Original article

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Comparison of microdiscectomy and microdiscectomy with cage interbody fusion in lumbar–sacral disc herniation

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Objective: To optimize the selection of surgical treatment strategy for patients with lumbar and lumbosacral disc herniation by performing a comparative analysis of the outcomes of microdiscectomy and microdiscectomy with interbody cage fusion in order to improve treatment results.

Materials and methods: The study included 200 patients with lumbar and lumbosacral disc herniation treated at the Romodanov Neurosurgery Institute of the National Academy of Medical Sciences of Ukraine between 2015 and 2022. Neurological status was assessed based on the severity of pain syndrome, the presence of segmental instability was determined. Magnetic resonance imaging, computed tomography, and radiographic findings were evaluated. The following surgical techniques were used: microdiscectomy for lumbar and lumbosacral disc herniation.

Results: Microdiscectomy with interbody cage fusion eliminated manifestations of instability and provided more effective stabilization of the lumbosacral spine compared with microdiscectomy alone. The recurrence rate of disc herniation after microdiscectomy with cage fusion lower (3%) compared with microdiscectomy alone (9%). In the group treated with microdiscectomy and cage fusion, a more pronounced reduction in pain intensity (–82%) and a greater decrease in the Oswestry Disability Index (–81%) were observed, indicating higher effectiveness of the stabilization technique. According to the Macnab and Prolo scales, excellent and good outcomes were recorded more frequently in the microdiscectomy with cage fusion group than in the microdiscectomy group (91% vs 78% and 91% vs. 77%, respectively). The Wilcoxon test confirmed a high level of within-group improvement ($p<0.001$), while the t-test demonstrated statistically significant differences between the groups.

Conclusions: The lumbosacral segment with an implanted cage is more stable and withstands greater mechanical loads during motion, reduces the recurrence rate of disc herniation, and decreases pain severity. Microdiscectomy with interbody cage fusion may be considered in carefully selected patients with signs of segmental instability as an approach that combines decompression and stabilization and is associated with better long-term clinical outcomes.

Keywords: *lumbar–sacral disc herniation; microdiscectomy; microdiscectomy with cage interbody fusion*

Introduction

According to statistical data, herniation localized in the lumbosacral region of the spine occurs most frequently. Such herniations are among the leading causes of chronic pain syndrome and temporary disability [1, 2]. In the majority of cases (59%), intervertebral disc herniations affecting the lumbar and sacral nerve roots are located at the L4–L5 level (with compression of the L5 nerve root). The second most common level is L5–S1 (with compression of the S1 nerve root), accounting for 30% of cases [3, 4].

The gold standard for surgical treatment of lumbosacral disc herniation is microdiscectomy (microsurgical removal of the herniated intervertebral disc). The main advantage of this method is the ability to remove herniations of any density, location, and size, including cases associated with spinal canal stenosis and sequestrated intervertebral disc herniation [5]. However, this technique does not prevent the development of recurrent herniation or instability of the lumbosacral spine, which may necessitate repeat surgical intervention [6, 7]. Thus, the choice of the optimal surgical strategy (microdiscectomy alone versus microdiscectomy combined with interbody fusion using a cage) remains a relevant clinical issue.

Aim: to optimize the selection of surgical treatment strategy for patients with lumbosacral disc herniation through a comparative analysis of outcomes following microdiscectomy and microdiscectomy combined with interbody cage fusion, with the goal of improving treatment results.

Materials and methods

Study participants

The study included 200 patients with lumbosacral disc herniation who were treated at the A.P. Romodanov Institute of Neurosurgery of the National Academy of Medical Sciences of Ukraine between 2015 and 2022.

Written informed consent for participation in the study and for publication of the data was obtained from all patients.

The study protocol was approved by the Ethics and Bioethics Committee of the A.P. Romodanov Institute of Neurosurgery of the National Academy of Medical Sciences of Ukraine (Minutes No. 3, dated November 24, 2022).

Inclusion criteria:

1. Patient age 19–70 years.
2. Presence of L4–L5 or L5–S1 intervertebral disc herniation confirmed by magnetic resonance imaging (MRI).
3. No prior stabilization surgery in the lumbar spine.
4. Duration of clinical symptoms of at least 6 weeks with ineffective conservative treatment.
5. Written informed consent to participate in the study.

Exclusion criteria:

1. Multisegmental involvement (>1 spinal level).
2. Traumatic, infectious, or neoplastic lesions of the spine.
3. Severe comorbid conditions increasing surgical risk.
4. Pregnancy or inability to undergo postoperative rehabilitation.

