CNS Podcasts

OPEN

# The Timing of Diskectomy as a Predictor of Outcomes in Patients With Lumbar Disk Herniation: A Cohort Study on Varying Durations of Preoperative Symptoms

**Peter Solar, MD, PhD** [*‡], **Dusan Ondirko, MD** [*‡], **Petra Wesela, MSc** [§], **Radim Jancalek, MD, PhD** [*‡]

*Department of Neurosurgery, St. Anne's University Hospital Brno, Brno, Czech Republic; ‡Faculty of Medicine, Masaryk University, Brno, Czech Republic; §Department of Biostatistics, St Anne's University Hospital Brno, Brno, Czech Republic

**Correspondence:** Radim Jancalek, MD, PhD, Department of Neurosurgery, St. Anne's University Hospital Brno, and Faculty of Medicine, Masaryk University, Pekarska 53, Brno 656 91, Czech Republic. Email: radim.jancalek@fnusa.cz

**Received,** January 18, 2025; **Accepted,** July 09, 2025; **Published Online,** October 23, 2025.

*Neurosurgery 98:1051–1062, 2026*

https://doi.org/10.1227/neu.0000000000003727



**BACKGROUND AND OBJECTIVES:** Currently, the treatment of lumbar disk herniation (LDH) consists of conservative treatment followed by surgery when symptoms persist; however, the optimal timing of surgery to achieve the best clinical outcome is not clear. To evaluate the impact of durations of preoperative low back pain, disability, radicular leg pain, motor, and sensory deficit on postoperative outcomes in patients with LDH who underwent microdiskectomy.

**METHODS:** In our cohort study, we prospectively enrolled patients with different durations of preoperative LDH symptoms scheduled for microdiskectomy. The intensity and duration of radicular pain and disability were assessed using patient questionnaires. The motor deficit was classified based on the Medical Research Council scale. The sensory deficit was divided into present and absent. These parameters were assessed preoperatively and during postoperative 6-week, 6-, 12-, and 24-month follow-up visits.

**RESULTS:** In total, 1222 patients with LDH were enrolled. We observed that patients with LDH who underwent surgical intervention within 1 month after the onset of symptoms achieved more favorable outcomes compared with patients with longer duration of symptoms. Residual motor and sensory deficits 2 years after surgery were least common in patients with LDH-associated neurological symptoms lasting up to 1 month.

**CONCLUSION:** Our results support the importance of timing surgery on the postoperative outcomes of patients with LDH. Surgery for LDH within 1 month of the onset of symptoms leads to a faster improvement in neurological deficit and more significant relief from radicular pain compared with the duration of the symptoms for more than 1 month.

**KEY WORDS:** Lumbar disk herniation, Diskectomy, Radiculopathy, Spine, Low back pain, Motor deficit

Degenerative disease of the spine is among the most prevalent causes of disability worldwide. The degeneration cascade is a complex process that involves various factors and interactions between physical and biological mechanisms. It begins at the level of an intervertebral disk and primarily presents with low back pain (LBP).[1] The degenerative disk disease can result in lumbar disk

**ABBREVIATIONS: FU,** follow-up; **LBP,** low back pain; **LDH,** lumbar disk herniation; **MRC,** Medical Research Council; **NRS,** Numeric Rating Scale; **ODI,** Oswestry Disability Index.

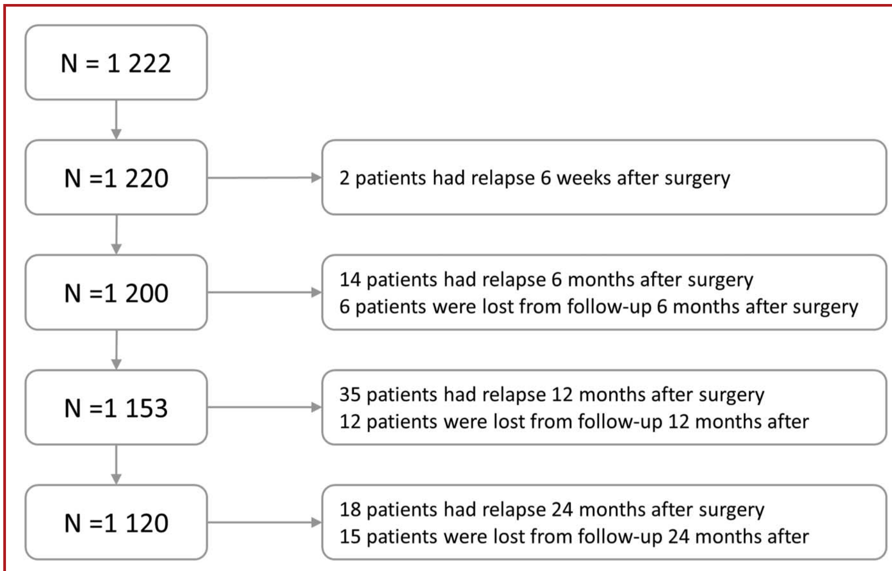


**FIGURE 1.** *A flowchart depicting the count of patients excluded and those included in the statistical analysis. A total of 1222 patients were included in the study. Overall, 69 patients had recurrent disk herniation with subsequent surgery, and 33 patients were lost to follow-up visits.*

herniation (LDH) and compression of nerve roots.[2,3] Typical symptoms of LDH with sciatica include radicular pain, sensory abnormalities, and weakness affecting the distribution of 1 or more lumbosacral nerve roots.[4,5]

Typically, the initial step in managing symptoms associated with LDH involves conservative treatment that should continue for several weeks to several months.[6-8] On the other hand, early surgery for patients with LDH leads to quicker relief of leg pain and a faster return to normal activities compared with conservative care.[6] An example is cauda equina syndrome, where emergency surgery is crucial for significantly improving neurological deficits.[9] Emerging evidence suggests early surgery in patients with motor deficits positively affects their postoperative outcomes.[10,11] However, the complex and often confusing healthcare systems, low awareness, and patient reluctance contribute to delays in the surgical treatment and frequently result in unsatisfactory postoperative outcomes. It is important to note that the advantages of early surgery for LDH, such as quicker recovery from neurological deficits, pain relief, and a return to normal daily activities, are becoming increasingly recognized with the advancement of minimally invasive techniques such as endoscopic diskectomy.[12,13] These benefits of endoscopic diskectomy are likely to play an even more crucial role in the timing of surgery and in promoting faster recovery.

The objective of this study was to evaluate the impact of various durations of preoperative LBP, disability, radicular leg pain, motor deficit, and sensory deficit on postoperative outcomes in patients with LDH who underwent microdiskectomy. The secondary aim was to determine whether the timing of surgery affected residual motor and sensory deficits 2 years after the microdiskectomy.

## METHODS

### Study Design

The study design constitutes a prospective cohort study encompassing patients with varying LBP and LDH-associated radicular symptomatology durations. It was conducted between April 2015 and October 2022. All adult patients scheduled for microdiskectomy because of symptomatic LDH were prospectively screened for eligibility to participate. This study was executed following the Declaration of Helsinki and received approval from the Institutional Review Board.

### Patient Enrollment

A written informed consent was obtained from each participant. To be included in the study, each patient was required to meet the following inclusion criteria: lumbar or lumbosacral radiculopathy with or without sensory and/or motor deficits, positive straight leg raise test, and current MRI or computed tomography scans demonstrating LDH enabling surgical treatment. The exclusion criteria encompassed any history of trauma, presence of an unknown radiographic mass, MRI or computed tomography findings inconsistent with clinical symptoms, existing inflammatory arthritis, or other rheumatologic diseases.

