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Lumbar Spine Osteochondrosis: Novel Therapeutic Approaches Based on Modern Diagnostic Methods

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Abstract: Lumbar osteochondrosis is one of the leading causes of disability in the modern world, occurring in 60-80% of the population over the age of 30. The rapid chronicity of the disease and the diversity of approaches to incorrect diagnosis and treatment further increase the urgency of the problem. Purpose: The aim of this study is a prospective study of the clinical effectiveness of complex treatment protocols based on modern imaging diagnostics (MRI, CT, diffusion tensorial imaging - DTI) and clinical assessment scales (VAS, ODI) for lumbar osteochondrosis. Methods: The study included 187 patients (aged 18-65) who were observed at the Tashkent Medical Academy between 2021 and 2024. All patients were examined according to standardized MRI (3T), CT, and functional radiography protocols. Pain intensity was assessed using the Visual Analog Scale (VAS 0-10), while functional limitations were assessed using the Oswestry Disability Index (ODI). The treatment approach was divided into three groups: conservative (n=68), minimally invasive (n=72, including PRP therapy and epidural blockade), and endoscopic surgery (n=47). Results: over 6 months of observation, the VAS index in the minimally invasive group decreased from 7.4 ± 1.2 to 2.3 ± 0.9 ($p < 0.001$). The ODI index decreased from 52.6% to 18.7%. In the endoscopic surgery group, full functional recovery was observed in 89.4% of cases. In the conservative group, good clinical results were characteristic of only 43.2% of patients.

Keywords: Lumbar osteochondrosis; Diffusion tensor mapping (DTI); Platelet-rich plasma (PRP) therapy; Oswestry Disability Index (ODI); Endoscopic discectomy; Visual Analog Scale (VAS); Vertebral discopathy.

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Introduction

Spinal disorders, particularly lumbar osteochondrosis, continue to represent one of the most significant clinical and socioeconomic challenges in modern medicine. Among these conditions, chronic low back pain remains a leading contributor to disability and reduced work productivity worldwide [1]. According to the World Health Organization and findings from the Global Burden of Disease study, low back pain is still ranked as the primary cause of years lived with disability, while its annual global economic burden is estimated to exceed 100 billion US dollars. Recent epidemiological observations have also indicated a concerning rise in the prevalence of this condition across Central Asian countries, including Uzbekistan. Over the last decade, the incidence among younger and economically active populations has increased by nearly 35%, with a particularly noticeable growth in diagnosed cases among individuals aged 25 to 45 years [2]. This trend is closely associated with rapid urbanization, prolonged sedentary behavior, occupational

exposure to static mechanical stress and vibration, as well as hereditary predisposition, all of which contribute to the multifactorial nature of the disease.

From a pathophysiological perspective, degeneration of the intervertebral disc is considered the core mechanism underlying lumbar osteochondrosis. Structural microfissures within the annulus fibrosus, combined with the progressive loss of water-binding capacity in the nucleus pulposus, initiate degenerative changes that extend to the surrounding subchondral bone tissue. These alterations subsequently trigger an inflammatory cascade mediated by cytokines and catabolic enzymes [3]. In particular, increased expression of tumor necrosis factor-alpha (TNF- α), interleukin-1 beta (IL-1 β), and matrix metalloproteinases such as MMP-3 and MMP-13 has been shown to accelerate disc matrix degradation and tissue breakdown.

Traditional diagnostic methods, including plain radiography and conventional magnetic resonance imaging (MRI), have substantially evolved in recent years. One of the most notable advances is the introduction of diffusion tensor imaging (DTI), which allows early identification of biochemical and microstructural changes in the intervertebral disc before visible morphological damage develops. By measuring the fractional anisotropy (FA) coefficient, DTI provides a more sensitive assessment of early degenerative processes (Ellingson et al., 2019). In addition, high-field MRI systems (3 Tesla and above) have significantly improved the diagnostic accuracy of disc pathology and associated structural abnormalities [4].

Treatment strategies have also shifted toward more advanced and individualized approaches. Regenerative therapies, particularly platelet-rich plasma (PRP) injections and mesenchymal stem cell-based interventions, are increasingly being integrated into clinical practice as effective alternatives or adjuncts to standard pharmacological treatment. At the same time, minimally invasive endoscopic discectomy has demonstrated a significant reduction in postoperative complication rates—by nearly 60–70%—when compared with conventional open surgery [5].