Group characteristics

All patients underwent surgical treatment for lumbosacral disc herniation. Of these, 100 patients underwent microdiscectomy, while the remaining patients underwent microdiscectomy combined with interbody fusion using cages.

Indications for microdiscectomy (MD):

1. Presence of clinical symptoms of nerve root compression (lumboischialgia-type pain syndrome, positive nerve tension signs).
2. Presence of L4–L5 or L5–S1 intervertebral disc herniation confirmed by MRI.
3. Absence of signs of advanced degeneration of adjacent structures (Modic type 0–I, without significant loss of disc height).
4. Ineffectiveness of conservative treatment for 6–8 weeks.
5. Stability of the motion segment on functional radiographs (displacement <3 mm, angular deformation <10°).

Thus, microdiscectomy was predominantly performed in patients with isolated disc herniation without structural instability.

Microdiscectomy combined with interbody cage fusion (MD + Cage) was applied in patients with discogenic pathology accompanied by structural or biomechanical segmental instability, in whom decompression alone was insufficient to stabilize the spine and prevent herniation recurrence.

Main indications for microdiscectomy with interbody cage fusion:

1. Disc herniation combined with radiographic signs of segmental instability (vertebral body displacement >3 mm or pathological mobility >10° on functional studies).
2. Modic type II changes on MRI (signs of endoplastic degeneration, cystic remodeling, or fibrosis).
3. Recurrent disc herniation after prior discectomy.
4. Marked loss of disc height (>50%) or post-discectomy segmental deformity.
5. Clinical manifestations of mechanical pain relieved in unloading positions (a sign of motion segment instability).

Thus, microdiscectomy with interbody fusion using a cage was performed in patients for whom decompression alone was insufficient to stabilize the spinal segment and prevent recurrence.

Contraindications to microdiscectomy:

1. Severe somatic condition (grade III–IV cardiac, respiratory, or renal failure).
2. Systemic infections, febrile conditions, coagulopathies, or use of anticoagulants without the possibility of temporary discontinuation.
3. Mental disorders that preclude adequate postoperative rehabilitation.
4. Spinal segment instability (displacement>3 mm, pathological mobility >10°).
5. Significant loss of disc height with collapse of the vertebral bodies.
6. Severe degenerative changes (cystic–fibrotic alterations, Modic type II–III changes).

Contraindications to microdiscectomy with interbody fusion using a cage:

1. Severe osteoporosis that prevents stable cage implantation.
2. Active infectious spondylodiscitis.
3. Anatomical inaccessibility of the surgical approach (congenital anomalies, cicatricial–adhesive changes after multiple surgeries).
4. Pronounced grade III spinal segment instability (displacement >6 mm, pathological mobility >15°), which constitutes an indication for spinal fusion.

Study design

A comparative study was conducted involving two groups of patients who underwent microdiscectomy and microdiscectomy with cage fixation, respectively. The analysis focused on the surgical techniques, the recurrence rate following both types of procedures, and neurological outcomes in the early and long-term postoperative periods. Based on the obtained results, indications for the use of these surgical methods and corresponding clinical recommendations were developed.

All patients underwent neurological assessment, including evaluation of pain syndrome manifestations, pain intensity measured using the Visual Analog Scale (VAS), functional status assessed by the Oswestry Disability Index (ODI), the Macnab Scale (***Table 1***), and the Prolo functional–economic outcome scale (***Table 2***). In addition, recurrence rates were recorded. The surgical techniques applied included microdiscectomy and microdiscectomy of lumbosacral disc herniations with interbody fusion using cages at the L4–L5 or L5–S1 levels. The posterior interlaminar approach at the L4–L5 or L5–S1 level was predominantly used; in isolated cases with a narrow interlaminar space, a microscopic transforaminal lumbar interbody fusion (TLIF) approach was employed. Titanium or PEEK (polyetheretherketone) cages manufactured by "Medtronic" or "Novo Spine" were used. The cages were of "banana" and "bullet" shapes, with the size selected individually based on the intraoperative height of the intervertebral disc space. The space inside and around the cage was not filled with autologous bone graft material. No additional fixation

was applied. In the comparison group, only the stand-alone cage technique was used.

Among the main preoperative complaints, low back pain radiating to the lower limb, inability to walk for prolonged periods, and difficulty maintaining an upright position predominated. Foot paresis was observed in 12.5% of patients, while pelvic dysfunction was identified in 4.2%.