### Patient Characteristics

Demographic data, including sex, age, body mass index (BMI), workload (sedentary, light, heavy, or retirement pension), intervertebral segments involved, and intensity of LBP, radicular leg pain, and neurological symptoms, were collected. LDH recurrence was found in 69 patients (5.65%) from 1222 patients who underwent microdiskectomy.

**TABLE 1. Basic Clinical Characteristics of the Included Patients**

| Characteristic | Median | IQR |
|---|---|---|
| Age | 47.0 | 38.0; 58.0 |
| BMI | 27.1 | 24.5; 30.3 |
| Duration of low back pain (mo) | 5.0 | 3.0; 12.0 |
| NRS of back pain preoperative | 5.0 | 4.0; 6.0 |
| NRS of back pain after 6 wk | 2.0 | 1.0; 2.0 |
| NRS of back pain after 6 mo | 1.0 | 0.0; 2.0 |
| NRS of back pain after 12 mo | 0.0 | 0.0; 1.0 |
| NRS of back pain after 24 mo | 0.0 | 0.0; 1.0 |
| Duration of radicular leg pain (mo) | 4.0 | 2.0; 6.0 |
| NRS of leg pain preoperative | 6.0 | 4.0; 7.0 |
| NRS of leg after 6 wk | 2.0 | 1.0; 2.0 |
| NRS of leg after 6 mo | 1.0 | 0.0; 2.0 |
| NRS of leg after 12 mo | 1.0 | 0.0; 1.0 |
| NRS of leg after 24 mo | 0.0 | 0.0; 1.0 |
| Assessment of functional status | | |
| ODI score preoperative | 42.0 | 30.0; 54.0 |
| ODI score after 6 wk | 18.0 | 12.0; 24.0 |
| ODI score after 6 mo | 10.0 | 4.0; 16.0 |
| ODI score after 12 mo | 4.0 | 0.0; 10.0 |
| ODI score after 24 mo | 0.0 | 0.0; 6.0 |
| Sex | N | % |
| Male | 656 | 58.6% |
| Female | 464 | 41.4% |
| Workload | | |
| Light | 205 | 18.3% |
| Heavy | 445 | 39.7% |
| Sedentary | 293 | 26.2% |
| Retirement pension | 177 | 15.8% |
| Level of herniation | | |
| L1/2 | 7 | 0.6% |
| L2/3 | 42 | 3.8% |
| L3/4 | 86 | 7.7% |
| L4/5 | 475 | 42.4% |
| L5/S1 | 510 | 45.5% |

**TABLE 1. Continued.**

| Characteristic | Median | IQR |
|---|---|---|
| Sensory deficit—Yes | | |
| Preoperative | 837 | 74.7% |
| After 6 wk | 728 | 65.0% |
| After 6 mo | 653 | 58.3% |
| After 12 mo | 529 | 47.2% |
| After 24 mo | 500 | 44.6% |
| Motor deficit—Yes (MRC 0-4) | | |
| Preoperative | 744 | 66.4% |
| After 6 wk | 586 | 52.3% |
| After 6 mo | 503 | 44.9% |
| After 12 mo | 412 | 36.8% |
| After 24 mo | 320 | 28.6% |

BMI, body mass index; MRC, Medical Research Council; NRS, Numeric Rating Scale; ODI, Oswestry Disability Index.

## Preoperative Assessment

On obtaining informed consent and meeting all requisite criteria, the patient completed questionnaires detailing the intensity and duration of pain, as well as disability, 1 day before the microdiskectomy. The intensity of LBP and radicular pain was quantified using the Numeric Rating Scale (NRS). Disability assessment was conducted using the Oswestry Disability Questionnaire. The degree of disability (level of function) was expressed as a percentage and was calculated from the sum of the points from all questions in the Oswestry Disability Questionnaire. Oswestry Disability Index (ODI) can take values from 0% to 100%, where 0% means no disability and 100% indicates maximum disability because of LBP. Motor deficits were assessed and graded by the Medical Research Council (MRC) scale and categorized as severe (MRC 0-2), moderate (MRC 3-4), or absent (MRC 5). Sensory deficits in the affected dermatome were classified as present or absent. These clinical assessments were conducted by a neurosurgical resident and subsequently validated by a board-certified neurosurgeon.

## Surgical Intervention

Following the established institutional protocols, patients presenting with significant motor deficits or profound disabilities related to LDH were subjected to acute surgical intervention within days or weeks. Conversely, the remaining patients received preoperative conservative treatment for varying durations. The surgery was performed using an operating microscope. An interlaminar approach was used in every case. The disk herniation was subsequently exposed and excised, along with the residual fragments of the nucleus pulposus within the intervertebral space.

## Postoperative Outcome

Postoperative on-site follow-up (FU) visits were conducted at 6 weeks, 6, 12, and 24 months after the surgical procedure. During FU visits, each

**TABLE 2. The Basic Characteristics of Patients Categorized Into Distinct Groups Based on the Duration of Low Back Pain, Radicular Leg Pain, and Neurological Deficits**

| | Age | | | Gender | | | Body mass index | | |
|---|---|---|---|---|---|---|---|---|---|
| **Duration of low back pain** | **Median** | **IQR** | ***P*-value** | **Men** | **Women** | ***P*-value** | **Median** | **IQR** | ***P*-value** |
| ≤1 mo | 46.5 | 40.0; 57.8 | .191 | 110 (64.7%) | 60 (35.3%) | .329 | 26.6 | 23.7; 29.8 | .108 |
| ≤6 mo | 46.0 | 37.0; 56.0 | | 306 (57.8%) | 223 (42.2%) | | 27 | 24.5; 30.2 | |
| ≤24 mo | 51.0 | 37.8; 60.0 | | 153 (58.0%) | 111 (42.0%) | | 27.4 | 24.9; 30.9 | |
| ≥25 mo | 50.0 | 38.0; 58.0 | | 87 (55.4%) | 70 (44.6%) | | 26.9 | 23.9; 30.4 | |
| **Duration of radicular leg pain** | **Median** | **IQR** | ***P*-value** | **Male** | **Female** | ***P*-value** | **Median** | **IQR** | ***P*-value** |
| ≤1 mo | 44.0 | 38.0; 56.0 | .101 | 135 (61.9%) | 83 (38.1%) | .655 | 26.6 | 24.0; 29.4 | .003 |
| ≤6 mo | 47.0 | 38.0; 57.0 | | 363 (57.3%) | 271 (42.7%) | | 26.9 | 24.2; 30.4 | |
| ≤24 mo | 52.0 | 38.0; 60.0 | | 116 (58.3%) | 83 (41.7%) | | 28.2 | 25.3; 31.3 | |
| ≥25 mo | 49.0 | 40.0; 58.0 | | 42 (60.9%) | 27 (39.1%) | | 26.8 | 23.8; 30.1 | |
| **Duration of neurological deficit** | **Median** | **IQR** | ***P*-value** | **Male** | **Female** | ***P*-value** | **Median** | **IQR** | ***P*-value** |
| ≤1 mo | 44.0 | 38.0; 56.0 | .059 | 151 (61.1%) | 96 (38.9%) | .735 | 26.5 | 23.8; 29.3 | .003 |
| ≤6 mo | 47.0 | 38.0; 57.0 | | 362 (57.2%) | 271 (42.8%) | | 27.1 | 24.4; 30.7 | |
| ≤24 mo | 52.0 | 38.0; 60.0 | | 101 (59.4%) | 69 (40.6%) | | 27.8 | 25.2; 31.2 | |
| ≥25 mo | 49.5 | 40.3; 58.0 | | 42 (60.0%) | 28 (40.0%) | | 26.9 | 23.9; 30.1 | |

patient completed the identical questionnaires administered before the operation. The neurological deficits were also evaluated using the same methodology as before the surgical intervention. These evaluations were executed by a neurosurgical resident and subsequently validated by a board-certified neurosurgeon.

