Tzu Chi Medical Journal 2024; 36 (3): 298-303

Original Article

Risk factors for reoperation after discectomy of lumbar herniated intervertebral disc disease

Cheng-Huan Peng[a,b], Ing-Ho Chen[a,b], Tzai-Chiu Yu[a,b], Jen-Hung Wang[c], Wen-Tien Wu[a,b], Kuang-Ting Yeh[a,b,d]**

[a]Department of Orthopedics, Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Hualien, Taiwan, [b]School of Medicine, Tzu Chi University, Hualien, Taiwan, [c]Department of Medical Research, Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Hualien, Taiwan, [d]Graduate Institute of Clinical Pharmacy, Tzu Chi University, Hualien, Taiwan

Submission : 21-Aug-2023
Revision : 17-Nov-2023
Acceptance : 22-Feb-2024
Web Publication : 30-Apr-2024

Abstract

Objectives: Discectomy is the most common surgery for lumbar herniated intervertebral disc (HIVD) disease. However, 5%–24% of patients undergo a second surgery due to recurrent disc herniation. **Materials and Methods:** This study was aimed to identify the risk factors for reoperation after discectomy of lumbar HIVD and recommend treatment for patients with a high risk of reoperation. We recruited patients diagnosed as having single-level lumbar HIVD who underwent open discectomy from January 1, 2000, to December 31, 2012 in our hospital. We used a survival curve to inspect the survival time and reoperation rate after surgery. We discussed the correlation of reoperation rate with discectomy level, body mass index, heavy lifting after surgery, sex, and age. Furthermore, we investigated the correlation between the experience of a surgeon and the reoperation rate. **Results:** A total of 619 patients were enrolled in our study. Most patients were 40–60 years old (48.8%), and most of them had herniation at L4/5 level (48.9%). The 8-year survival rate was 92%. Weight lifting after surgery may increase the reoperation rate by 115 and 18 times for those >60 years and <40 years, respectively. In addition, less experience of the surgeon and female sex had a high reoperation rate. **Conclusion:** Postoperative working modification may be very important for preventing patients from recurrent HIVD. For elderly people with HIVD, a more conservative therapy could be selected. If patients with lumbar spine hypermobility or severe degeneration require wide laminectomy, primary fusion should be considered.

Keywords: *Discectomy, Heavy lifting after surgery, Herniated intervertebral disc, Reoperation rate, Survival rate*

Introduction

Lumbar herniated intervertebral disc (HIVD) is a prevalent medical condition and stands as the leading cause of low back pain affecting a broad range of age groups, characterized by symptoms such as localized pain, sensory abnormalities, and motor deficits, the disease significantly impairs the quality of life of those who suffer from it. Encouragingly, available literature suggests that the medical history for up to 90% of HIVD patients is generally favorable, with leg pain substantially subsiding within an 8-week period from the onset of symptoms [1,2]. Numerous therapeutic strategies exist for managing HIVD, ranging from conservative treatments to more invasive surgical interventions. Physical therapy, when coupled with minimally invasive techniques such as epidural or selective nerve blocks, has proven effective in mitigating symptoms for a considerable subset of patients [3-5]. Surgical intervention becomes a viable option under specific circumstances: namely, the failure of conservative treatment protocols, the emergence of bowel or bladder dysfunctions, or the progressive worsening of motor deficits. Among surgical procedures, discectomy is the most frequently performed operation aimed at treating lumbar spine issues. Despite its popularity and generally favorable outcomes, a notable fraction of discectomy patients – ranging from 5% to 24% – require a subsequent surgical intervention due to the recurrence of disc herniation or other complications [6-12].

In light of this, our study undertakes a comprehensive review of HIVD patients who have undergone discectomy over the past 12 years. Our primary objective is to ascertain the incidence rate of revision surgeries and to identify the

***Address for correspondence:** Dr. Kuang-Ting Yeh, Department of Orthopedics, Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, 707, Section 3, Chung-Yang Road, Hualien, Taiwan.
E-mail: microgratt@tzuchi.com.tw
Dr. Wen-Tien Wu, Department of Orthopedics, Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, 707, Section 3, Chung-Yang Road, Hualien, Taiwan.
E-mail: timwu@tzuchi.com.tw

How to cite this article: Peng CH, Chen IH, Yu TC, Wang JH, Wu WT, Yeh KT. Risk factors for reoperation after discectomy of lumbar herniated intervertebral disc disease. Tzu Chi Med J 2024;36(3):298-303.

