The necessity and timing of exercise after lumbar disc herniation surgery

E. UYSAL[1], H.S. CINE[2], E. CETIN[3]

[1]Department of Neurosurgery, University of Health Sciences, Prof. Dr. Cemil Tascioglu City Hospital, Istanbul, Turkey
[2]Department of Neurosurgery, Istanbul Medeniyet University, Prof. Dr. Suleyman Yalcin City Hospital, Istanbul, Turkey
[3]Department of Neurosurgery, University of Health Sciences, Haydarpasa Numune Training and Research Hospital, Istanbul, Turkey

Abstract. – OBJECTIVE: Physical therapy and rehabilitation may improve low back pain and quality of life after lumbar disc herniation. However, there is no agreement on its optimal start time and rehabilitative methods. This study evaluates the effects of early and late rehabilitation on low back pain and quality of life following unilateral microdiscectomy.

PATIENTS AND METHODS: A total of 204 patients who underwent surgery for lumbar disc herniation were included and subsequently randomized into five groups: 1. No exercise, 2. The 2nd-week walking group, 3. 1st-month walking group, 4. 2nd-week waist exercise, 5. 1st-month waist exercise. Visual analog scale (VAS) and Oswestry Disability Index (ODI) were assessed at the 1st week, 1st, 3rd, and 6th, and 12th-month follow-up after surgery.

RESULTS: 1st-month VAS scores were analyzed, and a significant difference was found between the VAS scores of the 2nd-week walk (3.60±0.78) and 2nd-week waist exercise (3.38±0.67) groups and the other groups (*p*<0.001). 3rd-month VAS results were analyzed, and the VAS scores of the 1st-month walk group (2.67±0.48) were significantly higher than those of the 2nd-week walk group (1.73±0.45) (*p*<0.001). A significant difference was observed between the no-exercise group (2.93±0.91) and the other groups according to the 12-month VAS scores, with the VAS scores of the no-exercise group being significantly higher than the other groups (*p*<0.001). There was a significant difference between the ODI scores of both the 2nd-week walk (38±8.55) and the 2nd-week waist (33.8±6.61) exercise groups and the other groups according to the 1st-month ODI scores (*p*<0.001). A significant difference was observed between the no-exercise group (35.2±8.25) and the other groups according to the 12-month ODI scores, and the ODI scores of the no-exercise group were significantly higher than the other groups (*p*<0.001).

CONCLUSIONS: Regular exercise is highly recommended for long-term pain relief, as well as for achieving a speedy recovery after surgery, which is crucial to maintaining a high quality of life and preventing loss of earning potential. We believe that early implementation of exercises is ideal, but even if initiated later, standard back exercises can still expedite rehabilitation.

Key Words:
Lumbar disc herniation, Microdiscectomy, Exercise, Physiotherapy, Pain.

Introduction

Lumbar disc herniation (LDH) is a frequently encountered ailment in neurosurgery clinics and is prevalent among the general populace, with a reported incidence of about 2%[1]. As it is primarily observed in the workforce, it adversely affects their quality of life[2]. One common reason for referring a patient for surgery is the co-occurrence of radiculopathy and low back pain[3]. Typically, LDH is observed in the adult population who are in active occupation[4]. Most patients with LDH can be treated conservatively, but surgery may be necessary for around 13% of cases[5]. The decision to operate depends on the individual patient, but persistent radicular pain and neurological dysfunction unresponsive to conservative treatment are common indications. Minimally invasive surgical techniques are becoming more prevalent. Currently, microsurgery is the most common approach for LDH[6]. In addition, endoscopic and minimally invasive surgeries have become more prevalent[7].

Lumbar microdiscectomy is a surgical procedure that involves discectomy with the dissection of paravertebral muscles. Subsequently, patients may experience postoperative back pain, potentially impacting their quality of life[8]. Physical rehabilitation is frequently suggested after surgery[9]. Some studies[10] have indicated that physical

Corresponding Author: Hidayet Safak Cine, MD; e-mail: cinesafak@gmail.com

therapy and rehabilitation may not significantly improve low back pain and quality of life after LDH. There is yet to be an agreement on the effectiveness of physical therapy, its optimal start time, and rehabilitative methods[11]. This study evaluates the effects of early and late rehabilitation following unilateral microdiscectomy for LDH. It also examines the differences in low back pain and patients' quality of life due to exercise.

