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A 9-year retrospective cohort of patients with lumbar disc herniation

Comparison of patient characteristics and recurrence frequency by smoking status

Esen Sayın Gülensoy, Assistant Professor[a,*], Bülent Gülensoy, Assistant Professor[b]

Abstract

To evaluate the association between smoking status and patient characteristics and to identify risk factors associated with recurrence in patients who underwent surgery for lumbar disc herniation (LDH). This retrospective study was carried out at Lokman Hekim University, Ankara, Turkey between January 1, 2021 and January 1, 2022. The medical data of patients who underwent microsurgical discectomy for LDH were retrospectively recorded. Patients with any reemergence of LDH within a 6-month period after surgery were defined as having recurrent LDH. A total of 1109 patients were included in the study and mean age was 50.7 ± 14.3 years. The frequency of hernia at L2-L3 and L3-L4 levels was higher in the nonsmoker group ($P < .001$). The frequency of cases with Pfirrmann Grade 4 degeneration was higher in the nonsmoker group than in smokers and ex-smokers ($P < .001$). Protrusion-type hernias were more common in nonsmokers ($P = .014$), whereas paracentral hernias were more common in smokers ($P < .001$). The overall frequency of recurrence was 20.4%, and was higher in smokers than in non-smokers and ex-smokers ($P < .001$). Multivariable logistic regression revealed that current smoking (OR: 2.778, 95% CI [confidence interval]: 1.939–3.980, $P < .001$), presence of Pfirrmann Grade 4&5 disc degeneration (OR: 4.217, 95% CI: 2.966–5.996, $P < .001$), and paracentral herniation (OR: 5.040, 95% CI: 2.266–11,207, $P < .001$) were associated with higher risk of recurrence, whereas presence of sequestrated disc was associated with lower risk of recurrence (OR: 2.262, 95% CI:0.272–0.717, $P = .001$). Taken together, our data show that smoking, increased degree of degeneration and paracentral hernia increase the risk of LDH recurrence, while sequestrated disc appears to decrease risk. Taking steps to combat smoking in individuals followed for LDH may reduce the risk of recurrence in LDH patients.

Abbreviations: BMI = body mass index, CI = confidence interval, LDH = lumbar disc herniation, rLDH = recurrent LDH.

Keywords: intervertebral disc displacement, postoperative complications, recurrence, reoperation, risk factors, smoking, treatment outcome

1. Introduction

Lumbar disc herniation (LDH) is a degenerative disease of the lumbar spine with symptoms such as radicular pain, sensory abnormalities and weakness in the distribution of one or more lumbosacral nerve roots.[1] It is reported that a total of 266 million people (3.63%) worldwide have lumbar degenerative spine disease and the number of cases in low- and middle-income countries is 4 times higher than in high-income countries.[2]

Patients with LDH experience discomfort in their daily activities due to their symptoms. Conservative treatment in the form of medication and rest is usually the first management option and surgical intervention is planned for patients with severe symptoms for whom conservative treatment has failed, or for patients who develop severe complications affecting muscular function.[3] It has been reported that patients who undergo surgery for LDH experience greater improvement compared to patients treated non-surgically.[4] Despite significant advances in surgical techniques used in the treatment of LDH, recurrent LDH (rLDH) can occur, and this has been associated with poor outcome.[5] Symptoms also return in patients with rLDH.[4] Symptomatic recurrence, which is relatively common after primary microdiscectomy surgery, often necessitates repeat surgery.[6] It is reported that patients with surgically-proven lumbar disc prolapse have a 10-fold greater risk of requiring another disc prolapse surgery within 10 years, when compared to the general population.[7] Re-operation in a short time due to rLDH may cause physical and psychological discomfort for patients, as well as the economic burden it creates on the

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

[a] Ufuk University, Faculty of Medicine, Department of Chest Diseases, Ankara, Turkey, [b] Lokman HekimUniversity, Faculty of Medicine, Department of Neurosurgery, Ankara, Turkey.

** Correspondence: Esen Sayın Gülensoy, Ufuk University, Faculty of Medicine, Department of Chest Diseases, Mevlana Bulvarı 86/88 Balgat, Ankara 06520, Turkey (e-mail: esen_sayin@hotmail.com).*

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healthcare system. Factors such as sex, age, height, weight, body mass index (BMI), smoking and occupation are increasingly being investigated as risk factors for rLDH.[8] Particularly smoking has been associated with the development of LDH and disc degeneration.[9,10]

Given the high prevalence and chronicity of recurrence after LDH operation (particularly microdiscectomy), it is important to understand risk factors influencing recurrence in order to minimize the prevalence, cost and morbidity associated with LDH. The determination of lifestyle factors that can be changed by intervention, such as smoking, BMI and others, may have important effects in the clinical field.