Access this article online
Quick Response Code:
Website: www.tcmjmed.com
DOI: 10.4103/tcmj.tcmj_206_23

risk factors associated with such reoperations. Through this research, we aim to augment the current understanding of HIVD treatment paradigms and propose more targeted, effective treatment strategies for preventing the necessity of revision surgeries.

Materials and methods

Ethical approval for this retrospective study was granted by the Research Ethics Committee of Hualien Tzu Chi Hospital, under approval number IRB101-128. In alignment with the committee's guidelines, the requirement for written informed consent was waived. This was conducted in accordance with the Declaration of Helsinki.

We conducted a comprehensive review of medical records for patients diagnosed with single-level lumbar HIVD between January 1, 2000, and December 31, 2012, at Hualien Tzu Chi Hospital. Diagnoses were confirmed through magnetic resonance imaging (MRI) or myelographic studies. Patients were considered eligible for the study if they met the following inclusion criteria: (1) documented history of and ongoing sciatica symptoms; (2) single-level disc herniation, as verified through MRI; (3) a postoperative diagnosis by a qualified surgeon confirming the presence of disc herniation.

Patients were excluded from the study if any of the following criteria were present: (1) multilevel disc herniation or spinal stenosis; (2) a history of recurrent disc herniation; (3) prior spinal fusion accompanied by adjacent segment disease; (4) disc herniation with spinal instability requiring fusion; (5) presence of infection or discitis; and (6) incongruity between clinical symptoms and imaging findings.

All included patients underwent open discectomy procedures under general anesthesia while in a prone position. Surgical techniques utilized included annulotomy, subtotal discectomy, and the excision of extruded disc fragments.

To elucidate the etiological factors behind HIVD, we collected data on the incidence of herniation at each segment of the lumbar spine. This information was subsequently analyzed in conjunction with patient age and sex ratios. The endpoint for this study was defined as the time of reoperation. Survival curves were employed to evaluate the duration between initial discectomy and any subsequent reoperation. The study specifically aimed to assess the correlation between the rate of reoperation and various factors, including level of initial discectomy, body mass index, Modic change type measured from the T1-weighted and T2-weighted lumbar disc images, recent smoking habit, diabetes, incidence of heavy lifting postsurgery, sex, age, and surgeon's level of experience. For the purposes of this study, "occupational lifting" was defined as lifting weights >10 kg, with such lifting activities accounting for more than one-third of working hours, constituting significant physical loading [13]. The experience of the surgeon was also investigated as a potential risk factor for reoperation. For the context of this study, a surgeon was considered "senior" if they had 15 or more years of relevant surgical experience. Through this multifaceted approach, we aim to provide a comprehensive understanding of the risk factors associated with reoperation following discectomy for lumbar HIVD, thereby informing more effective treatment strategies for this patient population.

Statistical analysis

Descriptive statistics were calculated for all the variables of interest. Categorical measures were summarized as counts and percentages and continuous measures were summarized as means and standard deviations. The results for the continuous variables were compared using the independent two-sample *t*-test. The categorical variables were compared using the Chi-squared test or Fisher's exact test. Multivariate Cox proportional hazard models for demographic and clinical covariates were used to investigate reoperation risk. $P < 0.05$ was considered statistically significant. All statistical analyses were performed using the SPSS software (version 17.0; SPSS Inc., Chicago, IL, USA).

Results

Our study enrolled a total of 619 patients who underwent discectomy for lumbar HIVD between January 1, 2000, and

