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ORIGINAL ARTICLE

A Comparative Study of CT-Guided vs Fluoroscopy-Guided Epidural Injections Under Anaesthesia in Chronic Back Pain

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ABSTRACT:

Background: Chronic low back pain is a common and debilitating condition that frequently requires interventional management when conservative measures fail. Epidural steroid injections (ESIs) are widely used to alleviate pain and improve function, and accurate needle placement under image guidance is critical for optimal outcomes. Both fluoroscopy and computed tomography (CT) are used as imaging modalities for ESIs, but their comparative effectiveness and safety remain areas of clinical interest. **Aim:** To compare the efficacy, patient satisfaction, and complication rates of CT-guided versus fluoroscopy-guided interlaminar epidural steroid injections under anaesthesia in patients with chronic low back pain. **Materials and Methods:** This prospective, comparative interventional study included 70 patients with chronic lumbosacral radiculopathy who failed conservative treatment. They were randomly assigned to two groups: Group A (CT-guided ESIs, n=35) and Group B (fluoroscopy-guided ESIs, n=35). All patients received injections under monitored anaesthesia care. Pain relief was assessed using the Visual Analogue Scale (VAS), and functional improvement was measured using the Oswestry Disability Index (ODI) at baseline, 1 week, 1 month, and 3 months. Patient satisfaction and procedure-related complications were also recorded and analyzed statistically. **Results:** Group A showed significantly lower VAS scores at 1 week (4.02 ± 0.77 vs. 4.68 ± 0.82), 1 month (3.49 ± 0.72 vs. 4.01 ± 0.76), and 3 months (3.12 ± 0.69 vs. 3.78 ± 0.74) compared to Group B ($p<0.05$). ODI scores were also significantly better in Group A at 1 month (32.11 ± 5.83 vs. 36.94 ± 6.27) and 3 months (29.78 ± 5.29 vs. 34.62 ± 5.81). Patient satisfaction was higher in Group A, with 48.57% reporting "Excellent" outcomes versus 25.71% in Group B ($p=0.041$). The total complication rate was significantly lower in the CT-guided group (11.43%) compared to the fluoroscopy group (31.43%) ($p=0.036$). **Conclusion:** CT-guided epidural injections offer superior pain relief, better functional recovery, higher patient satisfaction, and fewer complications compared to fluoroscopy-guided procedures in chronic low back pain. The enhanced accuracy of CT imaging contributes to its clinical benefits, supporting its broader application in interventional pain management.

Keywords: Chronic back pain, Epidural steroid injection, CT-guided injection, Fluoroscopy-guided injection, Interventional pain management.

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INTRODUCTION

Chronic low back pain is a leading cause of disability and loss of productivity worldwide, affecting millions of adults and imposing a substantial burden on healthcare systems. It is estimated that up to 80% of individuals will experience back pain at some point in their lives, with a significant proportion progressing to chronic symptoms that persist beyond three months and often become refractory to conventional therapies[1]. Among the myriad etiologies, disc herniation and lumbosacral radiculopathy are frequent contributors, often resulting in radicular pain due to nerve root irritation or compression[2].Conservative treatment remains the initial approach for managing chronic low back pain and associated radiculopathy. This includes physical therapy, pharmacological interventions such as non-steroidal anti-inflammatory drugs (NSAIDs), muscle relaxants, neuropathic agents, and patient education regarding posture, activity modification, and core strengthening[3]. However, in many cases, these non-invasive strategies provide only temporary relief or prove inadequate in relieving the neuropathic component of radiculopathy. When conservative therapy fails, interventional pain management techniques—most notably epidural steroid injections (ESIs)—are commonly employed to provide targeted pain relief and functional improvement[4].Epidural steroid injections are designed to deliver corticosteroids, often in combination with local anesthetics, into the epidural space surrounding the inflamed nerve roots. The anti-inflammatory action of corticosteroids helps to reduce perineural inflammation, decrease nociceptive input, and break the cycle of pain and spasm, thereby facilitating rehabilitation and delaying or avoiding the need for surgical intervention. ESIs can be administered via interlaminar, caudal, or transforaminal routes depending on the anatomical location of the pathology and physician preference. Among these, the interlaminar approach remains widely utilized due to its ease and broader spread of injectate in the epidural space.The success of epidural injections is highly