### Statistical Analysis

Continuous variables were expressed as medians accompanied by IQR, whereas discrete variables were represented as counts (N) alongside their respective percentages. The Kruskal-Wallis test was used to analyze continuous variables, followed by a post hoc Dunn test with Bonferroni correction for multiple comparisons. For categorical variables, the $\chi^2$ test, augmented with Yates continuity correction, was used, and, subsequently, a post hoc $\chi^2$ test with Bonferroni correction was conducted. Adjustments were always calculated for an individual comparison. Post hoc tests, which were calculated on 2 × 2 tables, provided the CI for the difference in proportions, along with the *P*-values. The significance threshold was established at $P < .05$. The analysis used R version 4.2.3 (R Core Team 2021; R Foundation for Statistical Computing).

## RESULTS

A total of 1222 patients were prospectively enrolled in the study. Patients who experienced a recurrence of LDH (n = 69) or were lost to FU visits (n = 33) were excluded from the statistical analyses. Finally, 1120 patients underwent statistical analyses (Figure 1). The baseline characteristics of patients included in the study are presented in Table 1. The cohort was divided into 4 groups based on the duration of LDH-related symptoms, including radicular leg pain, LBP, disability, and neurological symptomatology: ≤1, ≤6, ≤24, and ≥25 months (Tables 2-4). We determined threshold values for improvement in LBP and leg pain by more than 3 points on the NRS and ODI by 30% or more at FU visits.[14-16]

### Analysis of Radicular Leg Pain

At the 6-week FU visits, individuals who experienced preoperative radicular pain for ≤1 month exhibited a more pronounced reduction in pain intensity (>3 points on the NRS) when compared with those with a duration of preoperative symptoms ≤6 months ($P$ = .007, CI = −0.228; −0.030), ≤24 months ($P$ = .003, CI = −0.299; −0.047), and ≥25 months ($P < .001$, CI = −0.446; −0.093) (Figure 2). Patients with a preoperative radicular leg pain duration of ≤1 month experienced a more significant decrease in pain intensity during the 6-month FU ($P < .001$, CI = −0.423; −0.069), 12-month FU ($P < .001$, CI = −0.417; −0.069), and 24-month FU ($P < .001$, CI = −0.421; −0.080) visits in comparison with those whose radicular pain persisted ≥25 months. Furthermore, a statistically significant decrease in pain intensity was also noted during the 6-month FU, 12-month FU, and 24-month FU visits for patients with preoperative radicular pain

**TABLE 3.** **The Levels of Intervertebral Disk Herniation Assessed in Relation With the Duration of Low Back Pain, Radicular Leg Pain, and Presence of Neurological Deficits**

| | Level of herniation | | | | |
|---|---|---|---|---|---|
| Duration of symptoms | L1/2 | L2/3 | L3/4 | L4/5 | L5/S1 |
| Duration of low back pain | | | | | |
| ≤1 mo | 0 (0.0%) | 6 (3.5%) | 18 (10.6%) | 76 (44.7%) | 70 (41.2%) |
| ≤6 mo | 7 (1.3%) | 26 (4.9%) | 30 (5.7%) | 220 (41.6%) | 246 (46.5%) |
| ≤24 mo | 0 (0.0%) | 5 (1.9%) | 27 (10.2%) | 115 (43.6%) | 117 (44.3%) |
| ≥25 mo | 0 (0.0%) | 5 (3.2%) | 11 (7.0%) | 64 (40.8%) | 77 (49.0%) |
| Duration of radicular leg pain | | | | | |
| ≤1 mo | 0 (0.0%) | 5 (2.3%) | 22 (10.1%) | 94 (43.1%) | 97 (44.5%) |
| ≤6 mo | 7 (1.1%) | 30 (4.7%) | 37 (5.8%) | 266 (42.0%) | 294 (46.4%) |
| ≤24 mo | 0 (0.0%) | 3 (1.5%) | 21 (10.6%) | 87 (43.7%) | 88 (44.2%) |
| ≥25 mo | 0 (0.0%) | 4 (5.8%) | 6 (8.7%) | 28 (40.6%) | 31 (44.9%) |
| Duration of neurological deficit | | | | | |
| ≤1 mo | 0 (0.0%) | 5 (2.0%) | 22 (8.9%) | 103 (41.7%) | 117 (47.4%) |
| ≤6 mo | 7 (1.1%) | 31 (4.9%) | 46 (7.3%) | 262 (41.4%) | 287 (45.3%) |
| ≤24 mo | 0 (0.0%) | 2 (1.2%) | 12 (7.1%) | 82 (48.2%) | 74 (43.5%) |
| ≥25 mo | 0 (0.0%) | 4 (5.7%) | 6 (8.6%) | 28 (40.0%) | 32 (45.7%) |

duration ≤6 months ($P$ = .039, CI = −0.339; −0.007, $P$ = .028, CI = −0.336; −0.007, and $P$ = .016, CI = −0.339; −0.013, respectively) and ≤24 months ($P$ = .001, CI = −0.434; −0.078, $P$ < .001, CI = −0.433; −0.084, and $P$ = .001, CI = −0.412; −0.067, respectively) when compared with the cohort with preoperative radicular pain lasting ≥25 months. We found a statistically significant difference in BMI ($P$ = .003) (Table 2) and the workload of patients divided according to the duration of radicular pain ($P$ = .014) (Table 4).

## Disability and LBP Associated With LDH

During the 6-week FU visits, patients who had experienced preoperative LBP for ≤1 month ($P$ = .028, CI = −0.286; −0.018) and ≤6 months ($P$ < .001, CI = −0.284; −0.071) exhibited a more pronounced reduction in pain intensity (>3 points vs ≤3 points on the NRS) when compared with patients with LBP persisting ≥25 months (Figure 3). As for disability, at the 6-week FU visit, a decrease of 30% or more in the ODI score (compared with ≤29%) was found significantly more often in patients with LBP-induced disability lasting ≤1 month compared with patients with duration of preoperative disability ≤24 months ($P$ < .001, CI = −0.310; −0.065) and ≥25 months ($P$ = .022, CI = −0.299; −0.023). We observed significant differences between the workload of patients divided according to the duration of LBP ($P$ = .017) (Table 4).

