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Clinical Effectiveness of Intradiscal Ozone Therapy with or Without Periforaminal Steroid Injection in Lumbar Disc Herniation: Revisiting an Underutilized Treatment

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Learning Point of the Article:

Fluoroscopy-guided intradiscal oxygen-ozone therapy effectively relieves pain and disability in lumbar disc herniation, while adjunctive periforaminal steroid injection accelerates early clinical recovery with minimal complications.

Abstract

Introduction: Lumbar disc herniation (LDH) often causes low back pain and radiculopathy, leading to significant disability. Most of the patients improve with conservative treatment, but some require interventional procedures. Intradiscal ozone therapy is a minimally invasive treatment that reduces inflammation and dehydrates discs, lowering disc volume and decompressing nerve roots. Despite these benefits, its clinical use is limited. This study evaluates the effectiveness of intradiscal ozone therapy, with or without periforaminal steroid injection, in patients with symptomatic LDH.

Materials and Methods: This retrospective cohort hospital-based observational study included 100 patients with clinically and radiologically confirmed LDH who had persistent symptoms despite conservative therapy. All patients underwent fluoroscopy-guided intradiscal injection of an oxygen-ozone mixture. Patients with significant radicular symptoms also received a periforaminal steroid injection. Clinical outcomes were assessed using the Visual Analog Scale (VAS) for pain and the Oswestry Disability Index (ODI) for functional disability at baseline and at 1-, 3-, and 6-months post-procedure. Treatment outcomes and complications were recorded.

Results: Pain and functional status improved during follow-up. VAS and ODI scores consistently decreased from baseline, indicating substantial pain relief and greater functional capacity. Patients treated with both intradiscal ozone therapy and periforaminal steroid injection experienced faster early relief of radicular symptoms than those receiving ozone therapies alone. Both groups maintained improvement at final follow-up. No major procedure-related complications occurred.

Conclusion: Fluoroscopy-guided intradiscal ozone therapy is a safe, effective, minimally invasive treatment for LDH. Adding a periforaminal steroid injection may speed early relief in patients with pronounced radicular pain. Intradiscal ozone therapy remains valuable yet underused for the management of LDH.

Keywords: Fluoroscopy-guided intradiscal ozone, lumbar disc herniation, ozone nucleolysis, periforaminal, refractory radicular pain.

Introduction

Low back pain is one of the most prevalent musculoskeletal disorders worldwide and a leading cause of disability and socioeconomic burden, affecting nearly 60–80% of individuals during their lifetime [1]. Lumbar disc herniation (LDH) is a common cause of lumbosacral radiculopathy, with an estimated

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annual incidence of 5–20 cases/1,000 adults, most frequently affecting individuals between the third and fifth decades of life [2]. Herniation of the nucleus pulposus through defects in the annulus fibrosus results in mechanical compression and inflammatory irritation of adjacent nerve roots, producing radicular pain, sensory disturbances, and functional disability [3].

Although most of the patients improve with conservative management, including analgesics, physiotherapy, and activity modification, approximately 10–20% develop persistent symptoms requiring interventional or surgical treatment [4]. Surgical discectomy remains the standard intervention for refractory cases or progressive neurological deficits; however, it is associated with potential complications such as infection, dural tears, nerve injury, and recurrent disc herniation [5]. Therefore, minimally invasive procedures have gained increasing attention as alternatives that may provide effective symptom relief while reducing surgical morbidity.

Intradiscal oxygen-ozone therapy has emerged as a promising minimally invasive modality for the management of LDH. The technique involves injection of a regulated oxygen-ozone mixture into the affected intervertebral disc under imaging guidance, leading to oxidative degradation of proteoglycans within the nucleus pulposus, disc dehydration, and reduction in herniated disc volume [6]. In addition to mechanical decompression, ozone demonstrates anti-inflammatory, analgesic, and immunomodulatory effects that contribute to symptomatic improvement [7]. Previous studies have reported significant reductions in pain and disability following intradiscal ozone therapy, with low complication rates, supporting its use as an alternative to surgery in selected patients [8]. The procedure can be performed under local anesthesia using fluoroscopic or computed tomography guidance, allowing outpatient management with reduced procedural morbidity [9].