The aim of the study was to assess relationships between LDH and smoking, and to determine risk factors associated with recurrence in patients who were operated for LDH.

2. Methods

This retrospective study was carried out at Lokman Hekim University, Ankara, Turkey between January, 1, 2021 and January, 1, 2022. Ethics committee approval (date: March 29, 2022, decision number:1) was obtained from Lokman Hekim University Non-Interventional Clinical Research Ethics Committee in order to carry out the study.

Within the scope of the study, the medical records of patients who were operated for LDH with the microsurgical discectomy technique (also called microdiscectomy or microdecompression) at the Neurosurgery Department of Lokman Hekim University, between 2013 and 2021, were retrospectively analyzed and relevant data (including comorbidities such as rheumatic diseases, coronary artery disease, hypertension, diabetes mellitus) were recorded. Patients with missing data in terms of the variables examined in their medical records were not included. Among these patients, those who developed recurrent LDH at the same or different level/direction in a 6-month period (with or without symptoms) and who had undergone surgery were defined as having rLDH.

The herniation types of LDH patients were classified as protrusion, extrusion or sequestration. The degree of disc degeneration was evaluated on T2-weighted sagittal MRI sequences and classified according to Pfirrmann criteria.[11] Microsurgical discectomy operations were performed using the microdiscectomy or open discectomy technique as previously reported and standardized by Mixter.[12] BMI was calculated using weight and height parameters obtained from medical records with the weight/height^2 (kg/m^2) formula.[13] Smoking status was evaluated considering the period preceding the initial surgery and the smoking data of individuals were recorded as "smoker," "nonsmoker," and "quit smoking (ex-smoker)." Pack-years were questioned and recorded.

2.1. Statistical analysis

All analyses were subject to a $P < .05$ significance threshold and were performed on IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY). Histogram and Q-Q plots were used to determine whether continuous variables were normally distributed. Data are given as mean ± standard deviation or median (1st quartile-3rd quartile) for continuous variables according to normality of distribution, and as frequency (percentage) for categorical variables. Between groups analyses of age were performed with 1-way analysis of variances (ANOVA). Between groups analysis of smoking pack-year was performed with the Mann–Whitney *U* test. Between groups analysis of categorical variables were performed with the chi-square tests or the Fisher-Freeman-Halton exact test. Pairwise comparisons were adjusted with the Bonferroni correction method. Logistic regression analyses were performed to determine significant risk factors independently associated with recurrence. Odds ratios were calculated for each variable with univariate logistic regression analysis, and then significant variables were included in the multivariable logistic regression analysis to identify independent risk factors.

3. Results

A total of 1109 patients, 49.1% female and 50.9% male, were included in the study and the mean age of the patients was 50.7 ± 14.3 years. Of these patients, 70.1% (n = 777) were nonsmokers, 23.4% (n = 260) were smokers and 6.5% (n = 72) were ex-smokers. In the groups formed according to smoking status, mean age ($P < .001$) and the frequency of female patients were significantly higher in the nonsmoker group ($P < .001$). The frequency of having a BMI greater than 30 ($P < .001$) and hypertension ($P < .001$) was higher in the nonsmoker group. The incidence of diabetes mellitus (DM) diagnosis was higher in the nonsmoker group than in the smoker group ($P < .001$). The median pack-year was higher in the smoking group compared to the ex-smoker group ($P < .001$). The frequency of hernia at L2-L3 and L3-L4 levels was higher in the nonsmoker group ($P < .001$). According to the Pfirrmann grading system, the frequency of patients with Grade 4 degeneration was higher in the nonsmoker group than in the other 2 groups ($P < .001$). The frequency of protrusion-type hernias was significantly higher in the nonsmoker group ($P = .014$). The frequency of paracentral hernia was higher in the smoker group ($P < .001$, Table 1).

The overall frequency of rLDH among the patients in the study group was 20.4% (n = 226). The frequency of recurrence was significantly higher in the smoker group than in the nonsmoker and ex-smoker groups ($P < .001$). The groups were similar in terms of the number of disc herniation recurrences ($P = .299$) and recurrence time ($P = .062$, Table 1, Fig. 1).