Table 1: Demographics of the patients who have received discectomy

Item	Female	Male	Total	*P*
n	208	411	619	
Age (years old)				
<40	47 (22.6)	118 (28.7)	165 (26.7)	0.027*
40–60	97 (46.6)	205 (49.9)	302 (48.8)	
≥60	64 (30.8)	88 (21.4)	152 (24.6)	
Level				
L1–2	1 (0.5)	0	1 (0.2)	0.022*
L2–3	0	12 (2.9)	12 (1.9)	
L3–4	23 (11.1)	40 (9.7)	63 (10.2)	
L4–5	109 (52.4)	194 (47.2)	303 (48.9)	
L5–S1	75 (36.1)	165 (40.1)	240 (38.8)	
Modic change type				
0	81 (38.9)	152 (37.0)	233 (37.6)	0.151
1	14 (6.7)	29 (7.1)	43 (6.9)	
2	41 (19.7)	90 (21.9)	131 (21.5)	
3	72 (34.6)	140 (34.1)	212 (34.2)	
Diabetes				
No	200 (96.2)	399 (97.1)	599 (96.8)	0.436
Yes	8 (3.8)	12 (2.9)	20 (3.2)	
Smoke habit				
No	207 (99.5)	406 (98.8)	613 (99)	0.068
Yes	1 (0.5)	5 (1.2)	6 (1.0)	
BMI				
Normal	73 (36.9)	111 (30.7)	184 (32.9)	0.095
Underweight	3 (1.5)	9 (2.5)	12 (2.1)	
Overweight	54 (27.3)	133 (36.8)	187 (33.5)	
Obese	68 (34.3)	108 (29.9)	176 (31.5)	
Surgeon				
Junior	7 (3.4)	22 (5.4)	29 (4.7)	0.318
Senior	201 (96.6)	389 (94.6)	590 (95.3)	
Occupational lifting after surgery				
No	188 (90.4)	276 (67.2)	464 (75.0)	<0.001*
Yes	20 (9.6)	135 (32.8)	155 (25.0)	

*$P<0.05$ was considered statistically significant after the test. Data are presented as *n* (%) or mean±SD. SD: Standard deviation, BMI: Body mass index

December 31, 2012. The cohort consisted of 411 men and 208 women, with a mean age of 49.1 years [Table 1]. The patients were followed up for an average period of 4.8 years. The age distribution was skewed toward middle age, with approximately 50% of the patients falling within the 40–60-year age bracket. Patients below 40 and above 60 years accounted for 25% of the population each. The most frequent sites for disc herniation were observed to be at the L4/5 (48.9%) and L5/S1 (38.8%) levels [Table 1]. 20 (3.2%) of them had diabetes, and 6 (1.0%) of them had recent smoking habit. 233 (37.6%) of the patients had Modic change type 0, 43 (6.9%) of them had Modic change type 2, 131 (21.5%) of them had Modic change type 2, and 212 (34.2%) of them had Modic change type 3. Notably, over 60% of the cohort was overweight, and 25% reported engagement in heavy lifting tasks [Table 1].

Analysis of survivorship data revealed that more than 92% of the 619 patients had a survival time exceeding 8 years postdiscectomy [Figure 1]. The overall reoperation rate was approximately 7.8% (48 patients), with an average interval to reoperation being 1.7 years. Among those who required reoperation, 25 patients (52%) underwent fusion surgery due to lumbar hypermobility, 20 patients (42%) had repeated discectomies, and the remaining 3 patients (6%) received debridement procedures.

Our multivariate analysis yielded significant insights into risk factors associated with reoperation. The significant risk factors included age more than 60 years ($P < 0.001$), female gender ($P = 0.001$), surgeon experience <15 years ($P = 0.047$), and occupational lifting after surgery ($P < 0.001$) [Table 2].

Discussion

HIVD results in lumbar pain and motor and sensory deficit. Approximately 70%–90% of patients received a positive outcome with a nonsurgical treatment [14-18]. For severe and persistent leg pain and persistent paresis such as motor deficit and bowel bladder and disturbance, discectomy could improve the symptoms. The results have shown worse outcomes after reoperation for patients with sciatica for a duration of >8 months [19,20]. The earliest discectomy was described in 1934 by Mixter and Barr, who demonstrated an effective treatment for sciatica symptoms caused by HIVD [21,22]. However, the long-term reoperation rate was up to 24% after lumbar discectomy [6-12,23], and the most common reason was recurrent disc herniation [11,24-46]. The average time for reherniation was 45.6–80.8 months [24,47]. Histological analysis showed that >75% of these recurrent substances were endplate material [25].