Radicular symptoms in LDH are mediated not only by mechanical compression but also by inflammatory cytokines released from degenerated disc material. Periforaminal steroid injections are therefore widely used to reduce perineural inflammation and nerve root edema. Combining intradiscal ozone therapy with periforaminal steroid injection may provide synergistic therapeutic benefits by addressing both mechanical and inflammatory mechanisms [8,9]. Despite increasing evidence supporting its safety and effectiveness, intradiscal ozone therapy remains underutilized in routine clinical practice in many regions. Therefore, the present study aimed to evaluate the clinical effectiveness of intradiscal ozone therapy, with or without periforaminal steroid injection, in patients with symptomatic LDH refractory to conservative treatment.

Materials and Methods

Study design and setting

This retrospective cohort, hospital-based observational study was conducted in patients who underwent percutaneous fluoroscopy-guided intradiscal ozone therapy, with or without adjunctive periforaminal steroid injection, for the management of symptomatic LDH. Patient data were obtained from the electronic medical records of the Department of Orthopaedics and Spine Surgery at Shree Narayana Hospital, Raipur, Chhattisgarh. Data collection and analysis were performed following approval from the Institutional Ethics Committee of Shree Narayana Hospital with Approval No. (SNH/IEC/Cert./SPINE1.1/2026). All study procedures adhered to the ethical principles outlined in the Declaration of Helsinki and its subsequent amendments. A total of 100 consecutive patients presenting with lumbar radiculopathy secondary to magnetic resonance imaging (MRI)-confirmed LDH, treated between January 2022 and December 2024, were included in the analysis. A consecutive sampling strategy was employed, wherein all eligible patients treated during the study who satisfied the predefined inclusion and exclusion criteria were included. Consequently, the final study cohort comprised 100 patients. Owing to the retrospective observational design of the study, no formal a priori sample size calculation was performed. Patients were retrospectively categorized according to the treatment they had received. The decision to administer

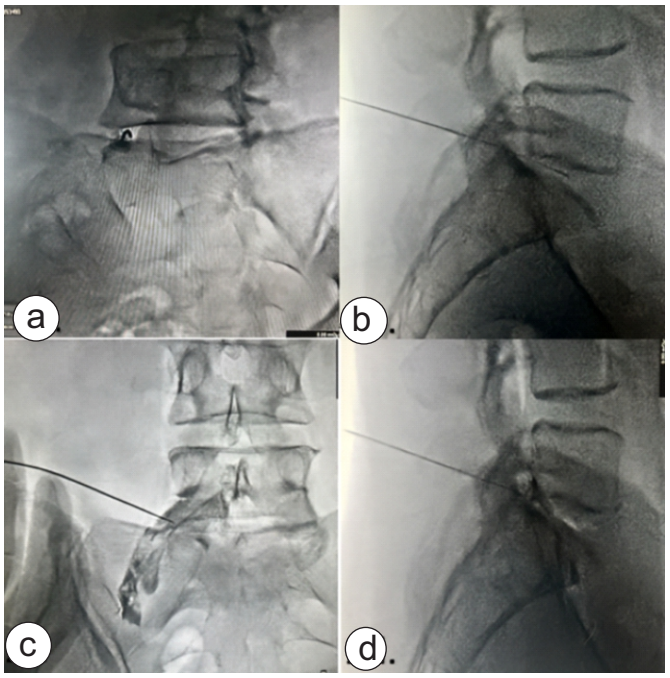

Figure 1: Fluoroscopic images of spinal needle inserted in L5-S1 intradiscal space. (a) Oblique fluoroscopic view demonstrating posterolateral needle advancement toward the L5-S1 intradiscal space. (b) Lateral fluoroscopic view confirming needle placement within the posterior third of the disc. (c) Post-contrast anteroposterior fluoroscopic view demonstrating appropriate intradiscal spread of contrast material. (d) Post-contrast lateral fluoroscopic view confirming adequate intradiscal distribution prior to ozone injection.

