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Short-term pain and disability outcomes after therapeutic transforaminal selective nerve-root block for single-level lumbar disc prolapse

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Abstract

Background: To evaluate short-term changes in pain and disability, procedure-related adverse events, and subsequent interventions, after a single therapeutic fluoroscopy-guided transforaminal selective nerve-root block (SNRB) in patients with single-level unilateral lumbar disc prolapse.

Methods: In this prospective observational study, 38 patients aged 18–50 with MRI-confirmed single-level lumbar disc prolapse and unilateral radiculopathy received a single fluoroscopy-guided transforaminal SNRB targeting the symptomatic nerve root (80 mg triamcinolone acetonide and 1 mL 0.5% bupivacaine) after ≥3 weeks of failed conservative care. Pain (VAS) and disability (ODI) were evaluated at baseline, 3 weeks, and 3 months alongside adverse events, repeat injections, and emergency surgery.

Result: Mean VAS decreased from 8.05 ± 0.61 at baseline to 2.74 ± 0.79 at three weeks and 1.66 ± 0.91 at three months. Mean ODI decreased from 67.87 ± 9.52% to 26.70 ± 6.85% and 13.14 ± 9.66% at the corresponding follow-ups. Changes across time were statistically significant for both outcomes ($p < 0.001$). Three-month improvement did not differ significantly by sex or disc level. No immediate or delayed procedure-related adverse event was recorded, and no participant required a repeat injection or emergency surgery during the three-month follow-up.

Conclusion: A single therapeutic transforaminal SNRB was associated with substantial short-term reductions in pain and disability. The findings do not establish comparative efficacy or procedural safety and require confirmation in larger controlled studies.

Keywords: Injections, Epidural, Intervertebral Disc Displacement, Radiculopathy, Lumbar Vertebrae, Pain Measurement, Triamcinolone Acetonide

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Introduction

Lumbar intervertebral disc herniation is a frequent cause of lumbosacral radiculopathy. Symptoms reflect both mechanical nerve-root compression and local inflammatory activity and may include dermatomal leg pain, sensory disturbance, reflex change, and, less often, motor weakness.

Low back pain is common, although lumbar disc herniation accounts for only a proportion of presentations. Symptomatic herniation occurs most often in working-age adults and commonly involves the L4-L5 or L5-S1 level. Many episodes of radiculopathy improve with non-operative care; image-guided injection or surgery may be considered when pain remains severe or disabling, or when neurological status requires escalation.[1-4]

Macnab's 1971 report of nerve-root infiltration during the evaluation of persistent radicular symptoms is commonly cited as the historical basis of fluoroscopically directed selective nerve-root injection.[5] Terminology remains inconsistent. A diagnostic SNRB generally uses a small volume of local anesthetic to test whether a specific root is the pain generator. By contrast, a therapeutic lumbar transforaminal epidural injection delivers corticosteroid, usually with local anesthetic, through the neural foramen into the periradicular and epidural region. Because the present protocol used a 3 mL steroid-containing injectate for treatment, the procedure is best understood anatomically as a therapeutic transforaminal epidural/periradicular injection directed to a selected nerve root; the term SNRB is retained to reflect common clinical usage, not diagnostic selectivity.[3,6] Corticosteroid may suppress inflammatory activity around the irritated root, while bupivacaine provides temporary neural blockade; these mechanisms may reduce radicular pain and facilitate activity.[3,7] The study evaluated pain, disability, adverse events, repeat injection, and emergency surgery over three months.

Methods

This prospective, single-arm pre-post observational study was conducted in the Orthopedics Department of a tertiary care center. Recruitment began after approval by the Institutional Review Committee on 15 August 2024 (Ref: 2081/82/02) and continued through July 2025. All eligible patients presenting during the study period were enrolled. Inclusion criteria were: (a) low back pain of less than three months with unilateral, single-level radicular symptoms; (b) concordant clinical and MRI evidence of nerve-root compression; (c) persistent, function-limiting symptoms despite at least three weeks of conservative treatment; and (d) age 18-50 years. Exclusion criteria were lumbar canal stenosis, clinical or radiological instability, motor deficit of MRC grade 3 or less, previous lumbar surgery, and spondylodiscitis. The three-week threshold was a prespecified study criterion rather than a claim that three weeks is a universal guideline standard. It allowed intervention for severe, function-limiting radicular pain after an initial non-operative trial. The NASS guideline supports contrast-enhanced fluoroscopic guidance and short-term benefit from transforaminal epidural steroid injection but does not stipulate a mandatory six-week minimum before injection; timing should be individualized in the absence of progressive neurological deficit or another urgent indication.[4] The mean symptom duration at enrollment was 7.2 ± 2.1 weeks.