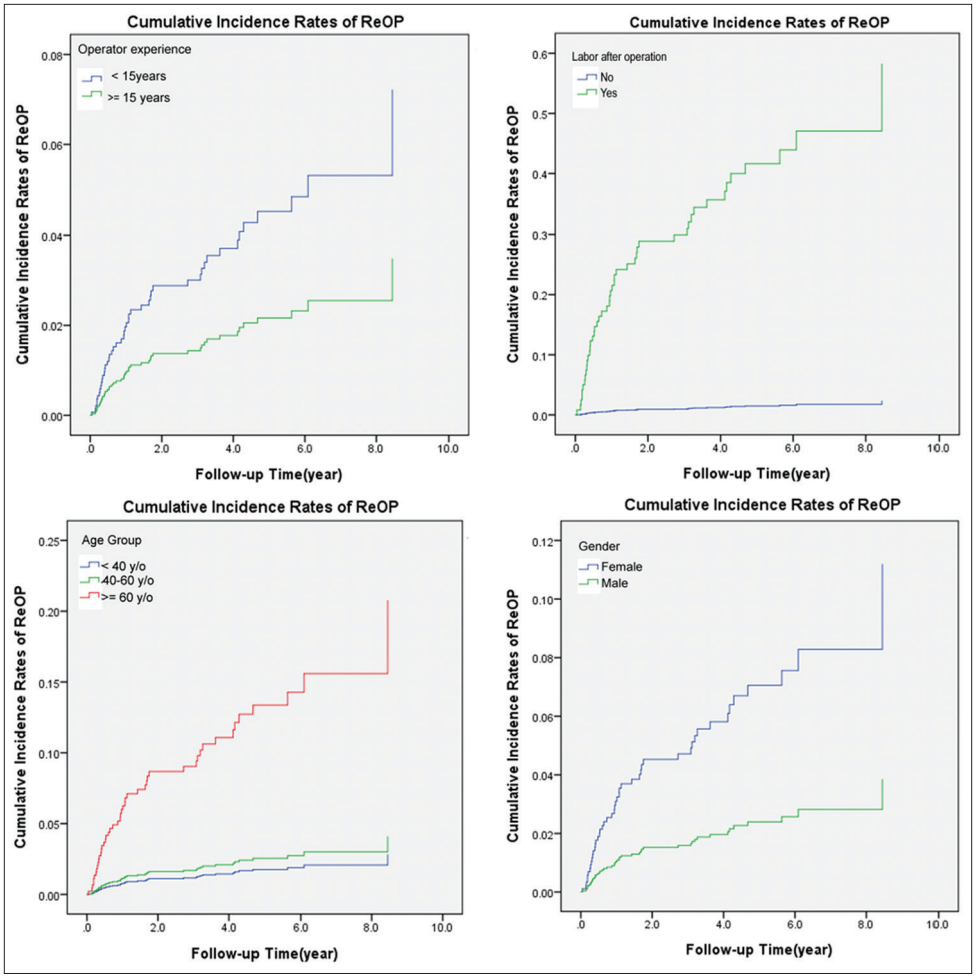

Figure 1: Cumulative incidence of reoperation after surgery of herniated intervertebral disc disease

Table 2: Hazard ratios for reoperation according to prognostic factors (*n*=606)

Prognostic variables	Reoperationa, *n* (%)	Hazard ratiob (95% CI)			
		Crude	*P*	Adjusted	*P*
Age group (years old)					
<40	13 (7.9)	1.00		1.00	
40–60	22 (7.5)	0.94 (0.48–1.89)	0.890	1.46 (0.67–3.18)	0.345
≥60	13 (8.8)	1.25 (0.58–2.71)	0.566	8.09 (2.81–23.35)	<0.001*
Gender					
Female	18 (8.7)	1.00		1.00	
Male	30 (7.5)	0.84 (0.47–1.50)	0.554	0.33 (0.17–0.65)	0.001*
Level					
L3–4	5 (7.9)	1.00		1.00	
L4–5	21 (6.9)	0.84 (0.32–2.22)	0.719	0.69 (0.24–1.93)	0.475
L5–S1	22 (9.2)	1.15 (0.44–3.04)	0.777	1.04 (0.36–3.01)	0.936
Modic change type					
0	15 (6.4)	1.00		1.00	
1	7 (16.3)	1.35 (0.74–2.03)	0.352	1.02 (0.71–2.02)	0.293
2	24 (18.3)	1.47 (0.81–2.16)	0.311	1.08 (0.82–2.23)	0.251
3	2 (0.9)	0.75 (0.54–1.12)	0.412	0.81 (0.62–1.17)	0.481
Diabetes					
No	42 (7.0)	1.00		1.00	
Yes	6 (30.0)	3.02 (1.02–3.61)	0.041*	1.84 (0.91–3.84)	0.098
Smoke habit					
No	46 (7.5)	1.00		1.00	
Yes	2 (33.3)	3.14 (1.21–4.32)	0.032*	2.01 (0.98–4.12)	0.085
BMI					
Normal	14 (7.7)	1.00		1.00	
Underweight	1 (8.3)	0.97 (0.13–7.39)	0.976	1.35 (0.17–10.71)	0.777
Overweight	19 (10.3)	1.36 (0.68–2.71)	0.383	1.35 (0.65–2.80)	0.423
Obesity	7 (9.9)	1.38 (0.56–3.43)	0.486	1.76 (0.70–4.47)	0.233
Surgeon experience (years)					
<15	38 (9.1)	1.00		1.00	
≥15	10 (5.3)	0.63 (0.31–1.26)	0.191	0.47 (0.23–0.99)	0.047*
Occupational lifting after surgery					
No	12 (2.6)	1.00		1.00	
Yes	36 (23.5)	9.67 (5.03–18.59)	<0.001*	36.40 (15.37–86.18)	<0.001*