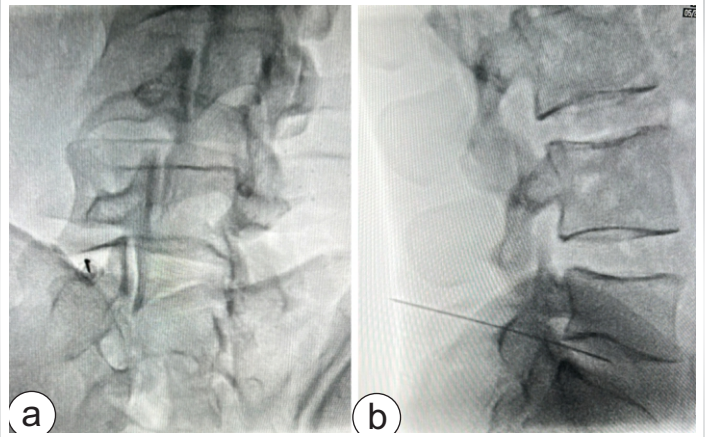

Figure 2: Fluoroscopic-guided periforaminal needle placement prior to steroid injection. (a) Oblique fluoroscopic view demonstrating posterolateral needle advancement toward the neural foramen at the target level (arrow indicating needle tip position adjacent to the exiting nerve root). (b) Lateral fluoroscopic view confirming appropriate periforaminal needle placement within the neural foramen prior to administration of steroid and local anesthetic.

intradiscal ozone therapy alone or in combination with a periforaminal corticosteroid and local anesthetic injection was made by the treating spine surgeon based on the patient's clinical presentation, severity of radicular symptoms, neurological findings, and MRI characteristics. Accordingly, Group 1 comprised patients treated with intradiscal ozone therapy alone, whereas Group 2 included patients who received intradiscal ozone therapy combined with a periforaminal corticosteroid and local anesthetic injection.

Patient selection

Patients presenting with low back pain accompanied by unilateral or bilateral radiculopathy suggestive of LDH were screened for eligibility. The diagnosis was established based on detailed clinical assessment and MRI findings demonstrating disc herniation corresponding to the patient's clinical symptoms and neurological findings. Eligible participants included patients aged 18–70 years with MRI-confirmed single-level LDH, particularly at the L4-L5 or L5-S1 level, presenting with low back pain with or without radiculopathy, as supported by clinical examination and imaging findings. Patients were required to have persistent symptoms for at least 6 weeks–3 months despite adequate conservative management, including pharmacological therapy, physiotherapy, and activity modification. Additional inclusion criteria included a Visual Analog Scale (VAS) pain score greater than 4, absence of previous lumbar spine surgery, and no history of interventional pain procedures within the preceding 6 months. Patients were excluded if they had progressive neurological deficits, cauda equina syndrome, sequestered or significantly migrated disc fragments requiring surgical intervention, or multilevel symptomatic disc disease. Additional exclusion criteria included previous lumbar spine surgery at the affected level, systemic infection, uncontrolled systemic illness, spinal malignancy, vertebral fracture, calcified disc herniation, coagulation disorders or ongoing anticoagulant therapy, hemorrhagic diathesis, glucose-6-phosphate dehydrogenase deficiency, pregnancy, or refusal to participate in the study.

Procedure technique

All procedures were performed under strict aseptic conditions and fluoroscopic guidance using a C-arm fluoroscopy system (Siemens Healthineers, Erlangen, Germany). The skin was prepared with povidone–iodine solution, and vital parameters were continuously monitored. Patients were placed in the prone position on a radiolucent operating table, with a pillow under the abdomen to reduce lumbar lordosis. After identifying the target level using anteroposterior, lateral, and oblique fluoroscopic views, the skin and subcutaneous tissues were infiltrated with 1% lidocaine. A 22-gauge, 15-cm spinal needle was advanced into the affected intervertebral disc through a posterolateral approach under fluoroscopic guidance. Proper needle placement in the center of the nucleus pulposus was confirmed using oblique, lateral, and post-contrast fluoroscopic views as shown in Fig. 1. Subsequently, 3–5 mL of an oxygen-ozone (O2-O3) mixture (ozone concentration 25–30 μg/mL) was generated using a medical ozone generator (Ozonosan Alpha Plus, Dr. Hänsler GmbH, Iffezheim, Germany). In patients with more severe or persistent radicular pain, as determined by the treating spine surgeon based on clinical examination and MRI findings, an additional periforaminal injection of dexamethasone (8 mg) combined with 1 mL of 0.05% bupivacaine was administered adjacent to the affected nerve root (Group 2). Needle placement within the neural foramen was confirmed fluoroscopically using oblique and lateral views before drug administration, as shown in Fig. 2. All procedures were performed by an experienced spine surgeon.