Patients and Methods

General Clinical Data

A total of 204 patients who underwent surgery for LDH were included and subsequently randomized into five groups. This study was designed as a retrospective review of prospectively collected data. One group served as the control and was advised not to participate in any postoperative exercise. The remaining groups were recommended different exercises, which began at various times after surgery. Prior to surgery, all patients received conservative treatment for a period of 4-6 weeks. Patients included in our study had radicular pain that persisted despite 4-6 weeks of conservative treatment, and magnetic resonance imaging (MRI) detection of single-level disc herniation resulted in lumbar microsurgery.

Inclusion Criteria

Those who underwent single-level unilateral lumbar microsurgery at the time of surgery and those with a surgical incision <3 cm were included in our study.

Exclusion Criteria

Those with more than one level of muscle exposure at the time of surgery and those with a skin incision >3 cm were excluded. Participants did not have any cardiopulmonary disease or physical limitations that would prevent them from performing exercise. Patients with a history of spinal surgery, unstable spines, or exercise restrictions due to internal or physical constraints and those who were found to have recurrent disc herniation during follow-up were excluded from the study.

Group Distributions

1. Group: The non-exercise group was selected as the control group. They were only instructed to perform their usual daily activities without any additional exercise.

2. Group: The 2nd-week walking group was advised to walk at a moderate or relaxed pace for 20 minutes on 3 occasions each week, starting in the second week after the surgery.

3. Group: The 1st-month walking group was advised to walk at a moderate or relaxed pace for 20 minutes on 3 occasions each week, starting in the first month after the surgery.

4. Group: The 2nd-week waist exercise group received standard postoperative rehabilitation training commencing in the 1st postoperative week.

5. Group: The 1st-month waist exercise group received standard postoperative rehabilitation training commencing in the 1st month postoperatively. This exercise regime focuses on strengthening the lumbar core muscles for spinal stability[12].

Indicators of Observation

Visual analogue scale (VAS)[13] and Oswestry Disability Index (ODI)[14] were assessed at 1st week, 1st, 3rd, and 6th, and 12th-month follow-up after surgery. Follow-up was mainly conducted through outpatient examination and telephone consultations.

Statistical Analysis

The data processing was conducted using SPSS 26.0 software (IBM Corp., Armonk, NY, USA). The mean±standard deviation was used to express quantitative data using VAS and ODI values that followed a normal distribution. Intergroup comparisons were conducted using independent sample *t*-tests, whereas intragroup comparisons were performed using paired *t*-tests. The statistical technique of analysis of variance (ANOVA) was employed to assess and compare the Visual Analog Scale (VAS) and Oswestry Disability Index (ODI) scores across various time points within the study population. The count data were converted into percentages and analyzed using the Chi-square test. A significance level of $p<0.05$ was deemed to indicate statistical significance.

Results

Basic Data

A total of 204 patients were included and operated on for single-level unilateral lumbar microdiscectomy in the study. The cases were divided into 5 groups. The number of patients in each group varied from 39 to 41. The mean age of all patients was 48±10.9 years, and there was no significant difference between the groups (p=0.980). In total, 51.9% of the patients were men and 48.03% were women. There was no significant difference in gender between the groups (p=0.802) (Table I).

The VAS scores at 1 week post-operatively were similar in all groups (p=1.000). When the 1st-month VAS scores were analyzed, a significant difference was found between the VAS scores of the 2nd-week walking (3.60±0.78) and 2nd-week waist exercise (3.38±0.67) groups and the other groups (p<0.001). VAS scores were significantly higher in the 1st-month walking (5.00±0.83) and 1st-month waist exercise (4.74±0.77) groups. When the 3rd-month VAS results were analyzed, the VAS scores of the 1st-month walking group (2.67±0.48) were significantly higher than those of the 2nd-week walking group (1.73±0.45) (p<0.001). When the 3rd-month VAS results were analyzed, the VAS scores of the no-exercise group (4.80±1.10) were significantly higher than all other groups (p<0.001) (Figure 1).