*P<0.05 was considered statistically significant, [a]Missing value for any predictor were excluded from the analysis, [b]Cox's proportional hazards model. CI: Confidence interval, BMI: Body mass index

Our study showed that the recurrent rate was approximately 7.8%, the average time was 20.3 months, and the reoperation rate was <8%. Some opine that subtotal discectomy is an acceptable technique to reduce the reherniation rate after lumbar discectomy [24]. However, sequestrectomy or discectomy cannot prevent reherniation [25]. Moreover, some authors have demonstrated that lumbar disc herniation with massive herniation or segmental instability require fusion at the first time of surgery [44,46,48]. Among patients undergoing reoperation, 20 (42%) received discectomy and 25 (25%) received fusion surgery. Most of the patients belonged to the working class, of which 44% consisted of laborers. However, 25% of the patients continued occupational lifting after the surgery, which is the most important risk factor for revision surgery. Furthermore, obesity increased the load of lumbar spine that may lead to low back pain and disc degeneration [49-54]. Hence, we hypothesized that obesity may increase the reoperation rate, but the difference was statistically nonsignificant. The notable presence of elderly patients representing a quarter of our study cohort with lumbar disc herniation reflects several broader trends. First, the aging global population and increased lifespan have resulted in a higher incidence of spinal conditions, including disc herniation, in the elderly [55]. Advances in diagnostic techniques, particularly MRI, have also improved the detection of such conditions in older adults. The evolving lifestyle and activity levels of modern elderly populations may predispose them to conditions traditionally associated with younger individuals. In addition, the elderly often present with a combination of degenerative spinal changes and disc herniation, necessitating intervention [56]. These factors, along with a need to reevaluate epidemiological perspectives on spinal conditions in different age groups, could explain the higher than expected proportion of elderly patients in our study.

For patients aged <40 and >60 years, the reoperation rate increased by 18 times. These results agree with previous studies that have indicated that young patients could obtain better outcomes [21]. For the elderly people, the discectomy may disturb the stability of the lumbar spine and increase the symptoms due to poor disc quality and combination hypermobility. Therefore, elderly patients may be considered

for the primary fusion, considering factors such as disc quality, symptoms with degeneration, and wide laminectomy. The primary fusion could reduce the reoperation rate. In addition, the reoperation rate was related to the operation experience of the surgeon involved. Therefore, the reoperation risk decreased if a senior surgeon performed the surgery. Our observation that female gender is a risk factor for reoperation after lumbar discectomy is multifaceted, influenced by biomechanical, hormonal, and lifestyle factors. Women's unique spinal biomechanics, including variations in pelvic structure and lumbar curvature, can affect lumbar disc stress [57]. Hormonally, estrogen plays a significant role in collagen synthesis within intervertebral discs, potentially impacting healing postdiscectomy [58]. Postmenopausal women are more susceptible to reduced bone density, influencing spinal stability. In addition, gender differences in muscle mass and pain perception could affect postoperative outcomes and pain management, leading to a higher reoperation rate in women [59]. Finally, lifestyle and occupational factors, such as heavy lifting, might disproportionately impact women due to these physiological differences [60].