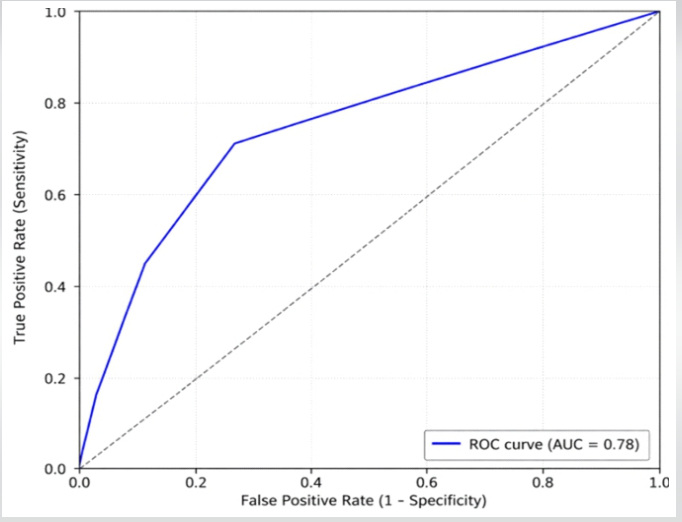

Figure 3: Receiver operating characteristic (ROC) curve analysis receiver operating characteristic. ROC curve assessing the ability of intradiscal ozone therapy combined with periforaminal steroid injection to predict clinically significant pain relief (≥50% reduction in Visual Analog Scale at 6 months). The area under the curve was 0.78, indicating moderate to good predictive accuracy.

Patients were observed for about 1 h after the procedure and discharged the same day, with advice on short-term rest, gradual mobilization, and physiotherapy.

Outcome measures

Clinical outcomes were assessed using the VAS and the Oswestry Disability Index (ODI). Pain intensity was evaluated using the 10-cm VAS, where 0 represents no pain, and 10 represents the worst imaginable pain, as originally described by Huskisson [10]. Functional disability was assessed using the ODI, a validated questionnaire consisting of 10 sections, with scores expressed as percentages ranging from 0% (no disability) to 100% (maximum disability), as described by Fairbank and Pynsent [11]. Baseline assessments were performed before the procedure, and follow-up evaluations were conducted at 1-, 3-, and 6-months post-procedure. Clinical improvement was defined as a ≥50% reduction in the VAS score accompanied by a corresponding reduction in the ODI score. Procedure-related complications, including infection, discitis, neurological deterioration, allergic reactions, and other adverse events, were also systematically documented.

Statistical analysis

The data collection was conducted using electronic medical records, which contain socio-demographic and clinical history as well as outcome details of the patients. Statistical analysis was performed using Statistical Package for the Social Sciences software. Continuous variables, such as VAS and ODI scores, were reported as mean ± standard deviation. Changes in clinical scores between baseline and follow-up visits were analyzed using paired t-tests or repeated-measures analysis of variance as appropriate. Categorical variables were expressed as frequencies and percentages. A $P < 0.05$ was considered statistically significant.

Results

Baseline demographic

A total of 100 patients completed the study, with 50 patients in Group 1 (intradiscal ozone therapy alone) and 50 patients in Group 2 (intradiscal ozone therapy combined with periforaminal steroid injection). The mean age of the cohort was 45.6 ± 11.2 years (range 18–70 years), with 56% males and 44% females. The most commonly affected disc levels were L4-L5 (58%) and L5-S1 (42%). Baseline demographic and clinical characteristics, including VAS and ODI scores, were comparable between groups ($P > 0.05$), confirming successful randomization as shown in Table 1.