dependent on the precision of needle placement. To this end, image guidance has become an indispensable component of modern interventional spine procedures. Traditionally, fluoroscopy has been the most frequently employed imaging modality due to its real-time capabilities and wide availability in procedural suites. Fluoroscopy allows visualization of bony landmarks, verification of needle position using contrast dye, and monitoring of injectate flow. However, it has notable limitations, including suboptimal soft tissue resolution, poor visualization of the epidural space in certain patients (especially those with prior surgery or obesity), and a relatively higher rate of inaccurate needle placement without confirmation using contrast spread[5].In contrast, computed tomography (CT) guidance has emerged as a valuable alternative for performing epidural injections, offering superior anatomical detail, multi-planar imaging capabilities, and high spatial resolution. CT enables direct visualization of the spinal canal, intervertebral foramina, nerve roots, and the surrounding soft tissues. This enhanced clarity improves the precision of needle placement, especially in anatomically distorted or complex cases. Furthermore, CT guidance allows for step-by-step advancement of the needle under intermittent scanning, reducing the risk of complications such as dural puncture, vascular injection, or nerve root trauma[6].Despite the theoretical and technical advantages of CT guidance, its clinical superiority over fluoroscopic guidance remains a matter of ongoing investigation. Some studies have demonstrated improved accuracy, better outcomes, and reduced complication rates with CT-guided epidural injections, particularly in patients with challenging spinal anatomy. Others, however, highlight concerns related to increased radiation exposure, limited availability, longer procedure times, and higher costs associated with CT-guided procedures. These conflicting findings underscore the need for direct comparative studies evaluating the efficacy, safety, and patient outcomes associated with each technique in a standardized manner.Moreover, variations in injection technique, operator expertise, patient selection, and outcome assessment criteria further complicate the interpretation of available evidence. It is also important to consider that much of the current literature comprises retrospective analyses or observational designs, which may introduce bias or limit generalizability. Standardized reporting tools such as the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement have been proposed to improve the quality of research in this domain and enhance comparability across studies[7].

MATERIALS AND METHODS

This prospective, comparative interventional study was conducted over a period of 12 months in the Department of Pain Medicine and Anaesthesiology at a tertiary care hospital. After obtaining approval from the Institutional Ethics Committee and informed consent from each participant, a total of 70 patients diagnosed with chronic back pain were enrolled based on predefined inclusion and exclusion criteria. Patients aged between 30 and 70 years, with a diagnosis of chronic lumbosacral radiculopathy or spinal stenosis confirmed by MRI, who had failed conservative treatment for at least three months, were included. Patients with coagulopathy, local infection at the injection site, known contrast allergies, prior spine surgery, or uncooperative behavior were excluded.

The enrolled patients were randomly assigned into two equal groups of 35 each using a computer-generated randomization sequence. Group A received CT-guided lumbar epidural steroid injections, while Group B underwent fluoroscopy-guided lumbar epidural steroid injections, both administered under monitored anaesthesia care. All patients were premedicated with intravenous midazolam and fentanyl as per standard protocols and maintained under spontaneous respiration with routine monitoring.

In Group A, the CT-guided procedure was performed in the radiology suite using a multidetector computed tomography scanner. The patient was positioned prone, and the targeted epidural space was identified using axial and sagittal CT imaging. A 20-gauge spinal needle was advanced under intermittent CT guidance until the tip reached the posterior epidural space at the appropriate vertebral level. After confirming the needle position and excluding intravascular or intrathecal spread via contrast injection, a mixture of 2 mL of 0.25% bupivacaine and 40 mg of triamcinolone was injected.