There were some limitations of this study. This was a retrospective study, and we did not record the pain-related score and functional outcomes, before and after the surgery. We analyzed only patients who underwent reoperation but excluded patients who refused surgery and were unable to undergo surgery due to lumbar hypermobility. Thus, we may have overestimated the reoperation rate by including patients who just needed conservative treatment but opted for an operation. We did not classify disc herniation based on severity, which may cause a difference in the reoperation rate.

Conclusions

The reoperation rate may decrease if a senior surgeon performs the surgery. Furthermore, the surgeon must educate the patients regarding the need to decrease occupational lifting after the discectomy. For elderly patients, HIVD may be considered for the degeneration of the lumbar spine, or a conservative treatment may be selected.

Data availability statement

All the data generated or analyzed during this study are included in this published article.

Acknowledgment

This manuscript was edited by Wallace Academic Editing.

Financial support and sponsorship

This work was supported by Buddhist Tzu Chi Medical Foundation (TCMF-A 111-01(113)).

Conflicts of interest

Dr. Ing-Ho Chen, an editorial board member at *Tzu Chi Medical Journal*, had no role in the peer review process of or decision to publish this article. The other authors declared no conflicts of interest in writing this paper.

References

1. Suzuki A, Matsumura A, Konishi S, Terai H, Tsujio T, Dozono S, et al. Risk factor analysis for motor deficit and delayed recovery associated with L4/5 lumbar disc herniation. J Spinal Disord Tech 2011;24:1-5.
2. Saal JA, Saal JS. Nonoperative treatment of herniated lumbar intervertebral disc with radiculopathy. An outcome study. Spine (Phila Pa 1976) 1989;14:431-7.
3. Martin BI, Mirza SK, Comstock BA, Gray DT, Kreuter W, Deyo RA. Reoperation rates following lumbar spine surgery and the influence of spinal fusion procedures. Spine (Phila Pa 1976) 2007;32:382-7.
4. Weinstein JN, Lurie JD, Tosteson TD, Skinner JS, Hanscom B, Tosteson AN, et al. Surgical versus nonoperative treatment for lumbar disk herniation: The Spine patient outcomes research trial (SPORT) observational cohort. JAMA 2006;296:2451-9.
5. Weinstein JN, Tosteson TD, Lurie JD, Tosteson AN, Hanscom B, Skinner JS, et al. Surgical versus nonoperative treatment for lumbar disk herniation: The Spine patient outcomes research trial (SPORT): A randomized trial. JAMA 2006;296:2441-50.
6. Yorimitsu E, Chiba K, Toyama Y, Hirabayashi K. Long-term outcomes of standard discectomy for lumbar disc herniation: A follow-up study of more than 10 years. Spine (Phila Pa 1976) 2001;26:652-7.
7. Vik A, Zwart JA, Hulleberg G, Nygaard OP. Eight year outcome after surgery for lumbar disc herniation: A comparison of reoperated and not reoperated patients. Acta Neurochir (Wien) 2001;143:607-10.
8. Davis RA. A long-term outcome analysis of 984 surgically treated herniated lumbar discs. J Neurosurg 1994;80:415-21.
9. Lewis PJ, Weir BK, Broad RW, Grace MG. Long-term prospective study of lumbosacral discectomy. J Neurosurg 1987;67:49-53.
10. Best NM, Sasso RC. Success and safety in outpatient microlumbar discectomy. J Spinal Disord Tech 2006;19:334-7.
11. Suk KS, Lee HM, Moon SH, Kim NH. Recurrent lumbar disc herniation: Results of operative management. Spine (Phila Pa 1976) 2001;26:672-6.
12. Swartz KR, Trost GR. Recurrent lumbar disc herniation. Neurosurg Focus 2003;15:E10.
13. Hangai M, Kaneoka K, Kuno S, Hinotsu S, Sakane M, Mamizuka N, et al. Factors associated with lumbar intervertebral disc degeneration in the elderly. Spine J 2008;8:732-40.
14. Zhang YG, Sun Z, Zhang Z, Liu J, Guo X. Risk factors for lumbar intervertebral disc herniation in Chinese population: A case-control study. Spine (Phila Pa 1976) 2009;34:E918-22.
15. Komori H, Shinomiya K, Nakai O, Yamaura I, Takeda S, Furuya K. The natural history of herniated nucleus pulposus with radiculopathy. Spine (Phila Pa 1976) 1996;21:225-9.
16. Weber H. Lumbar disc herniation. A controlled, prospective study with ten years of observation. Spine (Phila Pa 1976) 1983;8:131-40.
17. Hidalgo-Ovejero AM, Garcia-Mata S, Martinez-Grande M. Natural history and nonoperative treatment of lumbar disc herniation. Spine (Phila Pa 1976) 1998;23:508-10.
18. Saal JA. Natural history and nonoperative treatment of lumbar disc herniation. Spine (Phila Pa 1976) 1996;21:2S-9S.
19. Liu K, Zhu W, Shi J, Jia L, Shi G, Wang Y, et al. Foot drop caused by lumbar degenerative disease: Clinical features, prognostic factors of surgical outcome and clinical stage. PLoS One 2013;8:e80375.
20. Nygaard OP, Kloster R, Solberg T. Duration of leg pain as a predictor of outcome after surgery for lumbar disc herniation: A prospective cohort study with 1-year follow up. J Neurosurg 2000;92:131-4.
21. Mixter WJ. Rupture of the lumbar intervertebral disk: An etiologic factor for so-called "sciatic" pain. Ann Surg 1937;106:777-87.
22. Mixter WJ. The relation of the surgeon to his government. N Engl J Med 1952;246:403-7.
23. Keskimäki I, Seitsalo S, Osterman H, Rissanen P. Reoperations after lumbar disc surgery: A population-based study of regional and interspecialty variations. Spine (Phila Pa 1976) 2000;25:1500-8.
24. Wera GD, Dean CL, Ahn UM, Marcus RE, Cassinelli EH, Bohlman HH, et al. Reherniation and failure after lumbar discectomy: A comparison of fragment excision alone versus subtotal discectomy. J Spinal Disord Tech