We performed logistic regression analysis to determine significant risk factors associated with recurrence. Multivariable logistic regression analysis revealed that, active smokers had 2.778-fold higher risk of recurrence than other patients (OR: 2.778, 95% CI: 1.939–3.980, $P < .001$). Patients with Pfirrmann disc degeneration grade 4&5 had 4.217-fold higher risk of recurrence than those with grade 2&3 (OR: 4.217, 95% CI: 2.966–5.996, $P < .001$). Patients with paracentral herniation had 5.040-fold higher risk of recurrence than in the other patients (OR: 5.040, 95% CI: 2.266–11.207, $P < .001$). Finally, we also found that patients with sequestrated discs had 2.262-fold lower risk of recurrence than other patients (OR: 0.442, 95% CI: 0.272–0.717, $P = .001$) (Table 2).

4. Discussion

When planning and applying treatment for LDH, physicians are faced with significant heterogeneity in patient selection, surgical indication, type of surgery and final patient outcomes. This lack of predictability results in poor patient outcomes, including complications, and may increase the need for future intervention and increased costs for the healthcare system. Smoking is established to be associated with LDH, and our results further showed that active smoking at the time of initial surgery was independently associated with recurrence likelihood. Other factors are also associated with recurrence; however, accurately determining these risk factors in a highly heterogeneous patient population is rather difficult. Therefore, the need for large studies with high patient counts is necessary to investigate rLDH in order to draw data that may provide clinical guidance for surgeons to reduce the rate of reoperation, and thus, improve patient outcomes.[14] This large retrospective cohort demonstrated that recurrence was independently associated with disc degeneration grade, paracentral herniation and disc sequestration, as well as active smoking.

Table 1

Summary of patients and herniation characteristics with regard to smoking status.

	Total (n = 1109)	nonsmoker (n = 777)	Smoker (n = 260)	Ex-smoker (n = 72)	*P*
Age	50.69 ± 14.34	54.17 ± 14.26 [a]	42.95 ± 10.75 [b]	41.17 ± 10.91 [b]	**<.001**
Sex					
Female	544 (49.1%)	463 (59.6%)	64 (24.6%)	17 (23.6%)	**<.001**
Male	565 (50.9%)	314 (40.4%) [a]	196 (75.4%) [b]	55 (76.4%) [b]	
Body mass index					
≤30	611 (55.1%)	464 (59.7%)	115 (44.2%)	32 (44.4%)	**<.001**
>30	498 (44.9%)	313 (40.3%) [a]	145 (55.8%) [b]	40 (55.6%) [b]	
Rheumatic diseases	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	N/A
Coronary artery disease	48 (4.3%)	29 (3.7%)	16 (6.2%)	3 (4.2%)	.251
Hypertension	139 (12.5%)	121 (15.6%) [a]	16 (6.2%) [b]	2 (2.8%) [b]	**<.001**
Diabetes mellitus	78 (7.0%)	70 (9.0%) [a]	5 (1.9%) [b]	3 (4.2%) [ab]	**<.001**
Smoking pack yr	12 (7 - 19.5)	-	14 (9 - 21)	6 (3.5 - 9)	**<.001**
Level of disc herniation					
L1-L2	16 (1.4%)	15 (1.9%)	1 (0.4%)	0 (0.0%)	**<.001**
L2-L3	46 (4.1%)	37 (4.8%) [a]	3 (1.2%) [b]	6 (8.3%) [a]	
L3-L4	133 (12.0%)	112 (14.4%) [a]	17 (6.5%) [b]	4 (5.6%) [ab]	
L4-L5	583 (52.6%)	401 (51.6%)	151 (58.1%)	31 (43.1%)	
L5-S1	331 (29.8%)	212 (27.3%) [a]	88 (33.8%) [ab]	31 (43.1%) [b]	
Side of disc herniation					
Right	523 (47.2%)	361 (46.5%)	131 (50.4%)	31 (43.1%)	.422
Left	586 (52.8%)	416 (53.5%)	129 (49.6%)	41 (56.9%)	
Pfirrmann grading system					
Grade 1	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	**<.001**
Grade 2	37 (3.3%)	20 (2.6%)	13 (5.0%)	4 (5.6%)	
Grade 3	528 (47.6%)	313 (40.3%) [a]	160 (61.5%) [b]	55 (76.4%) [b]	
Grade 4	532 (48.0%)	433 (55.7%) [a]	86 (33.1%) [b]	13 (18.1%) [c]	
Grade 5	12 (1.1%)	11 (1.4%)	1 (0.4%)	0 (0.0%)	
Type of disc herniation					
Protrusion	177 (16.0%)	141 (18.1%) [a]	30 (11.5%) [b]	6 (8.3%) [b]	**.014**
Extrusion	751 (67.7%)	505 (65.0%) [a]	194 (74.6%) [b]	52 (72.2%) [ab]	
Sequestration	181 (16.3%)	131 (16.9%)	36 (13.8%)	14 (19.4%)	
Location of disc herniation					
Central	35 (3.2%)	29 (3.7%)	5 (1.9%)	1 (1.4%)	**<.001**
Paracentral	996 (89.8%)	679 (87.4%) [a]	252 (96.9%) [b]	65 (90.3%) [a]	
Foraminal	36 (3.2%)	32 (4.1%) [a]	1 (0.4%) [b]	3 (4.2%) [a]	
Far lateral	42 (3.8%)	37 (4.8%) [a]	2 (0.8%) [b]	3 (4.2%) [ab]	
Recurrence	226 (20.4%)	140 (18.0%) [a]	79 (30.4%) [b]	7 (9.7%) [a]	**<.001**
Number of recurrences					
One	200 (88.5%)	126 (90.0%)	69 (87.3%)	5 (71.4%)	.299
Two or more	26 (11.5%)	14 (10.0%)	10 (12.7%)	2 (28.6%)	
Time until recurrence from initial surgery					
1–3 mo	41 (18.5%)	29 (20.7%)	12 (16.0%)	0 (0.0%)	.062
3–11 mo	16 (7.2%)	9 (6.4%)	4 (5.3%)	3 (42.9%)	
1–2 yrs	38 (17.1%)	24 (17.1%)	13 (17.3%)	1 (14.3%)	
2–3 yrs	61 (27.5%)	33 (23.6%)	25 (33.3%)	3 (42.9%)	
3–5 yrs	39 (17.6%)	27 (19.3%)	12 (16.0%)	0 (0.0%)	
5–10 yrs	15 (6.8%)	9 (6.4%)	6 (8.0%)	0 (0.0%)	
Above 10 yrs	12 (5.4%)	9 (6.4%)	3 (4.0%)	0 (0.0%)	