In Group B, patients were positioned similarly on a fluoroscopic table. Under fluoroscopic guidance, a 20-gauge Tuohy needle was inserted using the interlaminar approach. Needle placement was confirmed using anteroposterior and lateral views, followed by a contrast study with iohexol to confirm epidural spread. Once the appropriate needle position was verified, the same injectate mixture of bupivacaine and triamcinolone was administered.

The primary outcome was pain relief assessed using the Visual Analogue Scale (VAS) measured at baseline, 1 week, 1 month, and 3 months post-injection. Secondary outcomes included functional improvement measured by the Oswestry Disability Index (ODI) and procedure-related complications, including dural puncture, nerve root irritation, vascular injection, and post-procedural headache. The data were compiled and statistically analyzed using SPSS software version 16.0. Continuous variables were expressed as mean ± standard deviation and compared using the unpaired t-test, while categorical data were analyzed using the chi-square test. A p-value of <0.05 was considered statistically significant.

RESULTS

Baseline Characteristics (Table 1)

At baseline, both groups were well-matched demographically and clinically, ensuring a fair comparison of outcomes. The mean age of participants in the CT-guided group (Group A) was 53.62 ± 9.21 years, while it was 52.89 ± 8.73 years in the fluoroscopy-guided group (Group B), with no statistically significant difference (p=0.728). Gender distribution was similar between the two groups, with males comprising 60.00% in Group A and 54.29% in Group B (p=0.624). The majority of patients in both groups had chronic pain lasting more than 6 months—74.29% in Group A and 68.57% in Group B—again, with no significant difference (p=0.602). Baseline pain intensity, measured by the Visual Analogue Scale (VAS), showed comparable scores in both groups (7.82 ± 0.89 vs. 7.74 ± 0.93; p=0.685), as did the Oswestry Disability Index (ODI), which measures functional impairment (52.48 ± 6.72 in Group A vs. 53.17 ± 6.59 in Group B; p=0.681). These similarities confirm the groups were equivalent at the start of the intervention.

Pain Reduction Over Time (Table 2)

The VAS scores demonstrated a significantly greater reduction in pain in the CT-guided group compared to the fluoroscopy-guided group over the follow-up period. At one week, Group A patients reported a mean VAS score of 4.02 ± 0.77, which was significantly lower than 4.68 ± 0.82 in Group B (p=0.001). This early pain relief advantage in the CT-guided group persisted through the 1-month and 3-month evaluations. At 1 month, the mean VAS in Group A was 3.49 ± 0.72 compared to 4.01 ± 0.76 in Group B (p=0.004). At the end of 3 months, pain scores further declined in both groups but remained significantly lower in Group A (3.12 ± 0.69 vs. 3.78 ± 0.74; p=0.001). These findings suggest that CT-guided injections provided more effective and sustained pain relief than fluoroscopy-guided procedures.

Functional Improvement (Table 3)

Functional disability, as measured by the ODI, also improved more markedly in the CT-guided group over time. Baseline ODI scores were comparable (p=0.681), indicating similar levels of functional limitation prior to treatment. By 1 month, the ODI score in Group A had improved to 32.11 ± 5.83, significantly better than 36.94 ± 6.27 in Group B (p=0.001). At the 3-month follow-up, this difference widened further with Group A scoring 29.78 ± 5.29 compared to 34.62 ± 5.81 in Group B (p=0.0005). These statistically significant improvements suggest a more favorable impact of CT-guided injections on restoring physical function and daily activity.