The VAS scores of the 1st-month walk group (2.41±0.50) were significantly higher than those of the 2nd-week walking group (1.73±0.45), according to the 6th-month VAS scores (p<0.001). The VAS scores of the no-exercise group were significantly higher than all other groups (p<0.001), according to the 6th-month VAS scores. A significant difference was observed between the no-exercise group (2.93±0.91) and the other groups, according to the 12th-month VAS scores, with the VAS scores of the no-exercise group being significantly higher than the other groups (p<0.001) (Table II).

There was a significant difference between the ODI scores of both the 2nd-week walking (38±8.55) and the 2nd-week waist (33.8±6.61) exercise groups and the other groups, according to the 1st-month ODI scores (p<0.001). The ODI scores of the 2nd-week walking and 2nd-month waist exercise groups were significantly lower. When looking at the 3rd-month ODI results, it was observed that the ODI scores of the 1st-month walking group (33.00±4.30) were significantly higher than those of the 2nd-week walking group (23.4±5.88) (p<0.001). When the 3rd-month ODI results were analyzed, it was observed that the ODI scores of the no-exercise group (48.90±9.80) were significantly higher than all other groups (p<0.001).

The ODI scores of the 1st-month walking group (30.7±4.48) were significantly higher than those of the 2nd-week walking group (23.4±5.88) according to the ODI scores of the 6th month (p<0.001). The ODI scores of the no-exercise group (49.1±10.6) were significantly higher than all other groups according to the ODI scores of the 6th month (p<0.001). A significant difference was observed between the no-exercise group (35.2±8.25) and the other groups according to the 12th-month ODI scores, and the ODI scores of the no-exercise group being significantly higher than the other groups (p<0.001) (Table III).

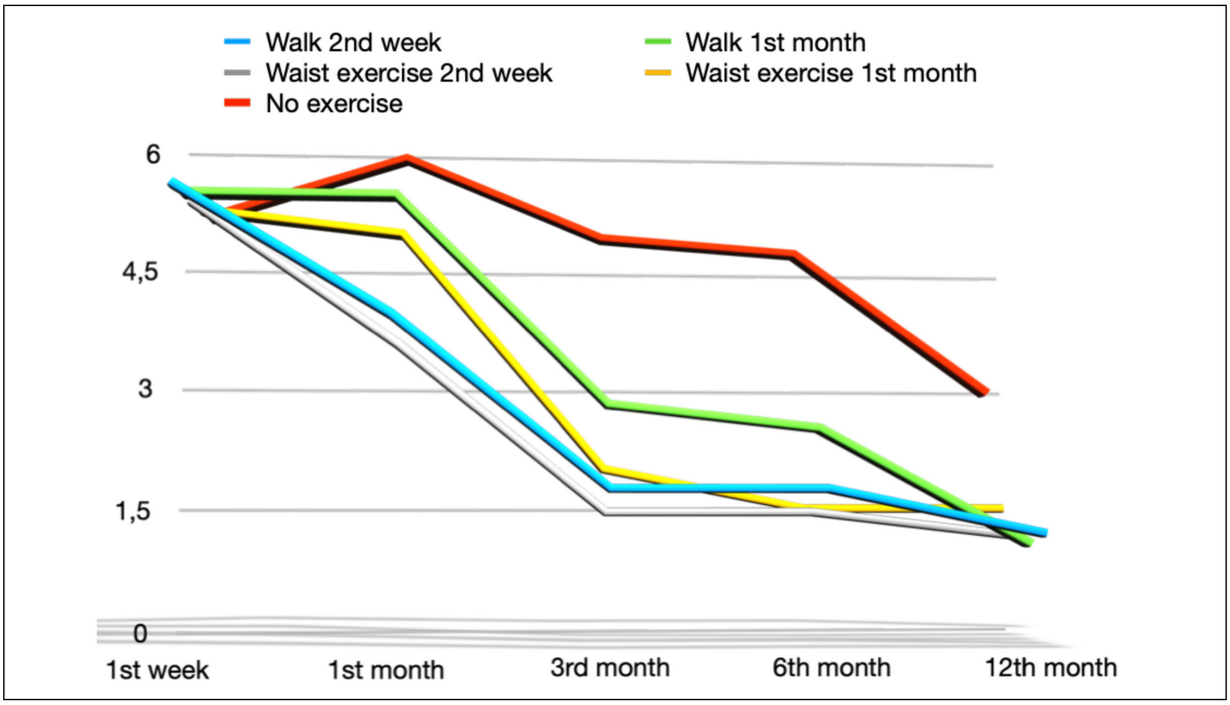

Figure 1. Chart showing the comparison of postoperative VAS scores between groups by exercise type and onset time.