2008;21:316-9.
25. Ruetten S, Komp M, Merk H, Godolias G. Recurrent lumbar disc herniation after conventional discectomy: A prospective, randomized study comparing full-endoscopic interlaminar and transforaminal versus microsurgical revision. J Spinal Disord Tech 2009;22:122-9.
26. Connolly ES. Surgery for recurrent lumbar disc herniation. Clin Neurosurg 1992;39:211-6.
27. Fandiño J, Botana C, Viladrich A, Gomez-Bueno J. Reoperation after lumbar disc surgery: Results in 130 cases. Acta Neurochir (Wien) 1993;122:102-4.
28. Miwa S, Yokogawa A, Kobayashi T, Nishimura T, Igarashi K, Inatani H, et al. Risk factors of recurrent lumbar disk herniation: A single center study and review of the literature. J Spinal Disord Tech 2015;28:E265-9.
29. Hirabayashi S, Kumano K, Ogawa Y, Aota Y, Maehiro S. Microdiscectomy and second operation for lumbar disc herniation. Spine (Phila Pa 1976) 1993;18:2206-11.
30. Stambough JL. Lumbar disk herniation: An analysis of 175 surgically treated cases. J Spinal Disord 1997;10:488-92.
31. Wenger M, Mariani L, Kalbarczyk A, Gröger U. Long-term outcome of 104 patients after lumbar sequestrectomy according to Williams. Neurosurgery 2001;49:329-34.
32. Carragee EJ, Spinnickie AO, Alamin TF, Paragioudakis S. A prospective controlled study of limited versus subtotal posterior discectomy: Short-term outcomes in patients with herniated lumbar intervertebral discs and large posterior anular defect. Spine (Phila Pa 1976) 2006;31:653-7.
33. Carragee EJ, Han MY, Suen PW, Kim D. Clinical outcomes after lumbar discectomy for sciatica: The effects of fragment type and anular competence. J Bone Joint Surg Am 2003;85:102-8.
34. Peng CW, Yeo W, Tan SB. Percutaneous endoscopic discectomy: Clinical results and how it affects the quality of life. J Spinal Disord Tech 2010;23:425-30.
35. Cinotti G, Roysam GS, Eisenstein SM, Postacchini F. Ipsilateral recurrent lumbar disc herniation. A prospective, controlled study. J Bone Joint Surg Br 1998;80:825-32.
36. Fakouri B, Patel V, Bayley E, Srinivas S. Lumbar microdiscectomy versus sequesterectomy/free fragmentectomy: A long-term (>2 y) retrospective study of the clinical outcome. J Spinal Disord Tech 2011;24:6-10.
37. Floman Y, Millgram MA, Smorgick Y, Rand N, Ashkenazi E. Failure of the Wallis interspinous implant to lower the incidence of recurrent lumbar disc herniations in patients undergoing primary disc excision. J Spinal Disord Tech 2007;20:337-41.
38. Kast E, Oberle J, Richter HP, Börm W. Success of simple sequestrectomy in lumbar spine surgery depends on the competence of the fibrous ring: A prospective controlled study of 168 patients. Spine (Phila Pa 1976) 2008;33:1567-71.
39. Thomé C, Barth M, Scharf J, Schmiedek P. Outcome after lumbar sequestrectomy compared with microdiscectomy: A prospective randomized study. J Neurosurg Spine 2005;2:271-8.
40. Faulhauer K, Manicke C. Fragment excision versus conventional disc removal in the microsurgical treatment of herniated lumbar disc. Acta Neurochir (Wien) 1995;133:107-11.