Forty-one patients entered the study. Three (7.3%) were lost to follow-up, leaving 38 patients who completed all assessments and were included in the complete-case analysis.

Intervention definition and procedural setting

All procedures were performed by a fellowship-trained spine surgeon in the operation theatre under C-arm guidance and were observed by the other investigators. The target was the symptomatic nerve root identified by concordant dermatomal symptoms, neurological findings, and MRI compression, rather than the disc-space label alone. Thus, a paracentral L4-L5 prolapse compressing the traversing L5 root was treated at the L5 root, while an L5-S1 prolapse compressing the S1 root was treated at the S1 root; foraminal or extraforaminal lesions were directed to the exiting root. A single therapeutic injection contained 2 mL triamcinolone acetonide (40 mg/mL; total dose 80 mg) mixed with 1 mL bupivacaine (0.5%).

Sample Size Calculation and Outcome Measures:

An a priori paired-samples t-test calculation was performed in G*Power version 3.1.9.7 for the primary outcome, change in VAS score. In the absence of a local pilot estimate or a directly comparable prior effect estimate, Cohen's conventional large within-participant standardized effect (dz = 0.8) was selected to represent a clinically substantial change.[8] This was a pragmatic assumption, and the calculation was intended to power the primary pre-post comparison rather than subgroup or safety analyses. With a two-sided alpha of 0.05 and 80% power, the minimum required sample was 15 participants. All eligible patients presenting during the study period were enrolled to improve precision and allow for attrition; 41 entered the study and 38 completed follow-up.

Pain was assessed using the Visual Analog Scale (VAS), a 10 cm horizontal line on which 0 represents "no pain" and 10 represents "the worst pain imaginable".[9] Scores were interpreted as 0 = no pain, 1–3 = mild pain, 4–6 = moderate pain, and 7–10 = severe pain.

Disability was assessed using the Oswestry Disability Index (ODI), version 2.0, a 10-item questionnaire in which each item is scored from 0 to 5.[10] The summed

score was doubled and expressed as a percentage: 0–20% = minimal disability, 21–40% = moderate disability, 41–60% = severe disability, 61–80% = crippled, and 81–100% = bed-bound or possible symptom exaggeration.

Technique for therapeutic transforaminal nerve-root block:

The patient was positioned prone, and the target level and side were confirmed using anteroposterior (AP) and lateral fluoroscopic views. After aseptic preparation, the skin and subcutaneous tissues were infiltrated with 10 mL of 1% lignocaine approximately 5-8 cm from the midline. A 22-gauge spinal needle was advanced using the traditional supraneural/subpedicular 'safe triangle' approach. Anatomically, this triangle is bounded superiorly by the inferior border of the pedicle, medially by the posterolateral vertebral body, and inferolaterally by the course of the exiting nerve root. The nerve root and foraminal vessels are not directly visualized on fluoroscopy; their positions are inferred from bony landmarks, and needle placement is verified by contrast spread. In the AP view, the needle tip was placed just caudal to the pedicle at approximately the 6 o'clock position; in the lateral view, it was maintained in the posterior-to-middle portion of the neural foramen. For an S1 block, the needle was directed to the superolateral aspect of the first sacral foramen. The expression 'safe triangle' is an anatomic convention intended to reduce direct neural injury and does not imply vascular safety. After negative aspiration, 1 mL of radiopaque contrast was injected under real-time fluoroscopy. AP and lateral images were assessed for periradicular/epidural spread and for absence of intravascular or intrathecal flow. The needle was repositioned if the contrast pattern was unsatisfactory. Paresthesia was not accepted as the sole confirmation of position; marked pain or persistent paresthesia prompted withdrawal or repositioning. Once satisfactory placement was confirmed, the medication was injected slowly.[6,11]

VAS and ODI were recorded before the procedure and at three weeks and three months. Immediate and delayed adverse events were actively sought, including vasovagal reaction, intravascular uptake, dural puncture or post-dural-puncture headache, allergic reaction, infection, new or worsening neurological deficit, and steroid-related symptoms. The injection was performed as a same-day outpatient/day-care procedure. Non-invasive blood pressure, pulse rate, oxygen saturation, verbal responsiveness, and neurological status were monitored. Oxygen, airway equipment, emergency drugs, and resuscitation facilities were immediately available. Patients were observed for 30 minutes and discharged after neurological reassessment. NSAIDs were permitted only as rescue medication, and patients received a standardized physiotherapy or home-exercise prescription after injection.