Table I. Distribution of demographic data according to the groups.

Demographic Data	Total (N=204)	2nd-week walking group (a) (N=40)	1st-month walking group (b) (N=39)	Waist exercise 2nd-week group (c) (N=42)	Waist exercise 1st-month group (d) (N=42)	No-exercise group (e) (N=41)	
	n (%) or mean±SD	n (%) or mean±SD	n (%) or mean±SD	n (%) or mean±SD	n (%) or mean±SD	n (%) or mean±SD	*p*-value
Age (years)	48±10.9	46.3±11.3	48.5±11.2	48.3±10.7	48.7±10.8	48.1±11	*0.980*
Gender							*0.802*
Male	106 (51.9)	20 (9.8)	20 (9.8)	23 (11.3)	22 (10.8)	21 (10.3)	
Female	98 (48.03)	20 (9.8)	19 (9.3)	19 (9.3)	20 (9.8)	20 (9.8)	

SD: Standart Deviation; a: 2nd-week walking group; b: 1st-month walking group; c: waist exercise 2nd-week group; d: waist exercise 1st-month group; e: No-exercise group.

Table II. Comparison of postoperative VAS scores based on the exercise type and commencement time across the groups.

	Exercise					
	2nd-week walking group (a) (N=40)	1st-month walking group (b) (N=39)	Waist exercise 2nd-week group (c) (N=42)	Waist exercise 1st-month group (d) (N=42)	No-exercise group (e) (N=41)	
VAS	Mean±SD (Min-Max)	Mean±SD (Min-Max)	Mean±SD (Min-Max)	Mean±SD (Min-Max)	Mean±SD (Min-Max)	*p*-value
1st-week VAS	5.00±0.82 (4-6)	5.00±0.83 (4-6)	5.00±0.83 (4-6)	5.00±0.83 (4-6)	5.00±0.59 (4-6)	*p=1.000*
1st-month VAS	3.60±0.78 (3-5)	5.00±0.83 (4-6)	3.38±0.67 (3-5)	4.74±0.77 (4-6)	5.76±0.86 (4-7)	*<0.001**
3rd-month VAS	1.73±0.45 (1-2)	2.67±0.48 (2-3)	1.48±0.51 (1-2)	1.98±0.60 (1-3)	4.80±1.10 (3-7)	*<0.001***
6th-month VAS	1.73±0.45 (1-2)	2.41±0.50 (2-3)	1.48±0.50 (1-2)	1.52±0.50 (1-2)	4.63±1.11 (3-7)	*<0.001#*
12th-month VAS	1.25± 0.44 (1-2)	1.13±0.40 (1-2)	1.21±0.42 (1-2)	1.52±0.51 (1-2)	2.93±0.91 (2-4)	*<0.001##*

SD: Standart Deviation, VAS: Visual Analogue Scale, *Between a-c and b-d-e, **Between b and a, between e and a-b-c-d, #Between b and a, between e and a-b-c-d, ##Between e and a-b-c-d. a: 2nd-week walking group; b: 1st-month walking group; c: waist exercise 2nd-week group; d: waist exercise 1st-month group; e: No-exercise group.

Table III. Comparison of postoperative ODI scores based on the exercise type and commencement time across the groups.

	Exercise					
	2nd-week walking group (a) (N=40)	1st-month walking group (b) (N=39)	Waist exercise 2nd-week group (c) (N=42)	Waist exercise 1st-month group (d) (N=42)	No-exercise group (e) (N=41)	
ODI	Mean±SD (Min-Max)	Mean±SD (Min-Max)	Mean±SD (Min-Max)	Mean±SD (Min-Max)	Mean±SD (Min-Max)	*p*-value#
1st week ODI	54.50±8.15 (40-68)	54.3±9.34 (40-74)	50.6±8.41 (40-66)	50.00±8.26 (40-68)	59.5±8.35 (50-70)	
1st-month ODI	38±8.55 (30-55)	50.00±8.27 (40-60)	33.8±6.61 (30-50)	47.4±7.67 (41-60)	58.4±9.96 (40-74)	*<0.001**
3rd-month ODI	23.4±5.88 (14-27)	33.00±4.30 (27-36)	20.2±6.57 (14-27)	26±6.77 (14-36)	48.90±9.80 (36-70)	*<0.001***
6th-month ODI	23.4±5.88 (14-27)	30.7±4.48 (27-36)	20.7±6.57 (14-27)	20.8±6.57 (13-27)	49.1±10.6 (36-72)	*<0.001#*
12th-month ODI	17.3± 5.70 (14-27)	15.7±4.40 (14-27)	16.8±5.4 (14-27)	20.8±6.57 (12-26)	35.2±8.25 (27-49)	*<0.001##*