Data are given as mean ± standard deviation or median (1st quartile - 3rd quartile) for continuous variables according to normality of distribution, and as frequency (percentage) for categorical variables. Same letters denote the lack of statistically significant difference between the noted groups.

According to the results of previous studies, the frequency of rLDH has been reported to be between 3.9% and 17.6%.[3,6,8,15–20] In the current study, the overall frequency of rLDH was 20.4% after LDH operation over a 9-year time period. Because the recurrence rate we found is higher than in other studies, it appears that factors related to LDH management and surgeries should also be examined. On the other hand, for each study, factors such as sociodemographic characteristics of patients, the surgical methods used and the experience of the performing surgeon may have caused the observed differences.

In the study of Kim et al, it was reported that 38.8% of LDH cases were operated again within 3 months of the initial surgery.[21] Similarly, Ono et al reported that 29.2% of LDH cases were operated again within 3 months and 70.8% after 3 months.[3] In the study of Cheng et al, it was reported that 76.5% of reoperations in LDH cases were performed within 6 months of primary surgery and the mean time between primary surgery and recurrence was 18.9 months.[16] While no cases were found to have been diagnosed with rLDH in the first 3 months in the current study, 42.9% of the recurrences were identified within the first year. Perhaps more importantly, all rLDH cases were diagnosed in the first 3 years.

In this study, BMI was not found to be independently associated with rLDH in neither univariate nor multivariate logistic regression analysis. In addition to various studies reporting similar findings with ours,[3,5,18,19,22] there are also studies reporting that an increase in BMI increases the risk of recurrence.[6,8,15,23–25] Differences between research groups in terms of age, comorbidity, body weight and height may explain the variations between results.