Data were analyzed using SPSS version 26. Categorical variables were summarized as number and percentage. VAS and ODI scores across baseline, three weeks, and three months were compared using one-way repeated-measures analysis of variance. Independent-samples t-tests were used to compare three-month improvement scores by sex and disc level. Pearson's correlation coefficient (r) was used to examine selected relationships between continuous variables. Analyses were based on participants with complete follow-up data. Subgroup and correlation analyses were exploratory and were interpreted cautiously. A two-sided p value < 0.05 was considered statistically significant.

Results

Of the 41 patients enrolled, 38 (92.7%) completed three months of follow-up and were included in the complete-case analysis. The cohort comprised 23 men (60.5%) and 15 women (39.5%). Disc prolapse was located at L4-L5 in 21 patients (55.3%) and at L5-S1 in 17 (44.7%).

All patients presented with low back pain and radicular leg pain. Symptoms involved the left leg in 22 patients (57.9%) and the right leg in 16 (42.1%). Numbness was reported by 28 patients (73.7%), and objective sensory deficit was documented in 18 (47.4%). A diminished deep tendon reflex was identified on examination in one patient (2.6%); this was a neurological sign rather than a presenting symptom or motor deficit. Table 1 summarizes the demographic and clinical findings.

Pain decreased substantially over follow-up. Mean VAS was 8.05 ± 0.61 at baseline, 2.74 ± 0.79 at three weeks, and 1.66 ± 0.91 at three months, corresponding to a total mean reduction of 6.39 points. The change across time was statistically significant ($p < 0.001$).

Functional disability improved in parallel. Mean ODI decreased from 67.87 ± 9.52% at baseline to 26.70 ± 6.85% at three weeks and 13.14 ± 9.66% at three months, an overall reduction of 54.73 percentage points. The change across time was statistically significant ($p < 0.001$).

Three-month improvements in VAS and ODI did not differ significantly by sex or by disc level (L4-L5 versus L5-S1).

Patients reporting numbness had higher baseline disability but reached follow-up outcomes similar to those without numbness. In an exploratory descriptive comparison, patients with objective sensory loss showed higher residual VAS at three weeks and three months and higher ODI at three months. Because subgroup sizes were small and no multivariable adjustment was performed, this pattern should be regarded as hypothesis-generating rather than a confirmed prognostic association.

Table 1. Demographic and Clinical Characteristics (N = 38)

Characteristic	N (%) / Mean ± SD
Age (years)	38.4 ± 8.7
Sex	
Male	23 (60.5%)
Female	15 (39.5%)
Level of Prolapse	
L4-L5	21 (55.3%)
L5-S1	17 (44.7%)
Side of Symptoms	
Left	22 (57.9%)
Right	16 (42.1%)
Clinical Symptoms and Signs	
Back pain	38 (100%)
Radicular leg pain	38 (100%)
Numbness	28 (73.7%)
Objective sensory deficit	18 (47.4%)
Diminished deep tendon reflex (examination sign)	1 (2.6%)
Duration of symptoms (weeks)	7.2 ± 2.1

Table 2. Exploratory comparison of three-month VAS and ODI improvement by sex and disc level

Comparison groups	Outcome	t statistic	df	p value
Sex (men vs. women)	VAS improvement at 3 months	0.42	36	0.677
	ODI improvement at 3 months	0.51	36	0.615
Disc level (L4-L5 vs. L5-S1)	VAS improvement at 3 months	0.38	36	0.709
	ODI improvement at 3 months	0.29	36	0.771

The prespecified subgroup comparisons and exploratory correlation analyses are presented in Tables 2 and 3.

Baseline VAS correlated strongly with baseline ODI ($r = 0.78$, $p < 0.001$), and longer symptom duration correlated with higher baseline VAS ($r = 0.65$, $p < 0.001$). Symptom duration was not shown to predict follow-up response. Higher residual VAS at three weeks was associated with higher ODI at three months ($r = 0.82$, $p < 0.001$); this was a bivariate association and does not establish predictive validity. No immediate or delayed procedure-related adverse event was recorded. No participant required emergency surgery, repeat SNRB, or another epidural injection during the three-month follow-up.