## Analysis of Motor Weakness Caused by LDH

At the 6-week FU visit, significant differences were found in postoperative improvement in motor deficit (transitioning MRC grades from 0-2 to 3-4, from 0-2 to 5, or from 3-4 to 5), nonimprovement, and normal muscle strength in patients with duration of radicular motor deficit of ≤1 month compared with patients with duration of radicular motor weakness of ≤6 months ($P$ < .001), ≤24 months ($P$ < .001), and ≥25 months ($P$ < .001) (Figure 4). Most patients who experienced motor improvements had motor weakness lasting ≤1 month. Similarly, during the 6-, 12-, and 24-month FU assessments, differences in improvement in motor deficit, nonimprovement, and normal muscle strength were observed in patients with a preoperative radicular motor deficit lasting ≤1 month relative to those with a duration of ≤6 months ($P$ < .001, $P$ < .001, and $P$ < .001, respectively), ≤24 months ($P$ < .001, $P$ < .001, and $P$ < .001, respectively), and ≥25 months ($P$ < .001, $P$ < .001, and $P$ < .001, respectively). In these cases, improvements in motor deficits were most often observed in patients with motor weakness lasting ≤1 month. In addition, at the 6-, 12-, and 24-month FU visits, differences in improvement in motor deficit, nonimprovement, and normal muscle strength between patients were also noted in patients with a preoperative motor deficit of ≤6 months ($P$ = .028, $P$ = .042, and $P$ < .001, respectively) and ≤24 months ($P$ = .028, $P$ = .008, and $P$ = .008, respectively)

**TABLE 4. The Workload Distribution Among Patient Groups Determined by the Duration of Low Back Pain, Radicular Leg Pain, and Neurological Deficits**

| | Workload | | | | |
|---|---|---|---|---|---|
| **Duration of symptoms** | **Light** | **Heavy** | **Sedentary** | **Retirement pension** | ***P*-value** |
| Duration of low back pain | | | | | |
| ≤1 mo | 31 (18.2%) | 77 (45.3%) | 37 (21.8%) | 25 (14.7%) | .017 |
| ≤6 mo | 96 (18.1%) | 209 (39.5%) | 148 (28.0%) | 76 (14.4%) | |
| ≤24 mo | 36 (13.6%) | 109 (41.3%) | 65 (24.6%) | 54 (20.5%) | |
| ≥25 mo | 42 (26.8%) | 50 (31.8%) | 43 (27.4%) | 22 (14.0%) | |
| Duration of radicular leg pain | | | | | |
| ≤1 mo | 40 (18.3%) | 97 (44.5%) | 52 (23.9%) | 29 (13.3%) | .014 |
| ≤6 mo | 108 (17.0%) | 253 (39.9%) | 174 (27.4%) | 99 (15.6%) | |
| ≤24 mo | 33 (16.6%) | 76 (38.2%) | 49 (24.6%) | 41 (20.6%) | |
| ≥25 mo | 24 (34.8%) | 19 (27.5%) | 18 (26.1%) | 8 (11.6%) | |
| Duration of neurological deficit | | | | | |
| ≤1 mo | 47 (19.0%) | 109 (44.1%) | 61 (24.7%) | 30 (12.1%) | .011 |
| ≤6 mo | 107 (16.9%) | 251 (39.7%) | 173 (27.3%) | 102 (16.1%) | |
| ≤24 mo | 27 (15.9%) | 66 (38.8%) | 41 (24.1%) | 36 (21.2%) | |
| ≥25 mo | 24 (34.3%) | 19 (27.1%) | 18 (25.7%) | 9 (12.9%) | |

when contrasted with patients exhibiting radicular motor weakness ≥25 months. At these FU visits, improvement in motor deficit was least common in patients with radicular weakness lasting ≥25 months. We also found significant differences between the BMI ($P$ = .003) and workload ($P$ = .011) of patients divided according to the duration of preoperative neurological deficit (Tables 2 and 4).

### Residual Motor Deficit

Residual motor deficit (MRC 0-4) 2 years after surgery was the least frequent in patients with a duration of preoperative motor deficit of ≤1 month (11.3%) compared with patients with radicular weakness lasting ≤6 months (31.3%; $P$ < .001, CI = 0.127; 0.272), ≤24 months (32.4%; $P$ < .001, CI = 0.102; 0.319), and ≥25 months (55.7%; $P$ < .001, CI = 0.278; 0.609) (Figure 5).

### Analysis of Sensory Deficit in Patients With LDH

FU assessments at 6 weeks, 6, 12, and 24 months postoperatively indicated differences in improvement in sensory deficit, nonimprovement, and normal sensory function among patients exhibiting preoperative sensory deficits lasting ≤1 month, in comparison with those whose sensory deficits persisted for ≤6 months ($P$ < .001, $P$ < .001, $P$ < .001, $P$ < .001, respectively), ≤24 months ($P$ < .001, $P$ < .001, $P$ < .001, $P$ < .001, respectively), and for durations ≥25 months ($P$ = .006, $P$ < .001, $P$ < .001, $P$ < .001, respectively) (Figure 6). During these FU visits, improvements in sensory deficits were found most often in patients with a neurological deficit lasting ≤1 month.

### Residual Sensory Deficit

At the 24-month FU visit, residual sensory deficits were observed least frequently in patients who experienced a duration of preoperative motor deficits of ≤1 month (29.6%) compared with those with a sensory deficit duration of ≤6 months (47.2%, $P$ < .001, CI = 0.084; 0.270), ≤24 months (47.1%, $P$ = .002, CI = 0.048; 0.302), and ≥25 months (68.6%, $P$ < .001, CI = 0.225; 0.555) (Figure 5).

## DISCUSSION

In this extensive prospective cohort study involving patients who underwent surgical treatment of LDH, we established that the duration of preoperative symptoms significantly influenced postoperative clinical outcomes. Our findings indicated that patients with LDH who underwent surgical intervention within 1 month after the onset of symptoms achieved the most favorable outcomes. Conversely, in cases where LDH symptoms persisted for a duration of 1 month to 2 years, patient outcomes were markedly impaired, particularly concerning motor and sensory deficits. Ultimately, we

