducing biases that arise in retrospective analyses. It is suggested that future studies that incorporate a larger sample size and a longer period of follow-up will be needed to assess the effects of long-term pain relief, functional outcomes, recurrence rates, and the sustainability of the treatment effects.

Also a comparison between CT-guided, fluoroscopy-guided and ultrasound-guided epidural injection would serve to elucidate the comparative merits in regard to accuracy, safety, radiation exposure and clinical outcome. Patient selection and treatment plans might be further refined by incorporating standardized outcome measures and imaging-based outcome prognostic factors in image-guided spine interventions.

Ethics Statement
The research took place after getting the consent of the institutional ethical committee of S.N. medical college, Jodhpur (SNMC/IEC/2025/Plan/1060). Since it was a retrospective study and analysis of previously available clinical and imaging data were being done, the ethical committee approved a waiver of informed consent.

Conflict of Interest
The authors address that they have no conflict of interest.

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