Analysis of patient distribution by age groups demonstrated that intervertebral disc herniation was most frequently diagnosed in patients aged 41–50 years (***Table 3***). The distribution of lumbosacral intervertebral disc herniations by spinal level was as follows: L4–L5 — 108 cases (54%) and L5–S1 — 92 cases (46%).

In the late postoperative period (12 months after surgery), patients completed a questionnaire-based assessment.

1. Subjective pain perception was evaluated using the VAS, represented by a 100-mm horizontal line, where 0 mm corresponds to the complete absence of pain and 100 mm indicates the maximum imaginable pain. Patients marked the level of pain intensity, and the distance from the zero point to the mark was measured in millimeters.

For analytical purposes, VAS scores were conditionally categorized into the following pain intensity levels:

- 0 mm — no pain;
- 1–20 mm — mild pain;
- 21–60 mm — moderate pain;
- 61–100 mm — severe pain.

For ease of clinical interpretation, VAS results were also presented on a 0–10 point scale, equivalent to the 0–100 mm range.

2. Oswestry Disability Index (ODI).

The Oswestry Disability Index (ODI) questionnaire (***Table 4***) is a validated instrument for the quantitative assessment of disability associated with degenerative spinal disorders. In the present study, ODI version 2.0

Table 1. Macnab scale [13]

Rating	Outcome characteristics
Excellent	Complete relief of pain; the patient has returned to normal daily activities and work
Good	Occasional mild pain that does not limit daily activities; the patient is able to work in the same position;
Fair	Persistent pain, but significantly reduced compared with the preoperative level; activity is partially limited, and the patient must change to less physically demanding work
Poor	No improvement or worsening of pain compared with the preoperative condition; the patient is unable to work

*Note.** Patient-reported assessment of treatment outcomes.

Table 2. Prolo functional–economic outcome scale [11]

1. Economic scale (E)	
Score	**Description**
1	The patient is unable to work and is completely disabled
2	Work capacity is partially preserved; the patient performs light or part-time work
3	The patient is able to work with limitations (change of profession or working conditions)
4	The patient works in the previous occupation with minor limitations
5	Full work capacity; return to previous professional activity
2. Functional scale (F)	
Score	**Description**
1	Severe pain; constant need for analgesics
2	Moderate pain; significant limitation of daily activities
3	Intermittent pain; partial limitation of activity
4	Mild pain; preservation of everyday activity
5	No pain; normal physical activity without limitations
Interpretation of the total score (E + F)	
Total score	**Outcome assessment**
9–10	Excellent
7–8	Good
5–6	Fair
<5	Poor

Note. * Designed for comprehensive assessment of the patient's functional and economic status after surgical treatment of lumbar spine pathology. The scale consists of two subscales: economic (E) and functional (F). Each subscale is scored from 1 to 5 points, with a maximum total score of 10 points.

Table 3. Patient distribution by age groups

Age groups, years	Number of patients	
	Abs.	%
19–30	25	12,5
31–40	51	25,5
41–50	53	26,5
51–60	49	24,5
61–70	22	11,0
Total	200	100,0

Table 4. Interpretation of ODI scores [12]

Level of disability	ODI%	Interpretation
Minimal disability	0–20	Patient is able to perform most activities of daily living
Moderate disability	21–40	Reduced activity level, predominantly due to pain
Severe disability	41–60	Significant limitation of work capacity
Crippling disability	61–80	Substantial functional limitations
Bed-bound state/ complete immobility	81–100	The patient is unable to work

[8] was used. This version comprises 10 items, each scored from 0 to 5 points. Initial scoring was performed in accordance with the questionnaire structure, after which the results were converted into percentages. This approach corresponds to the widely accepted method for interpreting ODI scores and enables standardized comparison with data reported in the literature.

The total ODI score (0–50) was converted into a percentage disability score using the following formula: ODI% = (Obtained score: 50) ×100.

Statistical analysis

Statistical data processing was performed using the Statistica 6.0 software package. Differences between the groups for all primary indicators (VAS, ODI, ΔVAS, ΔODI) were assessed using Welch's t-test, a statistical method for comparing the means of two independent samples that does not assume equality of variances. This test represents a more robust adaptation of Student's t-test, particularly when variances between samples differ substantially or when sample sizes are small.

Changes over time in quantitative dependent variables within each group were evaluated using the nonparametric Wilcoxon signed-rank test. Differences were considered statistically significant at $p < 0.05$.