ODI: Oswestry Disability Index *Between a-c and b-d-e, **Between b and a, between e and a-b-c-d, #Between b and a, between e and a-b-c-d, ##Between e and a-b-c-d. a: 2nd-week walking group; b: 1st-month walking group; c: waist exercise 2nd-week group; d: waist exercise 1st-month group; e: No-exercise group.

Discussion

LDH is characterized by pain that is mainly localized in the lower back and sometimes radiates down the leg[15]. Patients may have LDH because of muscle weakness, but LDH itself can also cause weakness in the back and leg muscles[16]. Chronic back pain and leg pain may result in structural and deformity disorders of the entire spine. This, in turn, can lead to an inability to walk and carry out ordinary physical activities[17]. LDH surgery involves removing the degenerated and herniated disc material that compresses the spinal cord and decompresses adjacent nerves. The surgical field is accessed during the procedure by dissecting the muscles from the bone they are attached to[18]. The greater the number of levels involved in lumbar surgeries, the more muscles must be dissected, potentially resulting in further weakening of muscles that are already atrophied. This ultimately results in more weakened muscle strength and spinal instability[19]. As a consequence, patients might experience chronic low back pain in the long term, as documented in 14.97% of patients subjected to surgical intervention for LDH[20]. Although endoscopic techniques, which require less muscle dissection, have been used to eliminate instability[21], microsurgery remains the most widely accepted and employed method globally[22]. However, in microsurgery, depending on the surgeon's experience and approach, carrying out surgery through the tiniest incision may be crucial for recovery after the operation and reducing morbidity[23]. Patients who have undergone lumbar disc surgery may experience low back pain, which can persist for both the short and long term, regardless of whether nucs discs are identified using lumbar MRI or not[24].

Studies[25] have demonstrated that patients suffering from low back pain perceive discomfort due to insufficient physical activity, which leads to the production of lactic acid from glycogen when the muscle tissue remains hypoxic. The objective of postoperative rehabilitation and functional exercises following lumbar disc surgery is to enhance the recovery rate by eliminating muscle atrophy, strengthening lumbar muscles, and ensuring spinal stability[26]. In addition, following the attainment of muscle stability, there is a reduction in compression of the surgically decompressed neural foramen and subsequent surgeries to treat constriction are prevented[27].

It is a subject of discussion as to when exercise should commence in the postoperative period after lumbar microsurgery for functional exercise to be successful. Furthermore, it is unclear which exercises can alleviate the patient's pain. This study displayed that performing walking or standard lumbar exercises at home reduced VAS and ODI scores significantly in patients compared to a non-exercising control group, both in the short and the long term, from the beginning of the exercise regime. Our findings indicate that engaging in physical exercise may help prevent muscle atrophy, improve muscle strength, and prevent instability, resulting in a reduction of low back pain during the postoperative period. Significant differences were observed in VAS and ODI scores between patients who started walking or lumbar exercises in the second week compared to those who started in the first month. Low back pain remained higher in the group who began exercising late until the third month compared to the group who started exercising earlier. At six months, the group that performed low back exercises had lower VAS and ODI scores compared to the walkers. The early initiation of walking or lumbar exercise had an equal effect on reducing postoperative pain; however, lumbar exercise was more effective in reducing pain more quickly and in a shorter period. It is advisable for patients to commence exercising as soon as possible. If exercising is commenced late, lumbar exercise may be recommended to provide faster pain relief. At 12 months, the exercise group showed no significant difference in their results, whereas the control group still exhibited high VAS and ODI scores. This indicates that all forms of exercise are efficacious for long-term alleviation of low back pain.