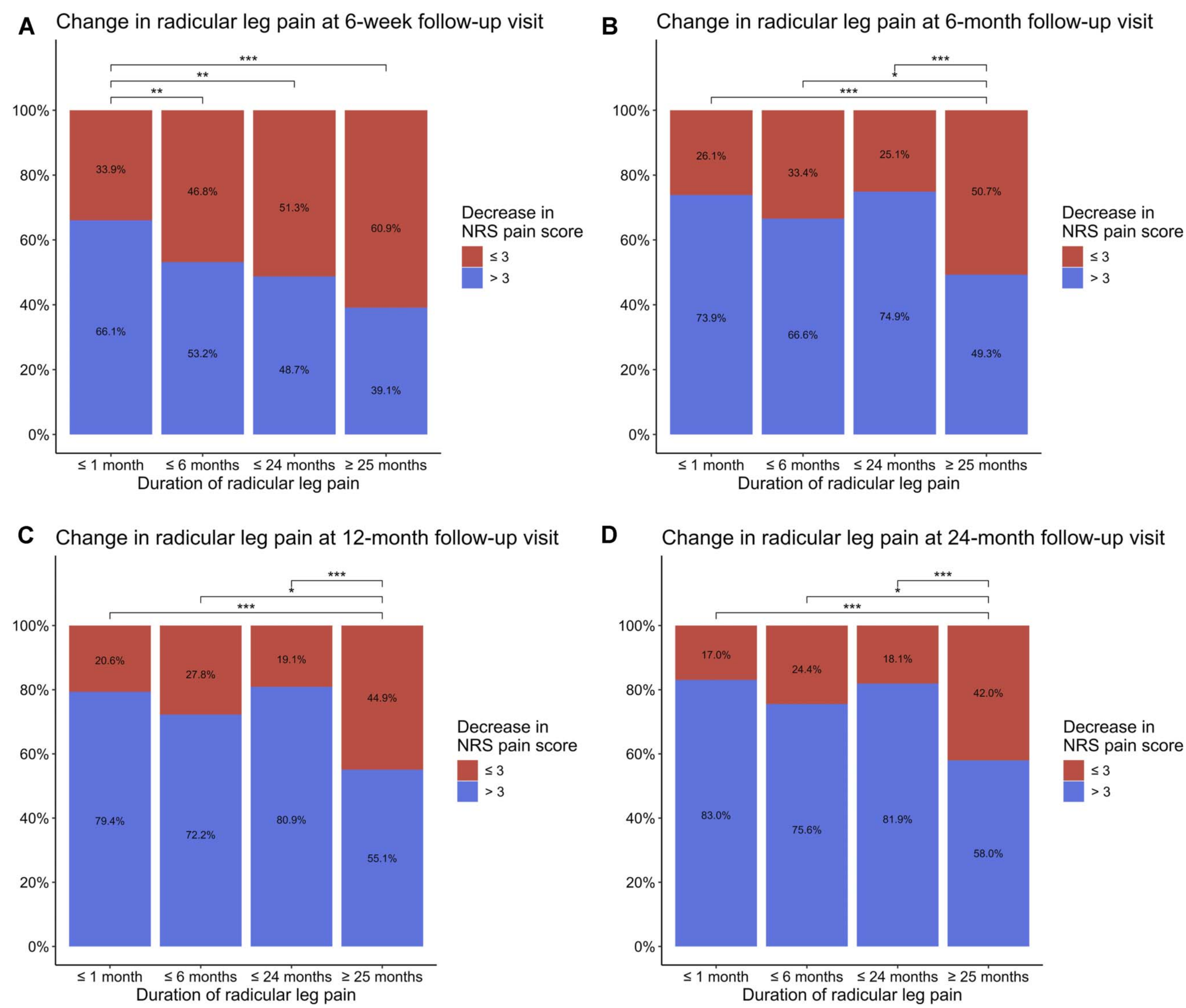


**FIGURE 2.** *The graphs illustrate a reduction in radicular leg pain, quantified as a decrease of 3 points or less (indicated by the red column) and 4 points or more (represented by the blue column), in accordance with the NRS across patient cohorts during the postoperative 6-week* **A**, *6-month* **B**, *12-month* **C**, *and 24-month* **D** *follow-up visits. Asterisks denote a statistically significant difference between the groups (*P < .05; ***P < .001). NRS, Numeric Rating Scale.*

noted the least favorable postoperative outcomes in patients presenting with LDH-associated symptoms lasting beyond 2 years, as these individuals exhibited the highest percentage of residual motor and sensory deficits, even 2 years postsurgery.

## Effectiveness of Early Surgery in Patients With LDH

The study presented highlights the critical importance of early surgical intervention on outcomes for patients diagnosed with LDH and relevant neurological symptoms. Consistent with our findings, the efficacy of prompt surgical treatment for LDH is supported by several publications emphasizing a more rapid recovery compared with conservative treatment.[6,17,18] Nevertheless, the studies above were not consistent and varied in their recommendations regarding the optimal timing for surgery in patients with LDH. Several factors, mainly the retrospective design of most studies, differences in measuring symptom duration or postoperative recovery, the lack of symptom severity assessments, and the overall quality of the studies, may have contributed to a notable degree of heterogeneity. By contrast, this study addresses many of these limitations, primarily through prospective data collection, a standardized assessment of symptoms and their severity, a substantial patient cohort, and a FU period of 24 months.

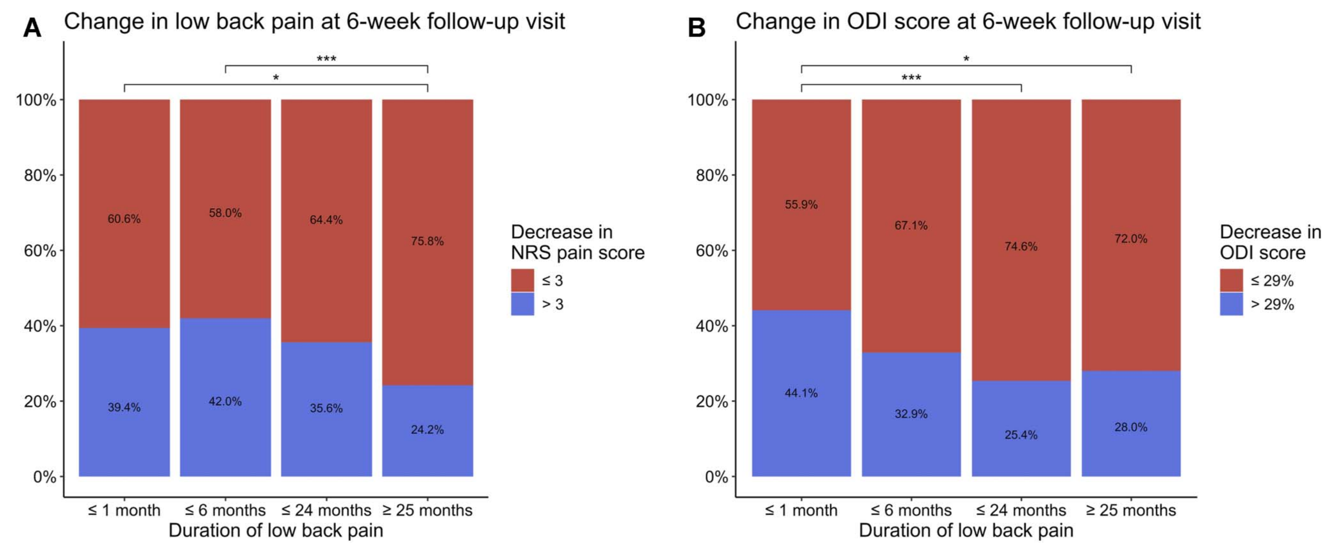


**FIGURE 3.** *Graph **A** illustrates a reduction in LBP scores of 3 points or fewer (indicated by the red column) and 4 points or more (represented by the blue column) among patient groups during the 6-week postoperative follow-up visit, as measured by the NRS. Graph **B** depicts a decrease in ODI scores of 29% or less (as shown in the red column) and 30% or more (as indicated by the blue column) among patients in distinct groups based on the preoperative duration of LBP during the same 6-week postoperative follow-up visit. Asterisks denote a statistically significant difference between groups (*P < .05; ***P < .001). LBP, low back pain; ODI, Oswestry Disability Index; NRS, Numeric Rating Scale.*

Furthermore, this study represents the first comprehensive examination of the impact of LDH surgery on patients experiencing radicular symptoms lasting beyond 2 years.