Results

According to the assessment of pain intensity using the VAS, the mean pain level in the MD group decreased by 5.3 points (corresponding to approximately 63.1% reduction), whereas in the MD + Cage group the decrease amounted to 7.1 points (82.6%). Thus, patients who underwent MD + Cage demonstrated a more pronounced postoperative reduction in pain, as well as a lower recurrence rate of intervertebral disc herniation (***Table 5***).

Prior to surgical treatment, the mean ODI values were high in both groups, indicating substantial functional limitation among patients (***Table 6***). At 12 months, a significant decrease in ODI was observed in both groups, with more pronounced improvement in the MD + Cage group.

The relative improvement in functional status was 61% in the MD group and 81% in the MD + Cage group, suggesting greater effectiveness of the combined surgical approach using cages in reducing disability as measured by the ODI.

A comparison of functional treatment outcomes according to the Macnab scale was performed (***Table 7***). The obtained data indicate better functional outcomes in the MD + Cage group, reflected by a higher proportion of excellent results and a lower proportion of fair and poor outcomes.

Evaluation using the Prolo functional–economic outcome scale was conducted across four categories depending on the degree of return to work, presence of pain syndrome, and functional limitations (***Table 8***). The results demonstrate more favorable functional and economic outcomes in the MD + Cage group, characterized by a higher proportion of excellent results and a lower proportion of fair and poor outcomes.

The application of the Wilcoxon signed-rank test demonstrated statistically significant improvement in both pain syndrome (VAS) and functional status (ODI) in both groups ($p < 0.001$). The magnitude of the effect was high ($r = 0.79–0.88$), indicating clinically significant postoperative improvement, with a more pronounced effect observed in the MD + Cage group (***Table 9***).

Table 5. Dynamics of pain syndrome and recurrence rate

Group	Mean VAS score (points)		Reduction, %	Recurrence rate, %
	before treatment	at 12 months		
MD	8,4	3,1	63,1	9 (9 out of 100)
MD + Cage	8,6	1,5	82,6	3 (3 out of 100)

Table 6. Dynamics of ODI, %

Indicator	MD (n=100)	MD+Cage (n=100)	Improvement
ODI before surgery	62	64	—
ODI at 12 months	24	12	—
Δ (reduction)	38	52	61/81

Table 7. Functional outcomes according to the Macnab scale, %

Outcome category	MD (n=100)	MD+Cage (n=100)
Excellent	46	63
Good	32	28
Fair	14	7
Poor	8	2
Total	100	100

Table 8. Assessment according to the Prolo functional–economic outcome scale

Outcome category	Description	MD (n=100)	MD+Cage (n=100)
Excellent (9–10 points)	Complete return to work, absence of pain	42 %	61 %
Good (7–8 points)	Mild pain, preservation of most functions, return to work achieved	35 %	30 %
Fair (5–6 points)	Moderate residual symptoms, partial work limitation	15 %	7 %
Poor (≤4 points)	Persistent disability, loss of working capacity	8 %	2 %
Total	—	100 %	100 %

Table 9. Results of the Wilcoxon signed-rank test

Group	Indicator	n	W (Statistics)	p-value	Effect size (r)	Interpretation
MD	VAS (before–after)	100	0	<0,001*	0,82	Significant reduction in pain
	ODI (before–after)	100	120	<0,001*	0,79	Improvement in functional status
MD+Cage	VAS(before–after)	100	0	<0,001*	0,88	Marked reduction in pain
	ODI (before–after)	100	45	<0,001*	0,84	Substantial functional improvement

Discussion

The obtained results confirm that both surgical methods—conventional microdiscectomy and microdiscectomy with cage-assisted interbody fusion—provide significant reduction of pain syndrome and improvement in functional status in patients with lumbosacral intervertebral disc herniation.

Postoperative reduction in VAS scores in the MD group averaged −63% (from 8.4 to 3.1 points), whereas in the MD + Cage group it reached −82% (from 8.6 to 1.5 points). The ODI decreased from 62% to 24% and from 64% to 12%, respectively, indicating more pronounced functional recovery with the use of cages.

Analysis according to the Macnab and Prolo scales demonstrated the superiority of microdiscectomy with cage-assisted interbody fusion:

- 91% of patients achieved "Excellent" or "Good" outcomes on the Macnab scale compared with 78% after conventional microdiscectomy;

- According to the Prolo scale, favorable outcomes were observed in 91% of patients in the MD + Cage group and in 77% in the MD group.

The recurrence rate in the MD group was 9%, whereas in the MD + Cage group it was only 3%, indicating improved segmental stability following interbody fixation.