In a study conducted by Dorow et al[27], it was demonstrated that sociodemographic and psychological factors are powerful risk factors for postoperative pain following lumbar surgery. The impact of physical activity on mental well-being is widely recognised[28]. This implies that physical activity ought to be suggested during the recovery phase.

Willems et al[29] investigated the reasons for the varying effectiveness of rehabilitation and recovery during the postoperative period, identifying that a crucial factor is the involvement of numerous parameters, such as the patient's preoperative pain status and personal factors. Patients' physical factors, such as muscle mass and body mass index (BMI), may have a positive impact on postoperative pain relief. Therefore, it is crucial to improve muscle mass.

Both age and physical structure are significant factors in postoperative pain rehabilitation. Zhu et al[26] have demonstrated a discrepancy in pain alleviation during the recovery process depending on the intervertebral disc type and the patient's age group. Patients commonly experience pain after surgery, which often results in physical restraints being implemented. Pester et al[30] highlighted the significance of early mobility in both the acute and chronic development of low back pain, emphasizing that postoperative movement should not be feared. Oosterhuis et al[31], in a systemic review, stated that there must be no restriction on movement after lumbar disc surgery and physical exercise should be initiated by the 4th-6th week. Ostelo et al[11] suggest that there should be no restrictions following lumbar surgery and that home exercises should commence at least 4-6 weeks later. Hebert et al[9] have demonstrated that initiating exercises on the 2nd week after lumbar microsurgery and engaging in multimodal exercise for 8 weeks is essential in developing the spinal trunk's strength and improving the surgery's quality. Our study indicates that early exercise is an effective approach to reducing pain and enhancing the quality of life after lumbar microsurgery.

Additionally, ongoing research is being conducted to determine the most effective type of exercise to be performed following lumbar surgery, although a consensus has not yet been reached. Filiz et al[32] conducted a study in which physical exercise was initiated one month after surgery, demonstrating that intensive exercises had greater short-term effectiveness than standard home exercises. In our study, we did not examine intensive exercise. However, we found that exercises targeting the lumbar muscles were more effective in correcting graying than moderate-paced walking. Gencay-Can et al[33] observed that starting aerobic exercises one month after the surgery was highly effective at the end of the second and eighth months. Nonetheless, the study did not investigate the long-term results.

Limitations

During follow-ups, exercises can be performed for a longer period of time and with different exercise groups. Since the patients' exercises were not followed exactly, it can be considered a limitation of the study. In addition, the fact that the pain scale is a rating scale that can vary from person to person is a limitation of the study.

Conclusions

We suggest that exercising can provide long-term pain relief. In addition, a prompt recovery following surgery is vital to maintaining a good quality of life and preventing loss of income. Physical exercises should be initiated as early as possible, and if delayed, we believe that standard back exercises can promote quicker rehabilitation.

Conflict of Interest
The authors declare no conflict of interest.

Funding
No funds were received.

Informed Consent
Written informed consent was obtained.

Ethics Approval
Ethics approval was obtained from Istanbul Medeniyet University Ethical Committee No.: 456/2023.

Data Availability
The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' Contributions
Research concept and design: HSC, EU, EÇ.
Data analysis and interpretation: HSC, EU, EÇ.
Collection and/or assembly of data: HSC, EU, EÇ.
Writing the article: HSC, EU, EÇ.
Critical revision of the article: HSC, EU, EÇ.
Final approval of the article: HSC, EU, EÇ.

ORCID ID
Ece Uysal: 0000-0002-2355-8395
Hidayet Safak Cine: 0000-0002-0808-5921
Eyup Cetin: 0000-0002-2045-6721.

References

1) Vialle LR, Vialle EN, Suárez Henao JE, Giraldo G. Lumbar Disc Herniation. Rev Bras Ortop 2015; 45: 17-22.
2) Kim YK, Kang D, Lee I, Kim SY. Differences in the Incidence of Symptomatic Cervical and Lumbar Disc Herniation According to Age, Sex and National Health Insurance Eligibility: A Pilot Study on the Disease's Association with Work. Int J Environ Res Public Health 2018; 15: 2094.
3) Hlubek RJ, Mundis GM Jr. Treatment for Recurrent Lumbar Disc Herniation. Curr Rev Musculoskelet Med 2017; 10: 517-520.