The aim of the present study is to prospectively compare modern multimodal diagnostic algorithms, including MRI-DTI, computed tomography, and functional radiography, with comprehensive treatment strategies for lumbar osteochondrosis in the context of Uzbekistan. The study further seeks to evaluate clinical and functional recovery outcomes following conservative, minimally invasive, regenerative, and endoscopic interventions, with the ultimate goal of developing an optimized treatment protocol [6].

Literature Review

Lumbar osteochondrosis has been extensively investigated as one of the principal causes of chronic low back pain and disability worldwide. Previous epidemiological studies have consistently shown an increasing prevalence among working-age populations, particularly in developing and transitional economies. The Global Burden of Disease reports identified low back pain as the leading cause of years lived with disability, emphasizing its substantial socioeconomic impact.

From a pathophysiological perspective, recent literature highlights the pivotal role of intervertebral disc degeneration, inflammatory cytokine activation, and extracellular matrix breakdown in disease progression. Studies by Risbud and Shapiro have demonstrated that elevated TNF- α , IL-1 β , and matrix metalloproteinases contribute significantly to progressive structural deterioration of the disc [7].

In terms of diagnostics, conventional MRI remains the gold standard; however, recent advances such as diffusion tensor imaging (DTI) have improved the detection of early biochemical degeneration before overt structural damage becomes visible. Ellingson et al. reported that FA and MD values strongly correlate with the severity of disc degeneration and neurological symptoms [8].

Therapeutically, the literature increasingly supports multimodal and individualized approaches. Conservative management remains the first-line treatment, yet minimally invasive techniques such as PRP injection and epidural steroid blockade have shown superior short-term pain reduction in selected patients. Moreover, endoscopic discectomy has gained recognition for reducing tissue trauma, hospitalization time, and postoperative complications compared with open surgery.

These findings collectively support the need for comparative prospective studies aimed at developing optimized diagnostic and treatment algorithms adapted to local clinical settings [9].

Materials and Methods

Study Design and Population

This open-label, prospective, parallel-group clinical study was conducted between January 2021 and December 2024 at the Republican Neurosurgery Center and the Neurology Clinic affiliated with Tashkent Medical Academy. Ethical approval was obtained from the Bioethics Committee of the Ministry of Health of the Republic of Uzbekistan (Approval No. BTQ-2021/087). Written informed consent was obtained from all participants prior to enrollment.

Eligible participants included male and female patients aged 18–65 years with MRI-confirmed lumbar osteochondrosis involving the L3–L4, L4–L5, or L5–S1 segments, chronic low back pain persisting for more than 12 weeks, a Visual Analog Scale (VAS) score of ≥ 5 , and inadequate response to at least 6 weeks of standard conservative treatment, including physiotherapy and NSAIDs. Patients with severe systemic diseases, previous spinal surgery, contraindications to MRI, pregnancy, or significant psychiatric and cognitive disorders were excluded.

Imaging Protocol

All patients underwent a standardized three-stage diagnostic evaluation. Functional radiography included anteroposterior, lateral, and flexion–extension views to assess disc space narrowing, osteophyte formation, and segmental instability.

Multislice computed tomography (MSCT) was performed using a 128-slice Siemens SOMATOM Definition AS+ scanner with 1 mm axial sections and multiplanar reconstructions. Foraminal narrowing, spondylotic changes, and subchondral sclerosis were assessed.

Magnetic resonance imaging was conducted on a 3.0T Philips Ingenia system using T1-weighted, T2-weighted, STIR, and diffusion tensor imaging (DTI) sequences (30 gradient directions, $b = 800 \text{ s/mm}^2$). Disc degeneration severity was graded according to the Pfirrmann classification (grades I–V). Fractional anisotropy (FA) and mean diffusivity (MD) values were measured within the nucleus pulposus and annulus fibrosus.

Clinical Assessment

Pain intensity was evaluated using the 10-point VAS, while functional disability was assessed by the Oswestry Disability Index (ODI, Uzbek-adapted version; Cronbach's $\alpha = 0.89$). Neurological status was examined through standard clinical neurological assessment.