One of the commonly used methods to evaluate degenerative disc disease is the Pfirrmann grading. It has been reported that an increase in the Pfirrmann grade may be directly associated with cell apoptosis and decrease in the fluid content

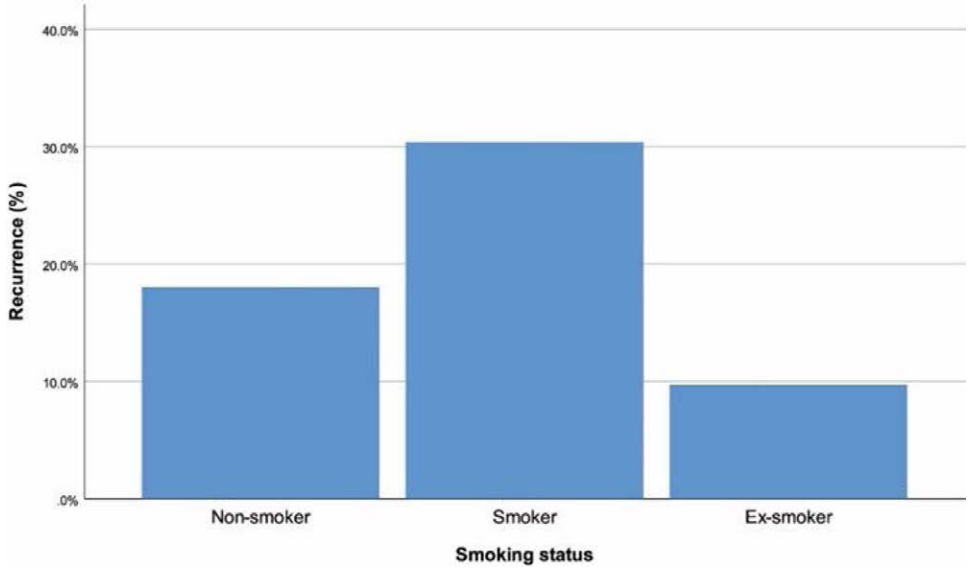

Figure 1. Recurrence percentages with regard to smoking status.

Table 2

Risk factors of the recurrence, logistic regression analysis results.

	Univariable		Multivariable	
	OR (95% CI)	*P*	OR (95% CI)	*P*
Age	1.006 (0.996–1.016)	.249		
Sex, Male	1.303 (0.971–1.749)	.077		
Body mass index, >30	1.265 (0.944–1.695)	.116		
Coronary artery disease	2.026 (1.091–3.762)	**.025**	1.148 (0.584–2.257)	.689
Hypertension	1.196 (0.782–1.830)	.409		
Diabetes mellitus	1.948 (1.182–3.211)	**.009**	1.515 (0.874–2.626)	.139
Smoking status, Smoker	2.084 (1.516–2.866)	**<.001**	2.778 (1.939–3.980)	**<.001**
Level of disc herniation	0.956 (0.806–1.135)	.607		
Side of disc herniation, Left	1.133 (0.845–1.520)	.405		
Pfirrmann grading system, Grade 4&5	3.234 (2.354–4.441)	**<.001**	4.217 (2.966–5.996)	**<.001**
Type of disc herniation, Sequestration	0.520 (0.327–0.827)	**.006**	0.442 (0.272–0.717)	**.001**
Location of disc herniation, Paracentral	4.268 (1.958–9.305)	**<.001**	5.040 (2.266–11.207)	**<.001**
Nagelkerke R^2	—		0.173	

CI = confidence interval.

of the lumbar discs, leading to a change in the intervertebral disc micro/nano-environment.[1] Similarly in this study, patients with Pfirrmann disc degeneration grade 4&5 had a 4.217-fold (95% CI: 2.966–5.996, $P < .001$) higher risk of recurrence compared to those with grade 2&3. In the study of Belykh et al, it was reported that having a Pfirrmann grade 3 was associated with LDH recurrence.[23] In the study of Jia et al, it was reported that the Pfirrmann grade could be used to predict overall recurrence rate of rLDH within 6 months.[1] In contrast to these results, there are also studies reporting no relationship between the degree of Pfirrmann degeneration and the risk of recurrence.[8] However, it appears that the majority of literature supports the notion that it would be useful to monitor LDH patients with higher Pfirrmann grade more closely.