Pain and functional outcomes

Both groups (Group 1, n = 50; Group 2, n = 50) demonstrated statistically significant reductions in VAS and ODI scores over follow-up. In Group 1, mean VAS decreased from 7.8 ± 1.1 at baseline to 4.2 ± 1.0 at 1 month, 2.9 ± 0.9 at 3 months, and 2.5 ± 0.8 at 6 months, representing a 68% reduction at 6 months. In Group 1, ODI improved from 56.3 ± 9.5 at baseline to 38.6 ± 7.8 at 1 month, 29.4 ± 6.5 at 3 months, and 27.1 ± 6.0 at 6 months. In Group 2, patients receiving combined therapy showed a faster and more pronounced improvement. VAS decreased from 7.7 ± 1.2 at baseline to 3.5 ± 0.9 at 1 month, 2.2 ± 0.7 at 3 months, and 1.9 ± 0.6 at 6 months (75% reduction at 6 months). In Group 2, ODI improved from 55.8 ± 10.2 at baseline to 34.2 ± 6.9 at 1 month, 25.1 ± 5.8 at 3 months, and 23.5 ± 5.3 at 6 months. Between-group comparisons at 6 months revealed a mean difference in VAS scores of 0.6 (95% confidence interval [CI]: 0.2–1.0, $P < 0.05$), and a mean difference in ODI scores of 3.6 (95% CI: 1.5–5.7, $P < 0.05$), indicating that the addition of periforaminal steroid injection produces a clinically meaningful and statistically robust enhancement in both early and sustained outcomes, as described in Tables 2 and 3.

Time-dependent improvement

The rate of improvement was faster in Group 2, with a 55% reduction in VAS by 1 month compared to 46% in Group 1.

Table 1: Baseline demographic and clinical characteristics of patients

Parameter	Group 1: Ozone only (*n*=50)	Group 2: Ozone+Steroid (*n*=50)	*P*-value
Age (years, mean±SD)	46.1±10.9	45.2±11.6	0.62
Sex (M/F)	28/22	28/22	1
Disc level L4–L5/L5–S1	30/20	28/22	0.68
Baseline VAS (mean±SD)	7.8±1.1	7.7±1.2	0.72
Baseline ODI (mean±SD)	56.3±9.5	55.8±10.2	0.78

Visual Analog Scale, ODI: Oswestry disability index

Table 2: VAS scores during follow-up

Time point	Group 1: Ozone only	Group 2: Ozone + steroid	*P*-value
Baseline	7.8±1.1	7.7±1.2	0.72
1 Month	4.2±1.0	3.5±0.9	0.01
3 Months	2.9±0.9	2.2±0.7	0.003
6 Months	2.5±0.8	1.9±0.6	0.002

Table 3: Oswestry Disability Index (ODI) scores during follow-up			
Time point	Group 1: Ozone only	Group 2: Ozone + steroid	*P*-value
Baseline	56.3±9.5	55.8±10.2	0.78
1 Month	38.6±7.8	34.2±6.9	0.01
3 Months	29.4±6.5	25.1±5.8	0.004
6 Months	27.1±6.0	23.5±5.3	0.002

Similarly, ODI improvement at 1 month was 39% in Group 2 versus 31% in Group 1, indicating accelerated early functional recovery with adjunctive periforaminal steroid injection as shown in Table 4.

Receiver operating characteristic (ROC) curve analysis

To evaluate the predictive value of combined therapy for achieving clinically meaningful pain relief, an ROC curve was constructed using ≥50% VAS reduction at 6 months as the outcome. In our cohort, ROC analysis yielded an area under the curve (AUC) of 0.78, indicating moderate discriminative ability for identifying patients achieving clinically meaningful pain reduction (≥50% VAS improvement) and supporting its potential usefulness in guiding patient selection, as shown in Fig. 3. This analysis shows that patients receiving combined therapy are more likely to achieve substantial VAS reduction than those receiving ozone therapy alone.

Complications

No major procedure-related complications occurred. Minor adverse events included transient local pain at the injection site in 6 patients (6%) and mild post-procedural muscle spasm in 4 patients (4%), both of which resolved spontaneously within 24–48 h. No patient experienced infection, neurological deficit, or systemic complications, and no additional interventions were required, as shown in Table 5.