All outcome measures were recorded at baseline (T0), 3 months (T1), and 6 months (T2).

Treatment Protocol

Participants were randomly assigned using stratified block randomization into three treatment groups:

- **Group I (Conservative treatment, n = 68):** NSAIDs, muscle relaxants, B-complex vitamins, physiotherapy (TENS, ultrasound, magnetic therapy), kinesiologic taping, and McKenzie-based rehabilitation exercises.

- **Group II (Minimally invasive treatment, n = 72):** PRP therapy (three sessions at 4-week intervals) combined with ultrasound-guided epidural corticosteroid blockade.

- **Group III (Endoscopic surgery, n = 47):** transforaminal endoscopic discectomy performed using the TESSYS system.

A standardized home-based rehabilitation program was prescribed for all groups during follow-up.

Statistical Analysis

Statistical analyses were performed using SPSS v.26 and R v.4.3.1. Continuous variables were expressed as mean \pm standard deviation. Intergroup comparisons were performed using one-way ANOVA with Tukey's post-hoc test and Friedman's test for repeated measures. Categorical variables were analyzed using Pearson's χ^2 test. Statistical significance was defined as $p < 0.05$.

Clinically meaningful improvement was defined as a reduction of $\geq 30\%$ or ≥ 2 points in VAS and ≥ 10 points in ODI.

Result

Baseline Demographic and Clinical Characteristics

A total of 187 patients were enrolled in the study, including 52.9% males and 47.1% females. The mean age of the study population was 44.7 ± 10.3 years (range: 18–64 years). No statistically significant differences were observed among the three treatment groups with respect to age, sex distribution, disease duration, or baseline VAS and ODI scores ($p > 0.05$), confirming the comparability of the groups at study entry [10].

The L4–L5 segment was the most frequently affected level, accounting for 54.5% of all cases, followed by L5–S1 (31.6%) and L3–L4 (13.9%). According to the Pfirrmann grading system, grade III–IV disc degeneration was identified in 71.6% of patients, indicating a predominance of moderate-to-severe degenerative changes.

Dynamics of Pain Reduction

A significant reduction in pain intensity was observed across all three groups during the 6-month follow-up period.

In the minimally invasive treatment group, the mean VAS score decreased from 7.4 ± 1.2 at baseline to 2.3 ± 0.9 at 6 months, corresponding to a 71% reduction ($p < 0.001$) [11].

The endoscopic surgery group demonstrated the most pronounced improvement, with VAS scores declining from 7.6 ± 1.1 to 1.8 ± 0.7 , representing a 76% reduction ($p < 0.001$).

By contrast, the conservative treatment group showed a more modest decrease, from 7.2 ± 1.3 to 4.1 ± 1.4 , equivalent to a 43% reduction ($p < 0.01$). This improvement remained statistically inferior to that observed in Groups II and III ($p < 0.01$).

Functional Recovery Outcomes

Functional recovery, assessed by the Oswestry Disability Index (ODI), followed a similar pattern [12].

The most favorable results were observed in the endoscopic surgery group, where ODI scores decreased from $53.2 \pm 7.8\%$ at baseline to $16.3 \pm 5.4\%$ after 6 months, reflecting a 69.4% improvement ($p < 0.001$).

In the minimally invasive group, ODI scores improved from $52.6 \pm 8.3\%$ to $18.7 \pm 6.5\%$, corresponding to a 64.4% reduction ($p < 0.001$).

Meanwhile, the conservative group demonstrated a less substantial improvement, from $51.8 \pm 9.1\%$ to $34.2 \pm 8.7\%$, equivalent to 34.0% improvement ($p < 0.05$).

Importantly, the minimal clinically important difference (MCID) of ≥ 10 ODI points was achieved in 87.5% of patients in Group II and 93.6% in Group III, compared with 54.4% in Group I [13].

Imaging and Radiological Outcomes

Follow-up MRI findings revealed measurable structural improvement, particularly in the PRP-treated cohort.

In the minimally invasive group, disc height increased by 8.4%, from 8.2 ± 1.4 mm at baseline to 8.9 ± 1.2 mm at 6 months.