4) Huang W, Han Z, Liu J, Yu L, Yu X. Risk Factors for Recurrent Lumbar Disc Herniation: A Systematic Review and Meta-Analysis. Medicine (Baltimore) 2016; 95: e2378.
5) Lewis RA, Williams NH, Sutton AJ, Burton K, Din NU, Matar HE, Hendry M, Phillips CJ, Nafees S, Fitzsimmons D, Rickard I, Wilkinson C. Comparative clinical effectiveness of management strategies for sciatica: systematic review and network meta-analyses. Spine J 2015; 15: 1461-1477.
6) Rasouli MR, Rahimi-Movaghar V, Shokraneh F, Moradi-Lakeh M, Chou R. Minimally invasive discectomy versus microdiscectomy/open discectomy for symptomatic lumbar disc herniation. Cochrane Database Syst Rev 2014; 9: CD010328.
7) Yoon SM, Ahn SS, Kim KH, Kim YD, Cho JH, Kim DH. Comparative Study of the Outcomes of Percutaneous Endoscopic Lumbar Discectomy and Microscopic Lumbar Discectomy Using the Tubular Retractor System Based on the VAS, ODI, and SF-36. Korean J Spine 2012; 9: 215-222.
8) Parker SL, Mendenhall SK, Godil SS, Sivasubramanian P, Cahill K, Ziewacz J, McGirt MJ. Incidence of Low Back Pain After Lumbar Discectomy for Herniated Disc and Its Effect on Patient-reported Outcomes. Clin Orthop Relat Res 2015; 473: 1988-1999.
9) Hebert JJ, Fritz JM, Thackeray A, Koppenhaver SL, Teyhen D. Early multimodal rehabilitation following lumbar disc surgery: a randomised clinical trial comparing the effects of two exercise programmes on clinical outcome and lumbar multifidus muscle function. Br J Sports Med 2015; 49: 100-106.
10) Barbosa TP, Raposo AR, Cunha PD, Cruz Oliveira N, Lobarinhas A, Varanda P, Direito-Santos B. Rehabilitation after cervical and lumbar spine surgery. EFORT Open Rev 2023; 8: 626-638.
11) Ostelo RW, de Vet HC, Waddell G, Kerckhoffs MR, Leffers P, van Tulder M. Rehabilitation following first-time lumbar disc surgery: a systematic review within the framework of the cochrane collaboration. Spine (Phila Pa 1976) 2003; 28: 209-218.
12) Vera-Garcia FJ, Irles-Vidal B, Prat-Luri A, García-Vaquero MP, Barbado D, Juan-Recio C. Progressions of core stabilization exercises based on postural control challenge assessment. Eur J Appl Physiol 2020; 120: 567-577.
13) Aksoy H, Ak M, Gökahmetoğlu G, Aksoy Ü. The comparison of intraincisional bupivacaine infiltration and intravenous paracetamol administration for pain alleviation after cesarean section: a double-blinded randomized placebo controlled clinical trial. Eur Rev Med Pharmacol Sci 2023; 27: 3467-3474.
14) Buysse DJ, Reynolds CF 3rd, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: A new Instrument for Psychiatric Research. Psychiatry Res 1989; 28: 193-213.
15) Mishra S, Regmi S, Garg K. Effect of Lumbar Discectomy or Lumbar Decompression on Axial Back Pain: Results of a Meta-Analysis. World Neurosurg 2023; 177: 109-121.
16) Zhang AS, Xu A, Ansari K, Hardacker K, Anderson G, Alsoof D, Daniels AH. Lumbar Disc Herniation: Diagnosis and Management. Am J Med 2023; 136: 645-651.
17) Hoffeld K, Lenz M, Egenolf P, Weber M, Heck V, Eysel P, Scheyerer MJ. Patient-related risk factors and lifestyle factors for lumbar degenerative disc disease: a systematic review. Neurochirurgie 2023; 69: 101482.
18) Bombieri FF, Shafafy R, Elsayed S. Complications associated with lumbar discectomy surgical techniques: a systematic review. J Spine Surg 2022; 8: 377-389.
19) Zhang T, Guo N, Wang K, Gao G, Li Y, Gao F, Yang W, Wang Y, Wang Y. Comparison of outcomes between tubular microdiscectomy and conventional microdiscectomy for lumbar disc herniation: a systematic review and meta-analysis of randomized controlled trials. J Orthop Surg Res 2023; 18: 479.
20) Alshammari HS, Alshammari AS, Alshammari SA, Ahamed SS. Prevalence of Chronic Pain After Spinal Surgery: A Systematic Review and Meta-Analysis. Cureus 2023; 15: e41841.
21) Ünsal ÜÜ, Şentürk S. Comparison of direct costs of percutaneous full-endoscopic interlaminar lumbar discectomy and microdiscectomy: Results from Turkey. A percutan endoszkópos interlamináris lumbalis discectomia és a microdiscectomia direkt költségeinek összehasonlítása: török eredmények. Ideggyogy Sz 2021; 74: 197-205.
22) Abu-Zahra MS, Mayfield CK, Thompson AA, Garcia O, Bashrum B, Hwang NM, Liu JN, Petrigliano FA, Alluri RK. Evaluation of Spin in Systematic Reviews and Meta-Analyses of Minimally Invasive Surgical Techniques and Standard Microdiscectomies for Treating Lumbar Disc Herniation. Global Spine J 2023; 21925682231181873.
23) Ren Z, Li Z, Li S, Xu D, Chen X. Small incision discectomy for lumbar disc herniation in 98 patients with 5-year follow-up: A retrospective case series study. Medicine (Baltimore) 2019; 98: e15569.
24) Musa G, Barrientos REC, Makirov SK, Chmutin GE, Antonov GI, Kim AV, Otarov O. Repeat discectomy for recurrent same level disc herniation: A literature review of the past 5 years. Surg Neurol Int 2023; 14: 100.
25) Zhang R, Zhang SJ, Wang XJ. Postoperative functional exercise for patients who underwent percutaneous transforaminal endoscopic discectomy for lumbar disc herniation. Eur Rev Med Pharmacol Sci 2018; 22: 15-22.
26) Zhu Y, Xia S, Yang W, Shi F, Ji H. Early efficacy of postoperative rehabilitation training for lumbar disc herniation. BMC Sports Sci Med Rehabil 2023; 15: 97.
27) Dorow M, Löbner M, Stein J, Konnopka A, Meisel HJ, Günther L, Meixensberger J, Stengler