In our patient group, the risk of recurrence was higher in LDH cases with paracentrally located hernia. In the study of Yao et al, it was reported that patients with central herniation were more likely to experience recurrent herniation compared to patients with paramedian herniation.[26] Similarly, in the study of Kim et al, it was reported that patients with paracentral disc herniation were more likely to experience early recurrence compared to patients with central and distant lateral herniation.[27] Although studies reporting no relationship between hernia location and recurrence exist, it is evident that such studies are a rarity.[28]

It has been reported that LDH of the protruding or subligamentous extrusion types may have residual disc material that can serve as a candidate for subsequent herniation.[3,29] It has been reported that protrusion-type discs may predispose to postoperative recurrences by causing rupture of the annulus fibrosus.[30] In the study of Ono et al, subligamentous extrusion-type LDH was reported to be a risk factor for recurrence.[3] In the study of Shi et al, it was reported that the rate of protrusion-type disc in the recurrent LDH group was significantly higher than the others.[31] In another study, it was reported that protrusion-type LDH was associated with rLDH.[23] In other previous studies, extrusion-type LDH was also found to be significantly associated with rLDH.[24,30] In the present study, sequestration-type LDH was found to yield a lower risk of recurrence than the extrusion and protrusion types. There are also studies reporting that no relation could be found between hernia type and LDH recurrence.[8,32]

According to the data of the World Health Organization, 22.3% of the world's population used tobacco in 2020,[33] and,

in addition to various other health hazards, it is reported that smoking promotes the development of LDH.[9] There are also several proposed mechanisms by which smoking increases the risk of recurrence of disc herniation. Smoking radically inhibits disc diffusion and impairs disc nutrition by causing vasoconstriction in capillaries separated from the bone-disc junction. At the same time, smoking significantly impairs the cellular uptake rate and metabolite production in the disc.[34] The vasoconstrictor effect of nicotine can also inhibit the synthesis of proteoglycans and lead to a more vulnerable and degeneration-prone disc.[35] Nicotine in cigarettes is an important inhibitor of cell proliferation in the nuclear pulp and extracellular matrix synthesis. Nicotine induces inhibition of total collagen, which can reduce the collagen content in ring fibrosis and predispose the ring to traumatic injury and degenerative changes.[36] On the other hand, interestingly, it has been reported that chronic cough due to smoking can increases intra-disc pressure, potentially leading to recurrence.[6] In the current study, smokers had a 2.778-fold (95%CI: 1.939–3.980, $P < .001$) higher risk of recurrence than other patients in the multivariable logistic regression analysis, which is similar to the literature on this topic.[3,5,6,20,22–24,37–39] However, there are also studies reporting that no association was found between smoking and rLDH.[18,19,25,32] Since smoking is a risk factor that can be changed with interventions, our result provides a clinical perspective in the management of LDH cases. While the degeneration of the annulus fibrosus is partially irreversible, the results of an experimental mouse study on the possibility that smoking-induced intervertebral disc degeneration can be repaired by smoking cessation are promising, since the amount of mucin (proteoglycan) in the nucleus pulposus and annulus fibrosus tends to increase with smoking cessation.[40] It was concluded that interventions to reduce smoking may be beneficial, especially in individuals at risk for LDH and in individuals who have undergone LDH operation. On the other hand, the evaluation of the effect of smoking cessation interventions on rLDH cases is an interesting topic for future studies.

5. Limitations

As this was a retrospective study, the main limitations of this study were selection bias and missing data. Another limitation is that the research was not community-based but single-centered. Therefore, the results of the study cannot be generalized to the general population. On the other hand, some factors such as surgical experience with LDH operation and the suitability of the chosen technique may have affected recurrence likelihood and the fact that these could not be evaluated in the study is another limitation. In addition to the parameters evaluated in this study, the inability to evaluate factors such as pain levels, neurological status, postoperative care, quality of life, functional outcomes and reasons for reoperation are other limitation. Finally, we excluded cases with suspected recurrence that healed with conservative treatment; therefore, the findings of the present study cannot be generalized to rLDH cases that benefit from conservative treatment. However, current research is valuable in assessing the impact of multiple clinical factors on the risk of LDH recurrence over a 9-year timeframe with the inclusion of a large set of patients who received similar management and post-surgical care.

6. Conclusions

As a result, it can be said that smoking will increase the risk of recurrence in LDH patients who undergo microdiscectomy. In addition, an increase in the degree of disc degeneration, having an extrusion and protrusion type hernia (relative to sequestration) and having a hernia in a paracentral location also increase the risk of LDH recurrence. Steps to be taken to combat smoking, which is a modifiable risk factor for people at risk for LDH and/or rLDH may prevent or reduce recurrence. Prospective studies evaluating factors affecting the risk of recurrence in LDH cases are needed.