A statistically significant difference ($p < 0.001$) between the groups was established using Welch's t-test for all primary indicators (VAS, ODI, ΔVAS, ΔODI).

Within-group analysis using the Wilcoxon signed-rank test (pre–post comparison) confirmed the high effectiveness of both methods ($p < 0.001$), with a larger effect size ($r = 0.84–0.88$) observed in patients who underwent microdiscectomy with cage-assisted interbody fusion.

The study groups were not entirely homogeneous in terms of clinical and radiological characteristics. Given the heterogeneity of disc pathology, achieving complete homogeneity between the study and comparison groups is practically impossible. In the microdiscectomy with interbody fusion group, signs of segmental instability and Modic type II changes were more frequently observed, which determined the indications for stabilization surgical techniques. To minimize the impact of this heterogeneity on the study results, a multivariate statistical analysis was performed, along with within-group dynamic comparisons (pre–post), ensuring an appropriate evaluation of the effectiveness of each investigated treatment method despite the lack of complete group homogeneity.

Based on the obtained results, the indications for microdiscectomy may include:

- the presence of clinical symptoms of nerve root compression (lumbosciatic pain syndrome, positive tension signs);

- the presence of L4–L5 or L5–S1 intervertebral disc herniation confirmed by MRI;

- absence of pronounced degeneration of adjacent structures (Modic type 0–I changes, without significant loss of disc height);

- ineffectiveness of conservative treatment for 6–8 weeks;

- stability of the motion segment on functional radiographs (displacement <3 mm, angular deformation <10°).

Thus, microdiscectomy is indicated for patients with predominantly isolated disc herniation without structural instability, whereas microdiscectomy with interbody cage fusion is indicated for patients with discogenic lesions accompanied by structural or biomechanical instability of the segment, when nerve root decompression alone is insufficient to stabilize the spine and prevent recurrence. These include the following conditions:

- disc herniation combined with radiological signs of segmental instability (vertebral body displacement >3 mm or pathological mobility >10° on functional testing);

- Modic type II changes on MRI (signs of endoplastic degeneration, cystic remodeling, or fibrosis);

- recurrent disc herniation after previous discectomy;

- significant loss of disc height (>50%) or post-discectomy segmental deformity;

- clinical manifestations of mechanical pain relieved in an unloading position (a sign of motion segment instability).

Our findings are consistent with the literature and confirm the effectiveness and safety of interbody cage application in lumbosacral disc herniation.

According to F. Lei *et al*. (2023) [9], the use of stabilization procedures for recurrent intervertebral disc herniation in carefully selected patients is associated with a lower recurrence rate compared with repeat discectomy.

Similar conclusions regarding the acceptable safety profile of interbody cages, provided appropriate patient selection and adherence to surgical technique, were reported by R.J. Mobbs *et al*. (2015) [10].

Therefore, the use of an interbody cage may be considered a safe and effective component of surgical treatment in selected clinical situations, which is consistent with the results of our study. In cases where MRI and dynamic radiographs demonstrate segmental instability or Modic type II changes, microdiscectomy with cage-assisted interbody fusion appears justified as a more stabilizing technique that provides a more durable functional outcome.

Conclusions

1. Both surgical techniques—microdiscectomy and microdiscectomy with cage-assisted interbody fusion—provide statistically significant improvement in pain and functional status in patients with lumbosacral disc herniation.

2. The recurrence rate after microdiscectomy with cage-assisted interbody fusion is significantly lower (3%) compared with microdiscectomy alone (9%).

3. The microdiscectomy with cage-assisted interbody fusion group demonstrated a more pronounced reduction in pain (−82%) and a greater decrease in ODI (−81%), indicating higher effectiveness of the stabilization technique.

4. According to the Macnab and Prolo scales, excellent and good outcomes were observed more frequently in the microdiscectomy with cage-assisted interbody fusion group (91% vs 78% and 91% vs 77%, respectively).

5. The Wilcoxon signed-rank test confirmed a high level of within-group improvement ($p < 0.001$), while the t-test demonstrated a statistically significant difference between the groups.

6. Microdiscectomy with cage-assisted interbody fusion may be considered for carefully selected patients with signs of segmental instability as an approach combining decompression and stabilization, characterized by superior long-term clinical outcomes.

Disclosure

Conflict of interest

The authors declare no conflict of interest.

Informed consent

Informed consent was obtained from each patient.

Ethical standards

All procedures performed in studies involving human participants were conducted in accordance with the ethical standards of the institutional and national research committee and with the 1964 Declaration of Helsinki and its subsequent amendments or comparable ethical standards.

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