K, König HH, Riedel-Heller SG. Risk Factors for Postoperative Pain Intensity in Patients Undergoing Lumbar Disc Surgery: A Systematic Review. PLoS One 2017; 12: e0170303.

28) Connor M, Hargreaves EA, Scanlon OK, Harrison OK. The Effect of Acute Exercise on State Anxiety: A Systematic Review. Sports (Basel) 2023; 11: 145.

29) Willems SJ, Coppieters MW, Rooker S, Ostelo R, Hoekstra T, Scholten-Peeters GGM. Variability in recovery following microdiscectomy and postoperative physiotherapy for lumbar radiculopathy: A latent class trajectory analysis. Clin Neurol Neurosurg 2023; 224: 107551.

30) Pester BD, Yoon J, Yamin JB, Papianou L, Edwards RR, Meints SM. Let's Get Physical! A Comprehensive Review of Pre- and Post-Surgical Interventions Targeting Physical Activity to Improve Pain and Functional Outcomes in Spine Surgery Patients. J Clin Med 2023; 12: 2608.

31) Oosterhuis T, Ostelo RW, van Dongen JM, Peul WC, de Boer MR, Bosmans JE, Vleggeert-Lankamp CL, Arts MP, van Tulder MW. Early rehabilitation after lumbar disc surgery is not effective or cost-effective compared to no referral: a randomised trial and economic evaluation. J Physiother 2017; 63: 144-153.

32) Filiz M, Cakmak A, Ozcan E. The effectiveness of exercise programmes after lumbar disc surgery: a randomized controlled study. Clin Rehabil 2005; 19: 4-11.

33) Gencay-Can A, Gunendi Z, Suleyman Can S, Sepici V, Çeviker N. The effects of early aerobic exercise after single-level lumbar microdiscectomy: a prospective, controlled trial. Eur J Phys Rehabil Med 2010; 46: 489-496.