Author contributions

Conceptualization: Esen Sayın Gülensoy.
Data curation: Bülent Gülensoy.
Formal analysis: Esen Sayın Gülensoy, Bülent Gülensoy.
Investigation: Esen Sayın Gülensoy, Bülent Gülensoy.
Methodology: Esen Sayın Gülensoy, Bülent Gülensoy.
Project administration: Esen Sayın Gülensoy.
Supervision: Esen Sayın Gülensoy.
Validation: Esen Sayın Gülensoy.
Writing – original draft: Esen Sayın Gülensoy, Bülent Gülensoy.

References

[1] Jia M, Sheng Y, Chen G, et al. Development and validation of a nomogram predicting the risk of recurrent lumbar disk herniation within 6 months after percutaneous endoscopic lumbar discectomy. J Orthop Surg Res. 2021;16:274.
[2] Ravindra VM, Senglaub SS, Rattani A, et al. Degenerative lumbar spine disease: estimating global incidence and worldwide volume. Global Spine J. 2018;8:784–94.
[3] Ono K, Ohmori K, Yoneyama R, et al. Risk factors and surgical management of recurrent herniation after full-endoscopic lumbar discectomy using interlaminar approach. J Clin Med. 2022;11:748.
[4] Lurie JD, Tosteson TD, Tosteson ANA, et al. Surgical versus nonoperative treatment for lumbar disc herniation: eight-year results for the spine patient outcomes research trial. Spine (Phila Pa 1976). 2014;39:3–16.
[5] Huang W, Han Z, Liu J, et al. Risk factors for recurrent lumbar disc herniation: a systematic review and meta-analysis. Medicine. 2016;95:e2378e23–78-e.
[6] Siccoli A, Staartjes VE, Klukowska AM, et al. Overweight and smoking promote recurrent lumbar disk herniation after discectomy. Eur Spine J. 2022;31:604–13.
[7] Bruske-Hohlfeld I, Merritt JL, Onofrio BM, et al. Incidence of lumbar disc surgery. A population-based study in Olmsted County, Minnesota, 1950-1979. Spine (Phila Pa 1976). 1990;15:31–5.
[8] Yaman ME, Kazancı A, Yaman ND, et al. Factors that influence recurrent lumbar disc herniation. Hong Kong Med J. 2017;23:258–63.
[9] Huang W, Qian Y, Zheng K, et al. Is smoking a risk factor for lumbar disc herniation? Eur Spine J. 2016;25:168–76.
[10] Elmasry S, Asfour S, De Rivero Vaccari JP, et al. Effects of tobacco smoking on the degeneration of the intervertebral disc: a finite element study. PLoS One. 2015;10:e0136137.
[11] Pfirrmann CW, Metzdorf A, Zanetti M, et al. Magnetic resonance classification of lumbar intervertebral disc degeneration. Spine (Phila Pa 1976). 2001;26:1873–8.
[12] Williams RW. Microlumbar discectomy: a conservative surgical approach to the virgin herniated lumbar disc. Spine (Phila Pa 1976). 1978;3:175–82.
[13] Nuttall FQ. Body mass index: obesity, bmi, and health: a critical review. Nutr Today. 2015;50:117–28.
[14] Steinmetz MP, Mroz T. Value of adding predictive clinical decision tools to spine surgery. JAMA Surg. 2018;153:643.
[15] Meredith DS, Huang RC, Nguyen J, et al. Obesity increases the risk of recurrent herniated nucleus pulposus after lumbar microdiscectomy. Spine J. 2010;10:575–80.
[16] Cheng J, Wang H, Zheng W, et al. Reoperation after lumbar disc surgery in two hundred and seven patients. Int Orthop. 2013;37:1511–7.
[17] Shin EH, Cho KJ, Kim YT, et al. Risk factors for recurrent lumbar disc herniation after discectomy. Int Orthop. 2019;43:963–7.
[18] Park CH, Park ES, Lee SH, et al. Risk factors for early recurrence after transforaminal endoscopic lumbar disc decompression. Pain Physician. 2019;22:E133–e8.
[19] Leven D, Passias PG, Errico TJ, et al. Risk factors for reoperation in patients treated surgically for intervertebral disc herniation: a subanalysis of eight-year SPORT data. J Bone Joint Surg Am. 2015;97:1316–25.
[20] Noh SH, Cho PG, Kim KN, et al. Risk factors for reoperation after lumbar spine surgery in a 10-year Korean national health insurance service health examinee cohort. Sci Rep. 2022;12:1–9.