It is acknowledged that approximately 20% to 40% of patients diagnosed with LDH require surgery despite undergoing conservative treatment.[19,20] The significance of surgical intervention in managing LDH is substantiated by numerous high-quality publications, which demonstrate superior outcomes in patients with LDH who underwent surgical procedures compared with those who received long-lasting nonsurgical treatment.[21,22] Nevertheless, in clinical practice, surgical treatment of patients presenting with LDH is frequently postponed. This delay may adversely affect postoperative recovery and overall outcomes. Previous research has shown that early surgery in patients with LDH leads to recovery that is about twice as fast compared with conservative treatment methods.[6,17,19] Other studies on motor deficits related to LDH have also highlighted the benefits of early surgical decompression.[10,11] These recommendations align with our results, which validate the importance of early surgery in improving neurological deficits among patients diagnosed with LDH. This also applies to sensory deficits, where a longer duration of preoperative neurological symptoms is associated with a greater likelihood of residual symptoms.

## Discogenic LBP and LDH Surgery

Discogenic LBP frequently occurs in patients with LDH. The generator of discogenic LBP is linked to degenerative disk disease.[23] The treatment of discogenic LBP typically encompasses conservative management, including pharmacotherapy and physical or psychological rehabilitation. If conservative treatments prove ineffective, surgical interventions involving fusion or artificial disk replacement should be contemplated.[24] In this study, we observed a more substantial reduction in LBP during the 6-week FU assessments among patients diagnosed with LDH who experienced a duration of LBP lasting up to 1 month before microdiskectomy. Like other evaluated parameters, patients with a history of discogenic LBP exceeding 2 years demonstrated the least significant reduction in pain levels.

LBP is often associated with the limitation of normal daily activities, which can be quantified by the ODI, a usual outcome metric.[4,25-27] The findings of our study indicated that a reduction in the ODI was most pronounced in patients with LDH and preoperative LBP, which persisted for less than 1 month. Similarly, we noted variances in the ODI only 6 weeks postsurgery. The rapid decline in LBP and ODI observed in patients undergoing microdiskectomy, occurring within 1 month of symptom onset, may be attributable to less advanced degenerative changes and more significant inflammatory processes associated with the early stages of disk degeneration.[28-30]

## Limitations

Our study presents several limitations. One of the primary limitations pertains to classifying motor and sensory deficits. The categorization of motor and sensory deficits has been simplified because of the number of groups involved, which restricts the statistical evaluation of a larger number of groups. However, the MRC classification system divides radicular motor

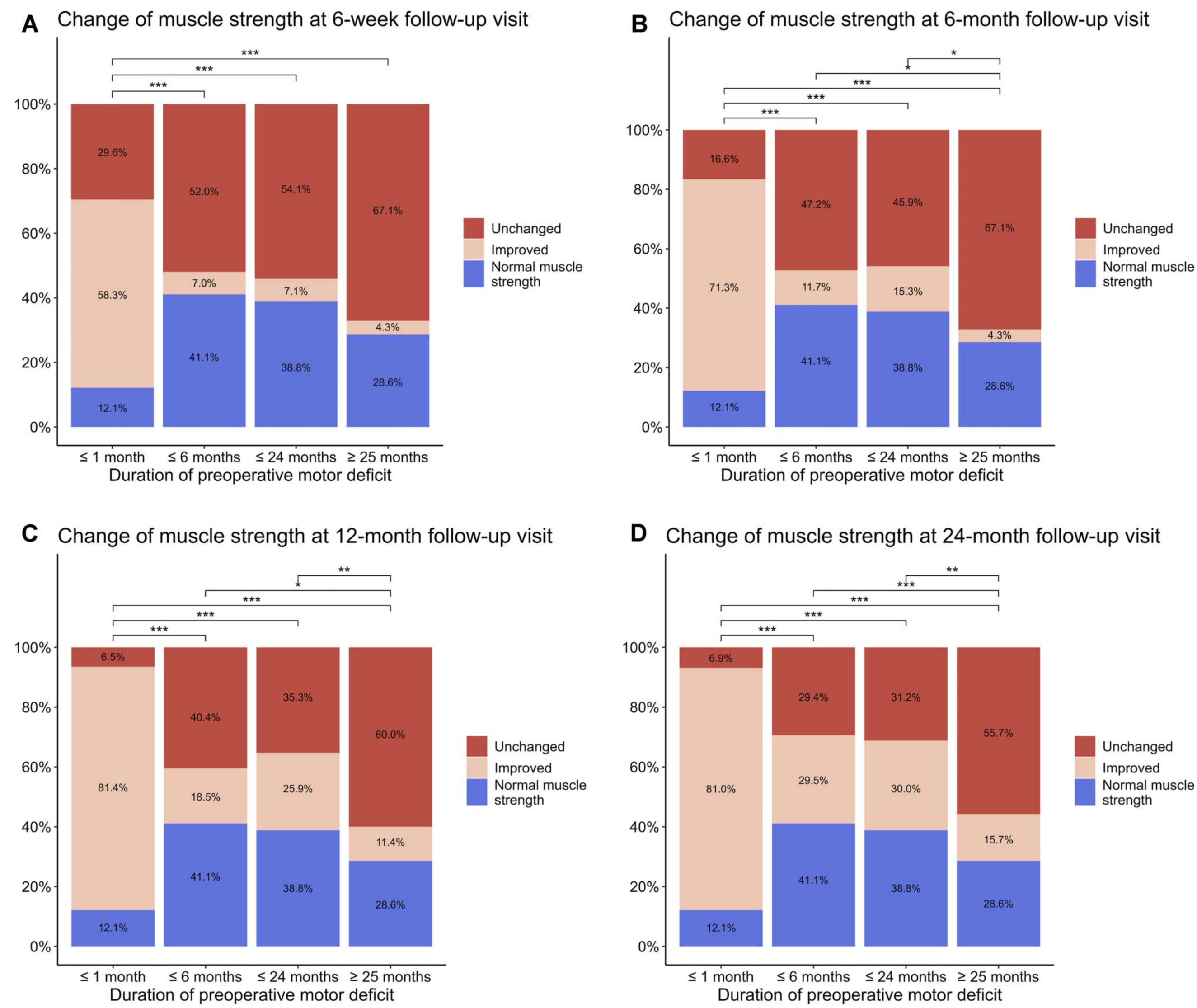


**FIGURE 4.** *The graphs illustrate the variations in muscle strength among patients categorized by the preoperative duration of radicular motor deficit, with specific columns representing unchanged strength (red column), improved strength (middle column), and normal muscle strength (blue column). This analysis encompasses postoperative 6-week* **A**, *6-month* **B**, *12-month* **C**, *and 24-month* **D** *follow-up visits. Asterisks denote statistically significant differences between the groups (*P < .05; **P < .01; ***P < .001).*