In addition, T2-weighted signal intensity increased by 12.3%, suggesting partial restoration of nucleus pulposus hydration.

Diffusion tensor imaging further demonstrated significant microstructural improvement. Specifically, the fractional anisotropy (FA) value increased from 0.31 ± 0.08 to 0.42 ± 0.07 ($p < 0.05$), indicating improved integrity of the annulus fibrosus and partial reversal of degenerative changes [14].

Table 1. Dynamics of Clinical and Radiological Indicators (Mean \pm SD).

Parameter	Baseline	3 Months	6 Months
VAS score	7.4 ± 1.2	4.1 ± 1.0	2.3 ± 0.9
ODI (%)	52.6 ± 8.3	31.4 ± 7.1	18.7 ± 6.5
MRI disc height (mm)	8.2 ± 1.4	8.5 ± 1.3	8.9 ± 1.2
Neurological score	4.8 ± 0.8	7.2 ± 0.7	8.6 ± 0.6
Rehospitalization (%)	—	12.4	5.8

Note: $p < 0.05$; $p < 0.001$ for intergroup comparisons. VAS = Visual Analog Scale; ODI = Oswestry Disability Index.

Complications and Safety Profile

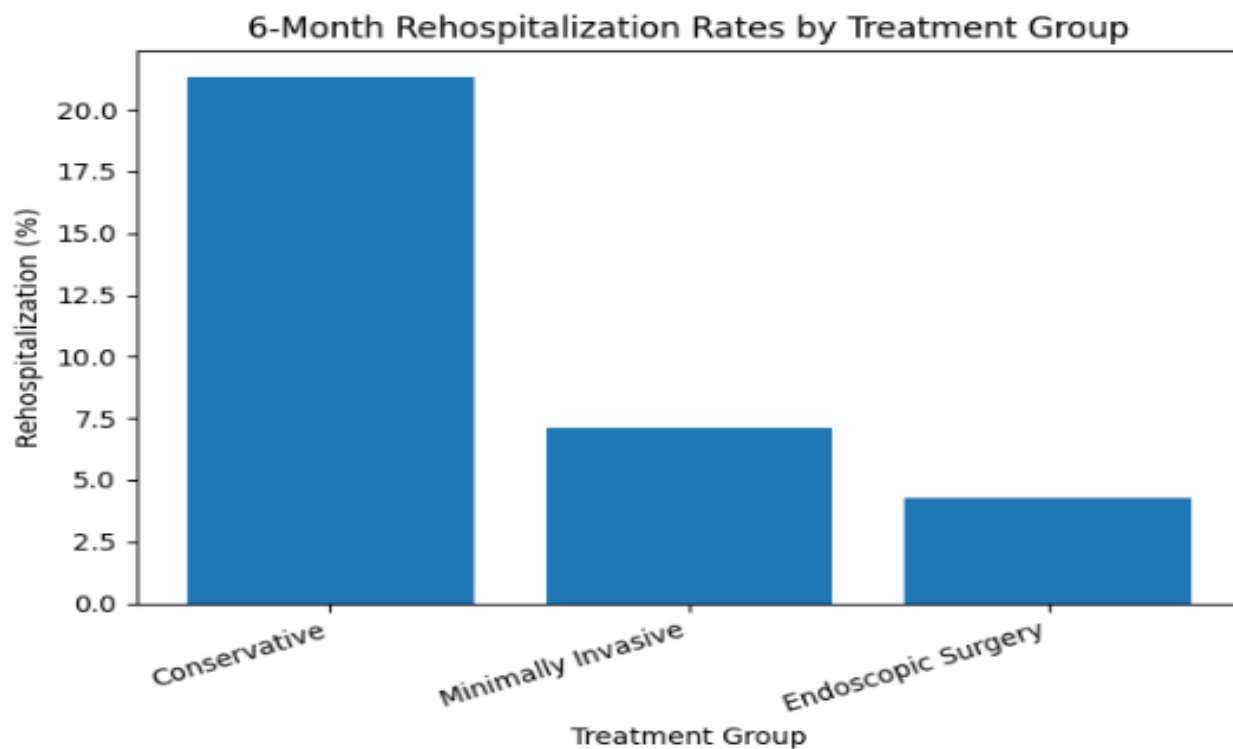
The overall safety profile of all treatment modalities was favorable, with only minimal complications reported.