Table 3. Bivariate correlations among study variables

Correlation	Pearson's r	p-value	Interpretation
Baseline VAS vs. Baseline ODI	0.78	<0.001	Strong positive
Symptom Duration vs. Baseline VAS	0.65	<0.001	Moderate-to-strong positive
3-Week VAS Score vs. 3-Month ODI Score	0.82	<0.001	Strong positive

VAS and ODI scores across the three assessment points are presented in Table 4.

Discussion

The principal finding was a large, statistically significant reduction in pain and disability over three months after a single therapeutic transforaminal SNRB. Mean VAS decreased by 6.39 points and ODI by 54.73 percentage points. The direction and timing of improvement are consistent with prospective reports of early benefit after fluoroscopy-guided nerve root injection. Nevertheless, the uncontrolled pre-post design cannot distinguish the observed change from natural recovery, regression to the mean, placebo or contextual effects, and concurrent care.[12-14]

Procedural terminology is important. A diagnostic SNRB is intended to identify a symptomatic nerve root and generally uses a small volume of local anesthetic. The present 3 mL steroid-containing injection was therapeutic and functioned anatomically as a transforaminal epidural/periradicular injection. Because injectate may spread beyond a single segment, these findings should not be interpreted as evidence of diagnostic selectivity.[3,6] The observed improvement is biologically plausible because corticosteroid may attenuate local inflammatory signaling while bupivacaine provides temporary neural blockade.[7]

Objective sensory loss showed a descriptive pattern of greater residual pain and disability. Longer symptom duration, however, was associated with worse baseline pain rather than with poorer treatment response.

Table 4. VAS and ODI scores across follow-up (N = 38)

Outcome measure	Baseline mean ± SD	3-week mean ± SD	3-month mean ± SD	Total improvement	F statistic (df)	p value
VAS score (0-10)	8.05 ± 0.613	2.74 ± 0.795	1.66 ± 0.909	6.39 points	112.5 (2, 74)	<0.001
ODI score (%)	67.87 ± 9.52	26.70 ± 6.85	13.14 ± 9.66	54.73 percentage points	245.8 (2, 74)	<0.001

Higher residual VAS at three weeks was also associated with higher ODI at three months. These observations may inform future prognostic research, but the small, unadjusted analyses do not establish independent predictors or show that earlier injection produces better outcomes. Published cohorts have reported sensory findings, symptom duration, and early response as possible prognostic factors, although results remain inconsistent.[14,15]

Sex and disc level did not modify the observed response. Disc level is, however, a crude anatomical category. Herniation morphology (protrusion, extrusion, or sequestration), location, size, and grade of nerve-root compression may influence response to transforaminal injection. Prior imaging studies suggest that herniation location and compression severity may be more informative than the disc-space level alone, whereas the prognostic value of morphology is inconsistent.[15,16] These MRI features were not stratified in the present study and remain potential confounders.

Complication reporting is essential because transforaminal injection can involve intravascular uptake, vasovagal or steroid-related reactions, dural puncture, infection, and, rarely, serious neurological injury. No procedure-related adverse event, repeat injection, or emergency operation occurred in this cohort. A sample of 38 patients is far too small to establish safety or exclude rare harm. Real-time contrast fluoroscopy, maintenance of patient responsiveness, readiness for adverse events, and systematic follow-up remain necessary, particularly when a particulate corticosteroid such as triamcinolone is used.[11,17,18] The three-month observation period cannot determine whether later repeat injection or surgery was required.

This study has several limitations. It was conducted at a single center, used a small complete-case cohort, and lacked a control or comparator group. The sample-size calculation assumed a large within-participant effect and was not designed to support subgroup analyses or safety conclusions. Follow-up was limited to three months, preventing assessment of recurrence, long-term surgery avoidance, or later repeat injections. Disc morphology, herniation location, and compression grade were not analyzed. Exploratory subgroup and correlation findings were unadjusted and may be unstable. Although rescue NSAIDs and post-injection exercise were standardized in principle, adherence and rescue-medication use were not quantified. The study was not blinded, and the precision of the adverse-event estimate is limited. Finally, use of 80 mg particulate triamcinolone should be considered when comparing these findings with protocols that use lower doses or non-particulate corticosteroid.

Conclusion

Among 38 patients with single-level unilateral lumbar disc prolapse, a single therapeutic fluoroscopy-guided transforaminal SNRB was associated with substantial short-term reductions in pain and disability. No procedure-related adverse event, repeat injection, or emergency surgery was recorded during three months, but the cohort was too small to establish safety. Larger controlled studies with standardized co-interventions, detailed MRI classification, complete effect estimates, and longer follow-up are required.

Conflict of Interest: None
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