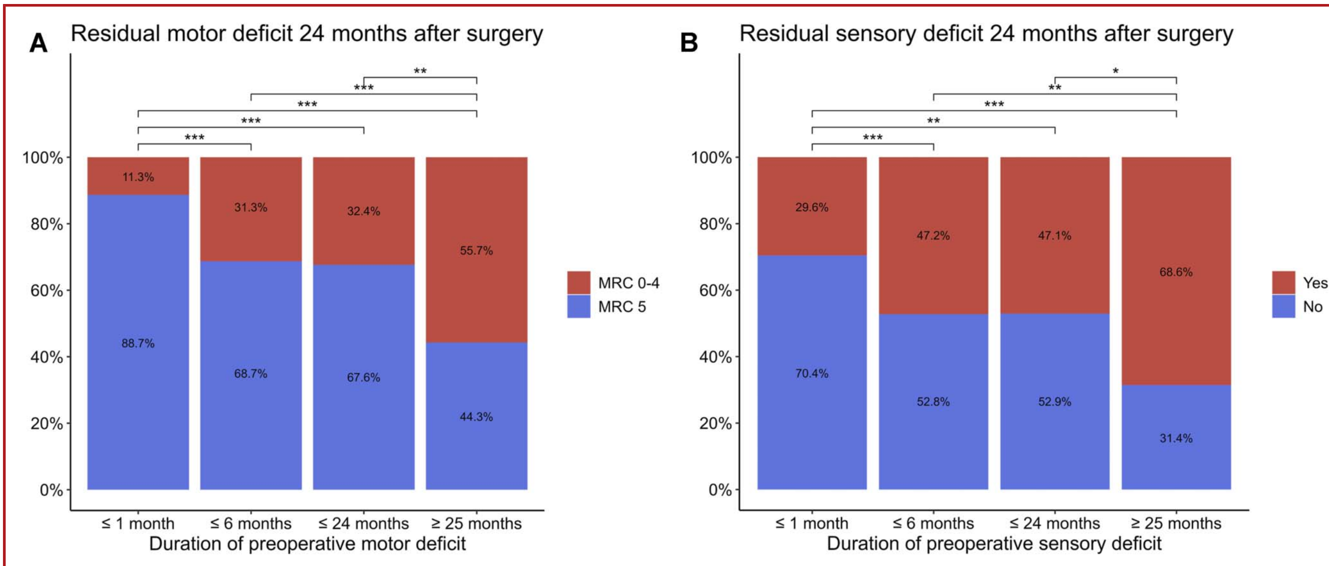


**FIGURE 5.** *The graphs show residual motor* **A** *and sensory* **B** *deficits 24 months after surgery. Graph* **A** *depicts a residual motor deficit (MRC 0-4), as shown in the red column, and full muscle strength (MRC 5), as indicated by the blue column. Graph* **B** *illustrates a residual sensory deficit (as shown in the red column) and normal sensory function (as shown in the blue column). Asterisks denote significant differences between groups (*P < .05; **P < .01; ***P < .001). MRC, Medical Research Council.*

deficits into severe, moderate-to-mild, and normal categories, along with the presence or absence of sensory deficits, reflecting standard clinical practice. In patients with a longer duration of symptoms, standard conservative treatment, including bed rest, analgesics, rehabilitation, periradicular therapy, or epidural steroid injections, was performed. This makes it difficult to compare clinical outcomes in patients after early surgery and patients with defined conservative treatment who underwent later surgery. Another limitation may be the absence of a long-term outcome, which may be the topic of a future study. Owing to the necessity of uniform FU visits for all patients, waiting 2 years from the operation date for the last enrolled patient becomes essential.

## CONCLUSION

Our findings substantiate the critical importance of the surgical intervention timing on the postoperative outcomes of patients with LDH. Surgical treatment within 1 month of the onset of symptoms associated with LDH results in a more rapid and pronounced alleviation of radicular pain and LBP, as well as enhancements in disability and motor and sensory deficits when compared with surgeries conducted at a later stage. Furthermore, residual motor and sensory deficits observed 2 years postsurgery were more prevalent among patients who experienced a preoperative duration of neurological symptomatology related to LDH exceeding 1 month.

### Funding

The study was supported by the Ministry of Health of the Czech Republic in cooperation with the Czech Health Research Council under project No. NW25J-10-00060.

### Disclosures

The authors have no personal, financial, or institutional interest in any drugs, materials, or devices described in this article.

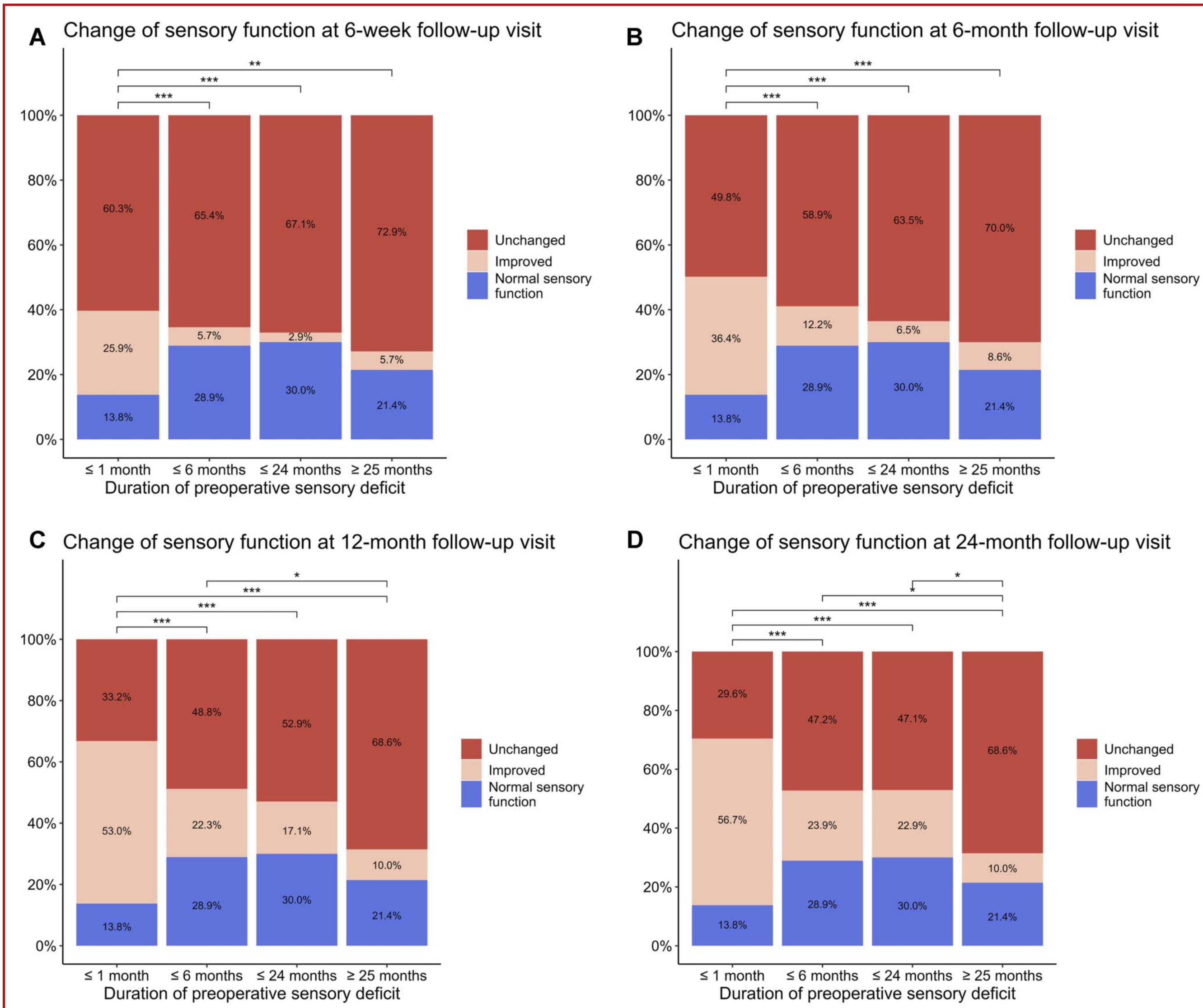


**FIGURE 6.** *The graphs illustrate the comparison of sensory function status among various patient groups based on the preoperative duration of sensory deficit. The indicated columns represent unchanged or loss of sensory function (red column), improved sensory function (middle column), and normal sensory function (blue column) over the 6-week* **A***, 6-month* **B***, 12-month* **C***, and 24-month* **D** *follow-up visits. Asterisks denote significant differences between groups (*P < .05; **P < .01; ***P < .001).*