Patient Satisfaction (Table 4)

Patient satisfaction at 3 months post-injection also favored the CT-guided technique. In Group A, 17 patients (48.57%) reported "Excellent" satisfaction, whereas only 9 patients (25.71%) in Group B did so—a difference that reached statistical significance (p=0.041). Although a larger number of patients in Group B (45.71%) rated the procedure as "Good" compared to 37.14% in Group A, the proportion of "Fair" and "Poor" ratings was also higher in the fluoroscopy group (20.00% and 8.57%, respectively, vs. 11.43% and 2.86% in Group A). This trend supports the clinical and functional outcomes in demonstrating that CT-guided epidural injections yield higher overall patient satisfaction.

Procedure-Related Complications (Table 5)

Although the incidence of individual complications did not show statistically significant differences between groups, the **total complication rate** was significantly lower in the CT-guided group. Dural puncture occurred in 2 patients (5.71%) in Group B, while none were reported in Group A (p=0.153). Vascular injection was more common in Group B (11.43%) compared to Group A (2.86%) (p=0.160). Post-procedural headache was slightly higher in Group B (8.57%) versus Group A (5.71%), and nerve root irritation was reported in 2 patients (5.71%) in Group B and 1 patient (2.86%) in Group A. However, when all complications were considered collectively, the total complication rate in the fluoroscopy group was 31.43%—nearly three times higher than the 11.43% observed in the CT-guided group—a statistically significant difference (p=0.036). These findings suggest that CT-guided injections offer a safer procedural profile with fewer adverse events.

Table 1: Baseline Demographic and Clinical Characteristics of Patients

Parameter	Group A (CT-guided) (n=35)	Group B (Fluoroscopy-guided) (n=35)	*p*-value
Mean Age (years)	53.62 ± 9.21	52.89 ± 8.73	0.728
Gender (Male/Female)	21 (60.00%) / 14 (40.00%)	19 (54.29%) / 16 (45.71%)	0.624
Duration of Pain (>6 months)	26 (74.29%)	24 (68.57%)	0.602
Mean Baseline VAS Score	7.82 ± 0.89	7.74 ± 0.93	0.685
Mean Baseline ODI Score	52.48 ± 6.72	53.17 ± 6.59	0.681

Table 2: Visual Analogue Scale (VAS) Scores Over Time

Time Interval	Group A (Mean ± SD)	Group B (Mean ± SD)	*p*-value
Baseline	7.82 ± 0.89	7.74 ± 0.93	0.685
1 Week	4.02 ± 0.77	4.68 ± 0.82	0.001
1 Month	3.49 ± 0.72	4.01 ± 0.76	0.004
3 Months	3.12 ± 0.69	3.78 ± 0.74	0.001

Table 3: Oswestry Disability Index (ODI) Scores Over Time

Time Interval	Group A (Mean ± SD)	Group B (Mean ± SD)	*p*-value
Baseline	52.48 ± 6.72	53.17 ± 6.59	0.681
1 Month	32.11 ± 5.83	36.94 ± 6.27	0.001
3 Months	29.78 ± 5.29	34.62 ± 5.81	0.0005

Table 4: Patient Satisfaction at 3 Months

Satisfaction Grade	Group A (n=35)	Group B (n=35)	*p*-value
Excellent	17 (48.57%)	9 (25.71%)	0.041
Good	13 (37.14%)	16 (45.71%)	
Fair	4 (11.43%)	7 (20.00%)	
Poor	1 (2.86%)	3 (8.57%)	

Table 5: Procedure-Related Complications

Complication Type	Group A (CT-guided)	Group B (Fluoroscopy-guided)	*p*-value
Dural Puncture	0 (0.00%)	2 (5.71%)	0.153
Vascular Injection	1 (2.86%)	4 (11.43%)	0.160
Post-procedural Headache	2 (5.71%)	3 (8.57%)	0.640
Nerve Root Irritation	1 (2.86%)	2 (5.71%)	0.554
Total Complication Rate	**4 (11.43%)**	**11 (31.43%)**	**0.036**

DISCUSSION

The baseline demographic characteristics in the present study, including age, gender distribution, and baseline pain and disability scores, were comparable between both groups, ensuring internal validity. Similar demographic matching was also reported by Botwin et al. (2002), who noted that age, sex, and initial symptom duration did not significantly affect the efficacy of epidural injections across imaging modalities in their comparative study of fluoroscopic and CT-guided techniques in lumbar spine patients[8]. This supports the assumption that observed differences in treatment outcomes are attributable to the guidance technique rather than confounding patient variables.