Table 4: Procedure-related complications			
Complication	Group 1 (*n*=50)	Group 2 (*n*=50)	Total (*n*=100)
Transient local pain	3 (6%)	3 (6%)	6 (6%)
Mild post-procedural spasm	2 (4%)	2 (4%)	4 (4%)
Infection	0	0	0
Neurological deficit	0	0	0
Systemic complications	0	0	0
Frequency of minor and major complications in both groups. No serious adverse events were observed. Data are presented as number of patients (%)			

Discussion

LDH represents a significant cause of chronic low back pain and radiculopathy, affecting a substantial portion of the adult population and imposing a high burden on quality of life and functional capacity [1]. The pathological process involves herniation or extrusion of the nucleus pulposus, which not only mechanically compresses the adjacent nerve roots but also triggers a cascade of inflammatory mediators, including interleukins (IL) and tumour necrosis factor-alpha (TNF-α), that amplify pain perception and contribute to nerve root irritation [2,3]. While initial management relies on conservative approaches such as analgesics, structured physiotherapy, and activity modification, a subset of patients with persistent radicular pain or functional limitation necessitates minimally invasive interventions or surgical therapy [4,5].

In the present study, both groups exhibited significant improvement in pain and disability scores over 6 months. Group 1, which received ozone therapy alone, demonstrated a mean VAS reduction of 68% and an ODI improvement of 52%, whereas Group 2, receiving ozone therapy with adjunctive periforaminal steroid injection, achieved a VAS reduction of 75% and an ODI improvement of 58%. Early improvement at 1 month was more pronounced in Group 2 (VAS reduction 55% vs. 46%), highlighting the benefit of combined therapy in rapidly reducing radicular pain. These findings are in concordance with previous studies, including Paoloni et al. [8] and Muto et al. [12], which demonstrated superior early pain control and functional improvement when peri radicular steroid therapy was combined with intradiscal ozone therapy.

Comparative analysis of prior literature further supports our results. Summarizes key studies evaluating intradiscal ozone therapy for LDH, highlighting consistent efficacy in pain reduction (60–75%) and functional improvement (ODI 50–55%), with a low rate of adverse events [9,13,14]. Several studies, including meta-analyses by Steppan et al. [9], have confirmed the safety and effectiveness of this minimally invasive approach, while studies assessing combined ozone and steroid therapy demonstrate that adjunctive steroid administration enhances early pain relief and accelerates functional recovery. ROC analysis yielded an AUC of 0.78, indicating that combined therapy demonstrates moderate discriminative ability for identifying patients achieving clinically meaningful pain reduction (≥50% VAS improvement) [9].

Intradiscal ozone therapy has emerged as a safe and effective minimally invasive treatment for symptomatic LDH,

Table 5: Comparative analysis of previous studies on intradiscal ozone therapy for lumbar disc herniation