[21] Kim CH, Chung CK, Park CS, et al. Reoperation rate after surgery for lumbar herniated intervertebral disc disease: nationwide cohort study. Spine (Phila Pa 1976). 2013;38:581–90.
[22] Andersen SB, Smith EC, Støttrup C, et al. Smoking is an independent risk factor of reoperation due to recurrent lumbar disc herniation. Global Spine J. 2018;8:378–81.
[23] Belykh E, Krutko AV, Baykov ES, et al. Preoperative estimation of disc herniation recurrence after microdiscectomy: predictive value of a multivariate model based on radiographic parameters. Spine J. 2017;17:390–400.
[24] Li Z, Yang H, Liu M, et al. Clinical characteristics and risk factors of recurrent lumbar disk herniation: a retrospective analysis of three hundred twenty-one cases. Spine (Phila Pa 1976). 2018;43:1463–9.
[25] Dobran M, Nasi D, Paracino R, et al. Analysis of risk factors and postoperative predictors for recurrent lumbar disc herniation. Surg Neurol Int. 2019;10:36.
[26] Yao Y, Liu H, Zhang H, et al. Risk factors for recurrent herniation after percutaneous endoscopic lumbar discectomy. World Neurosurg. 2017;100:1–6.
[27] Kim HS, You JD, Ju CI. Predictive scoring and risk factors of early recurrence after percutaneous endoscopic lumbar discectomy. Biomed Res Int. 2019;2019:1–10.
[28] Kong M, Xu D, Gao C, et al. Risk factors for recurrent L4-5 disc herniation after percutaneous endoscopic transforaminal discectomy: a retrospective analysis of 654 cases. Risk Manag Healthc Policy. 2020;13:3051–65.
[29] Carragee EJ, Han MY, Suen PW, et al. Clinical outcomes after lumbar discectomy for sciatica: the effects of fragment type and anular competence. JBJS. 2003;85:102–8.
[30] Li Y, Wang B, Li H, et al. Adjuvant surgical decision-making system for lumbar intervertebral disc herniation after percutaneous endoscopic lumber discectomy: a retrospective nonlinear multiple logistic regression prediction model based on a large sample. Spine J. 2021;21:2035–48.
[31] Shi H, Zhu L, Jiang Z-L, et al. Radiological risk factors for recurrent lumbar disc herniation after percutaneous transforaminal endoscopic discectomy: a retrospective matched case-control study. Eur Spine J. 2021;30:886–92.
[32] Abdu RW, Abdu WA, Pearson AM, et al. Reoperation for recurrent intervertebral disc herniation in the spine patient outcomes research trial: analysis of rate, risk factors, and outcome. Spine (Phila Pa 1976). 2017;42:1106–14.
[33] World Helath Organization. Tobacco, fact sheets. 2022. https://www.who.int/news-room/fact-sheets/detail/tobacco [access date June 25, 2022].
[34] Holm S, Nachemson A. Nutrition of the intervertebral disc: acute effects of cigarette smoking: an experimental animal study. Ups J Med Sci. 1988;93:91–9.
[35] Nasto LA, Ngo K, Leme AS, et al. Investigating the role of DNA damage in tobacco smoking-induced spine degeneration. Spine J. 2014;14:416–23.
[36] Akmal M, Kesani A, Anand B, et al. Effect of nicotine on spinal disc cells: a cellular mechanism for disc degeneration. Spine (Phila Pa 1976). 2004;29:568–75.
[37] Shimia M, Babaei-Ghazani A, Sadat BE, et al. Risk factors of recurrent lumbar disk herniation. Asian J Neurosurg. 2013;8:93–6.
[38] Miwa S, Yokogawa A, Kobayashi T, et al. Risk factors of recurrent lumbar disk herniation. J Spinal Disord Tech. 2015;28:E265–9.
[39] Kim K-T, Park S-W, Kim Y-B. Disc height and segmental motion as risk factors for recurrent lumbar disc herniation. Spine (Phila Pa 1976). 2009;34:2674–8.
[40] Nemoto Y, Matsuzaki H, Tokuhasi Y, et al. Histological changes in intervertebral discs after smoking cessation: experimental study using a rat passive smoking model. J Orthop Sci. 2006;11:191–7.