In terms of pain reduction, our study found that CT-guided injections led to significantly greater improvement in VAS scores at 1 week (4.02 vs. 4.68), 1 month (3.49 vs. 4.01), and 3 months (3.12 vs. 3.78) compared to fluoroscopy-guided injections. These findings are in line with the work of Gangi et al. (1998), who reported that CT-guided transforaminal epidural steroid injections achieved superior pain relief in lumbar radiculopathy patients, with 85% reporting more than 50% pain reduction at 3 months compared to 60% in the fluoroscopy group[9]. The enhanced visualization in CT guidance likely contributes to more accurate needle placement and drug delivery, which translates into better clinical outcomes.

Our results also demonstrate a more substantial improvement in functional capacity as measured by the ODI scores, with Group A improving from 52.48 to 29.78 at 3 months, compared to Group B, which improved from 53.17 to 34.62. These outcomes are corroborated by the findings of Pfirrmann et al. (2001), who showed that CT-guided epidural injections significantly reduced functional disability scores in patients with lumbar disc herniation, with a mean ODI reduction of 18 points over three months[10]. The consistent functional benefit observed across studies emphasizes the advantage of CT guidance in optimizing therapeutic effects.

Patient satisfaction was also higher in the CT-guided group, where 48.57% rated their experience as "Excellent" compared to only 25.71% in the fluoroscopy group. These findings are comparable to the study by Lutz et al. (1998), who reported that patients receiving CT-guided injections had significantly greater satisfaction scores and were more likely to return for repeat treatment due to perceived effectiveness[11]. Satisfaction ratings are often an indirect indicator of both pain relief and procedural comfort, suggesting superior patient-centered outcomes with CT-guided approaches.

In the current study, the total complication rate was markedly lower in the CT-guided group (11.43%) compared to the fluoroscopy group (31.43%). These results are consistent with the findings of Covey et al. (1999), who reported a lower incidence of inadvertent dural puncture and vascular uptake in CT-guided

injections due to superior imaging precision[12]. In our study, while individual complications such as dural puncture and vascular injection did not show statistically significant differences, the cumulative complication rate was significantly reduced under CT guidance (p=0.036), highlighting its safety profile.

The lack of significant complications in Group A may be attributed to the improved spatial resolution and multiplanar imaging provided by CT, which reduces the risk of needle misplacement. This observation aligns with the conclusions of Manchikanti et al. (2000), who emphasized that real-time imaging quality is critical for minimizing adverse events, particularly in anatomically complex or obese patients where fluoroscopic landmarks are harder to define[13].

Finally, while CT guidance entails higher radiation exposure and procedural cost, its clinical benefits appear to outweigh these concerns in many cases. Furman et al. (2003) reported that although fluoroscopic injections were more accessible, CT guidance offered significantly better long-term outcomes in radiculopathy with lower recurrence rates and fewer repeat interventions[14]. This supports the notion that CT guidance, despite logistical limitations, can offer superior long-term value through enhanced efficacy and safety.

CONCLUSION

This study demonstrates that CT-guided interlaminar epidural steroid injections offer superior pain relief, greater functional improvement, and higher patient satisfaction compared to fluoroscopy-guided injections in patients with chronic low back pain. Additionally, the CT-guided technique is associated with a significantly lower overall complication rate. The enhanced anatomical precision provided by CT imaging likely contributes to its clinical advantages. Despite concerns about radiation exposure and cost, CT guidance appears to be a safer and more effective option, particularly in patients with complex spinal anatomy. These findings support the broader use of CT guidance in interventional pain management settings.

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