Study	Intervention	Sample size	Follow-up	Outcomes (VAS/ODI) (%)	Key findings	Complications
Paoloni et al., 2009 [8]	Intramuscular O_2–O_3	60	6 months	Pain and disability improved	Significant reduction in pain and disability compared with simulated treatment	No adverse events reported
Muto et al., 2004 [12]	Intradiscal and intraforaminal O_2–O_3	2,200	6–18 months	Clinical success: 80% at 6 months; 75% at 18 months	Sustained clinical improvement in lumbar disc herniation	No significant complications reported
Steppan et al., 2010 [9]	O_2–O_3 therapy	Meta-analysis	Various	Significant improvement in pain and function	Overall favorable efficacy and safety	Low complication rate
Andreula et al., 2003 [14]	Intradiscal and periganglionic O_2–O_3 ± corticosteroid/local anesthetic	600	6 months	Pain and functional improvement	Effective minimally invasive treatment for lumbar disc herniation	No major complications reported
Gallucci et al., 2007 [16]	Intradiscal/intraforaminal O_2–O_3 + corticosteroid	159	6 months	Significant improvement in pain and disability	Favorable outcomes compared with steroid treatment alone	No major complications reported
Magalhaes et al., 2012 [17]	Percutaneous O_2–O_3 therapy	Systematic review/meta-analysis	Various	Improvement in pain and disability	Favorable clinical outcomes with low morbidity	Low morbidity
Liguori et al., 2018 [18]	Fluoroscopy-guided intradiscal O_2–O_3 (5 mL; 27–30 µg/mL) + periradicular O_2–O_3, steroid and local anesthetic	52	2 and 6 months	ODI improvement: 76%; pain improvement: 78% at 6 months	Significant reduction in pain and disability; ozone nucleolysis was considered a safe, minimally invasive treatment	No complications recorded
Bhatia et al., 2019 [19]	Percutaneous O_2–O_3	39	1, 6 and 12 months	At 12 months: ODI 68%; leg-pain VAS 64%; back-pain VAS 61% improvement	Significant improvement in pain and function	No adverse events/device-related complications
Zhang et al., 2016 [22]	O_2–O_3 + corticosteroid	85	6 months	VAS improvement	Combined therapy provided favorable pain relief	Transient muscle spasm
Rahimzadeh et al., 2018 [23]	Percutaneous intradiscal O_2–O_3	60	6 months	Improvement in pain and disability	Significant improvement in pain and functional outcomes compared with baseline	No major complications reported
Present study	O_2–O_3 ± corticosteroid	100	6 months	VAS ↓68/75%; ODI ↓52/58%	Combined therapy demonstrated greater early improvement in pain and disability	Transient local pain (6%); muscle spasm (4%)

combining mechanical decompression with biochemical anti-inflammatory effects. Adjunctive periforaminal steroid injection suppresses perineural inflammation and reduces nerve root edema, thereby facilitating early pain relief and functional recovery [15,16]. Mechanically, ozone oxidizes the proteoglycan matrix within the nucleus pulposus, leading to disc volume reduction and alleviation of nerve root compression. Biochemically, ozone decreases pro-inflammatory cytokines such as IL-1β, IL-6, and TNF-α, thereby modulating local inflammation and nociception [6,7,17].

Safety outcomes in this study were favourable, with only minor transient complications reported, including local injection site pain (6%) and post-procedural muscle spasm (4%), both resolving spontaneously without sequelae. No serious complications, neurological deficits, or infections occurred. These observations are consistent with prior studies and support the favourable safety profile of intradiscal ozone therapy [6,9,17]. These findings have important clinical implications. Fluoroscopy-guided intradiscal ozone therapy, particularly when combined with periforaminal steroid injection, may serve as a minimally invasive therapeutic option in appropriately selected patients with symptomatic LDH who fail conservative management. The rapid pain relief, sustained functional improvement, and low complication rate suggest that this approach may reduce the need for surgical intervention in appropriately selected patients [18,19,20,21]. As a result, conclusions regarding the relative effectiveness of ozone-based interventions versus surgery cannot be definitively drawn from these results. This limitation should be considered when interpreting the potential role of intradiscal ozone therapy as an alternative to surgical management.

However, several limitations should be acknowledged. This study was conducted at a single center, which may limit generalizability, and the follow-up duration was 6 months, preventing assessment of long-term efficacy and recurrence rates. Ongoing follow-up of this patient cohort is planned and will specifically monitor for sustained clinical improvement, late adverse events, and recurrence, to address the durability of treatment outcomes. In addition, the study design was non-blinded, introducing potential bias in outcome assessment, and a direct comparison with surgical interventions was not performed, limiting conclusions regarding relative effectiveness. Future multicenter randomized controlled trials with longer follow-up are warranted to confirm these findings, determine the durability of outcomes, and refine patient selection criteria.

Conclusion

Fluoroscopy-guided intradiscal oxygen-ozone therapy is an effective minimally invasive treatment for symptomatic LDH refractory to conservative management. Although both treatment strategies significantly improved pain and functional outcomes, the addition of a periforaminal steroid injection provided superior early pain relief and functional recovery, supporting its use in appropriately selected patients with significant radicular symptoms.

Clinical Message

Intradiscal oxygen-ozone therapy provides significant pain relief and functional improvement in lumbar disc herniation. Adjunctive periforaminal steroid injection may accelerate recovery and should be considered as part of a minimally invasive treatment strategy before surgery.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

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