## REFERENCES


1. Ravindra VM, Senglaub SS, Rattani A, et al. Degenerative lumbar spine disease: estimating global incidence and worldwide volume. *Glob Spine J.* 2018;8(8):784-794.
2. Schroeder JE, Dettori JR, Brodt ED, Kaplan L. Disc degeneration after disc herniation: are we accelerating the process? *Evid Based Spine Care J.* 2012;3(4):33-40.
3. Hadjipavlou AG, Tzermiadianos MN, Bogduk N, Zindrick MR. The pathophysiology of disc degeneration: a critical review. *J Bone Joint Surg Br.* 2008;90-B(10):1261-1270.
4. Takahashi H, Aoki Y, Inoue M, et al. Characteristics of relief and residual low back pain after discectomy in patients with lumbar disc herniation: analysis using a detailed visual analog scale. *BMC Musculoskelet Disord.* 2021;22(1):167.
5. Amin RM, Andrade NS, Neuman BJ. Lumbar disc herniation. *Curr Rev Musculoskelet Med.* 2017;10(4):507-516.
6. Peul WC, van den Hout WB, Brand R, Thomeer RTWM, Koes BW; Leiden-The Hague Spine Intervention Prognostic Study Group. Prolonged conservative care versus early surgery in patients with sciatica caused by lumbar disc herniation: two year results of a randomised controlled trial. *BMJ.* 2008;336(7657):1355-1358.
7. Lønne G, Solberg TK, Sjaavik K, Nygaard ØP. Recovery of muscle strength after microdiscectomy for lumbar disc herniation: a prospective cohort study with 1-year follow-up. *Eur Spine J.* 2011;21(4):655.
8. Aono H, Iwasaki M, Ohwada T, et al. Surgical outcome of drop foot caused by degenerative lumbar diseases. *Spine (Phila Pa 1976).* 2007;32(8):e262-e266.
9. Ahn UM, Ahn NU, Buchowski JM, Garrett ES, Sieber AN, Kostuik JP. Cauda equina syndrome secondary to lumbar disc herniation: a meta-analysis of surgical outcomes. *Spine (Phila Pa 1976).* 2000;25(12):1515-1522.
10. Thomé C, Kögl N, Grassner L, Vo AK, Kramer JLK, Petr O. Motor recovery depends on timing of surgery in patients with lumbar disk herniation. *Neurosurgery.* 2022;90(3):347-353.

11. Kögl N, Brawanski K, Girod PP, Petr O, Thomé C. Early surgery determines recovery of motor deficits in lumbar disc herniations—a prospective single-center study. *Acta Neurochir.* 2021;163(1):275-280.
12. Ruan W, Feng F, Liu Z, Xie J, Cai L, Ping A. Comparison of percutaneous endoscopic lumbar discectomy versus open lumbar microdiscectomy for lumbar disc herniation: a meta-analysis. *Int J Surg.* 2016;31:86-92.
13. Li WS, Yan Q, Cong L. Comparison of endoscopic discectomy versus non-endoscopic discectomy for symptomatic lumbar disc herniation: a systematic review and meta-analysis. *Glob Spine J.* 2022;12(5):1012-1026.
14. Ostelo RWJG, de Vet HCW. Clinically important outcomes in low back pain. *Best Pract Res Clin Rheumatol.* 2005;19(4):593-607.
15. Solberg T, Johnsen LG, Nygaard ØP, Grotle M. Can we define success criteria for lumbar disc surgery?: estimates for a substantial amount of improvement in core outcome measures. *Acta Orthop.* 2013;84(2):196-201.
16. Ostelo RWJG, Deyo RA, Stratford P, et al. Interpreting change scores for pain and functional status in low back pain: towards international consensus regarding minimal important change. *Spine (Phila Pa 1976).* 2008;33(1):90-94.
17. Peul WC, van Houwelingen HC, van den Hout WB, et al. Surgery versus prolonged conservative treatment for sciatica. *N Engl J Med.* 2007;356(22):2245-2256.
18. Schoenfeld AJ, Bono CM. Does surgical timing influence functional recovery after lumbar discectomy? A systematic review. *Clin Orthop Relat Res.* 2015;473(6):1963-1970.
19. Arts MP, Peul WC. Timing and minimal access surgery for sciatica: a summary of two randomized trials. *Acta Neurochir (Wien).* 2011;153(5):967-974.
20. Vroomen PC, de Krom MC, Slofstra PD, Knottnerus JA. Conservative treatment of sciatica: a systematic review. *J Spinal Disord.* 2000;13(6):463-469.
21. Atlas SJ, Keller RB, Wu YA, Deyo RA, Singer DE. Long-term outcomes of surgical and nonsurgical management of sciatica secondary to a lumbar disc herniation: 10 year results from the Maine lumbar spine study. *Spine (Phila Pa 1976).* 2005;30(8):927-935.
22. Weinstein JN, Lurie JD, Tosteson TD, et al. Surgical versus nonoperative treatment for lumbar disc herniation: four-year results for the Spine Patient Outcomes Research Trial (SPORT). *Spine (Phila Pa 1976).* 2008;33(25):2789-2800.
23. Peng BG. Pathophysiology, diagnosis, and treatment of discogenic low back pain. *World J Orthop.* 2013;4(2):42-52.
24. Zhao L, Manchikanti L, Kaye AD, Abd-Elsayed A. Treatment of discogenic low back pain: current treatment strategies and future options—a literature review. *Curr Pain Headache Rep.* 2019;23(11):86.
25. Fairbank JCT. Letter to the editor: Oswestry Disability Index. *J Neurosurg Spine.* 2014;20(2):239-242.
26. Kumar R, Alostaz M, Bansal A, et al. Describing functional low back pain disability in the American population: a crowd-sourced evaluation of the Oswestry disability index. *Spine J.* 2024;24(11):2165-2171.
27. Misterska E, Jankowski R, Glowacki M. Quebec Back Pain Disability Scale, Low Back Outcome Score and revised Oswestry low back pain disability scale for patients with low back pain due to degenerative disc disease: evaluation of Polish versions. *Spine (Phila Pa 1976).* 2011;36(26):e1722-e1729.
28. Kos N, Gradisnik L, Velnar T. A brief review of the degenerative intervertebral disc disease. *Med Arch.* 2019;73(6):421-424.
29. Altun I. Cytokine profile in degenerated painful intervertebral disc: variability with respect to duration of symptoms and type of disease. *Spine J.* 2016;16(7):857-861.
30. Sivan SS, Hayes AJ, Wachtel E, et al. Biochemical composition and turnover of the extracellular matrix of the normal and degenerate intervertebral disc. *Eur Spine J.* 2014;23(Suppl 3):S344-S353.



## Acknowledgments

Author contributions: P. S. and R. J. contributed to conceptualization; P. S., R. J., and D. O. contributed to the methodology, conducted operations, and collected data; P.W. performed data analysis; P. S., R. J., D. O., and P. W. contributed to writing and editing the manuscript; R.J. supervised the study. All authors reviewed the manuscript and agreed to its final version.