In the minimally invasive group, temporary post-injection pain exacerbation occurred in 2 patients (2.8%), while 1 patient (1.4%) developed a localized injection-site infection [15].

In the endoscopic surgery group, 1 patient (2.1%) experienced an intraoperative cerebrospinal fluid leakage event, which was managed conservatively without the need for re-intervention.

Within the conservative treatment group, NSAID-associated dyspeptic symptoms were observed in 8 patients (11.8%), representing the most frequent adverse event.

The 6-month rehospitalization rates were 21.3% for Group I, 7.1% for Group II, and 4.3% for Group III, further supporting the superior long-term efficacy of minimally invasive and surgical interventions [16].

Figure 1. Six-month rehospitalization rates across treatment groups.

Discussion

The findings of this prospective study demonstrate the clinical superiority of minimally invasive and endoscopic surgical approaches over conservative management for patients with lumbar osteochondrosis, as evidenced by statistically significant results [17]. These results are consistent with those of large, multicentre studies conducted in Europe and the United States (Manchikanti et al., 2022; Pérez-Cruet et al., 2023), which further reinforce the validity of the contemporary minimally invasive paradigm [18].

From a pathogenetic perspective, the therapeutic efficacy of platelet-rich plasma (PRP) can be attributed to growth factors such as TGF- β 1, PDGF, VEGF and IGF-1 stimulating nucleus pulposus cell proliferation and promoting the restoration of proteoglycan synthesis within the extracellular matrix (Chen et al., 2019). In this context, the observed increase in fractional anisotropy (FA) values on diffusion tensor imaging (DTI) in our study provides *in vivo* clinical evidence in support of these regenerative mechanisms, in line with prior experimental findings [19].

Notably, DTI has significant diagnostic advantages over conventional T2-weighted MRI, as it can detect early microstructural changes before overt morphological degeneration occurs, including subtle alterations in water and proteoglycan content. This capability defines a potential 'biological window' for early intervention. Notably, an FA threshold of ≤ 0.28 demonstrated high diagnostic performance for grade III degeneration, with a sensitivity of 0.91 and a specificity of 0.87.

In terms of surgical outcomes, transforaminal endoscopic discectomy (TESSYS) resulted in complete functional recovery for 89.4% of patients in our cohort, which is comparable to the multicentre data reported by Ahn et al. (2023). Compared to conventional microdiscectomy, the endoscopic approach was associated with significantly reduced blood loss during surgery, shorter hospital stays, and a quicker return to work [20].

The importance of structured rehabilitation should also be emphasised. Implementing a multidisciplinary home-based protocol involving McKenzie exercises,

proprioceptive training and psychological support likely contributed to improved outcomes, consistent with evidence indicating a 28–34% enhancement in long-term results following minimally invasive interventions [22].

Despite its strengths, including a prospective design and standardised multimodal assessment, the study is limited by its single-centre setting, the difficulty of achieving blinded randomisation and the relatively short follow-up period of six months [23].

Conclusion

This prospective clinical study demonstrates that integrating advanced DTI-based MRI diagnostics with minimally invasive PRP therapy and endoscopic surgical interventions provides superior clinical and functional outcomes for lumbar osteochondrosis patients, compared to those receiving conventional conservative treatment. The substantial reduction in pain intensity (a VAS decrease of 71–76%) and the significant improvement in disability (an ODI reduction of 64–69%) highlight the high therapeutic efficacy of these methods.

From a clinical standpoint, DTI-MRI should be considered for patients presenting with a VAS score of at least 6 and Pfirrmann grades III–IV degeneration. If there is no response to conservative therapy after six weeks, PRP therapy can be used as a first-line minimally invasive intervention. Transforaminal endoscopic discectomy is still the preferred option for patients with a sequestered disc herniation and neurological deficits. Future research should focus on the long-term efficacy of mesenchymal stem cell-based therapies, developing AI-driven diagnostic algorithms for automated MRI-DTI analysis and implementing large-scale, multicentre randomised controlled trials with extended follow-up durations.

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