41. Rogers LA. Experience with limited versus extensive disc removal in patients undergoing microsurgical operations for ruptured lumbar discs. Neurosurgery 1988;22:82-5.
42. Caldwell GA, Sheppard WB. Criteria for spine fusion following removal of protruded nucleus pulposus. J Bone Joint Surg Am 1948;30A: 971-80.
43. Loupasis GA, Stamos K, Katonis PG, Sapkas G, Korres DS, Hartofilakidis G. Seven- to 20-year outcome of lumbar discectomy. Spine (Phila Pa 1976) 1999;24:2313-7.
44. Rish BL. A comparative evaluation of posterior lumbar interbody fusion for disc disease. Spine (Phila Pa 1976) 1985;10:855-7.
45. Takeshima T, Kambara K, Miyata S, Ueda Y, Tamai S. Clinical and radiographic evaluation of disc excision for lumbar disc herniation with and without posterolateral fusion. Spine (Phila Pa 1976) 2000;25:450-6.
46. Vaughan PA, Malcolm BW, Maistrelli GL. Results of L4-L5 disc excision alone versus disc excision and fusion. Spine (Phila Pa 1976) 1988;13:690-5.
47. Schoeggl A, Reddy M, Matula C. Functional and economic outcome following microdiscectomy for lumbar disc herniation in 672 patients. J Spinal Disord Tech 2003;16:150-5.
48. Satoh I, Yonenobu K, Hosono N, Ohwada T, Fuji T, Yoshikawa H. Indication of posterior lumbar interbody fusion for lumbar disc herniation. J Spinal Disord Tech 2006;19:104-8.
49. Takatalo J, Karppinen J, Taimela S, Niinimäki J, Laitinen J, Sequeiros RB, et al. Association of abdominal obesity with lumbar disc degeneration – A magnetic resonance imaging study. PLoS One 2013;8:e56244.
50. Samartzis D, Karppinen J, Chan D, Luk KD, Cheung KM. The association of lumbar intervertebral disc degeneration on magnetic resonance imaging with body mass index in overweight and obese adults: A population-based study. Arthritis Rheum 2012;64:1488-96.
51. Urquhart DM, Berry P, Wluka AE, Strauss BJ, Wang Y, Proietto J, et al. 2011 Young investigator award winner: Increased fat mass is associated with high levels of low back pain intensity and disability. Spine (Phila Pa 1976) 2011;36:1320-5.
52. Samartzis D, Karppinen J, Mok F, Fong DY, Luk KD, Cheung KM. A population-based study of juvenile disc degeneration and its association with overweight and obesity, low back pain, and diminished functional status. J Bone Joint Surg Am 2011;93:662-70.
53. Shiri R, Karppinen J, Leino-Arjas P, Solovieva S, Viikari-Juntura E. The association between obesity and low back pain: A meta-analysis. Am J Epidemiol 2010;171:135-54.
54. Liuke M, Solovieva S, Lamminen A, Luoma K, Leino-Arjas P, Luukkonen R, et al. Disc degeneration of the lumbar spine in relation to overweight. Int J Obes (Lond) 2005;29:903-8.
55. Fehlings MG, Tetreault L, Nater A, Choma T, Harrop J, Mroz T, et al. The aging of the global population: The changing epidemiology of disease and spinal disorders. Neurosurgery 2015;77(Suppl 4):S1-5.
56. Wong AY, Karppinen J, Samartzis D. Low back pain in older adults: Risk factors, management options and future directions. Scoliosis Spinal Disord 2017;12:14.
57. Hay O, Dar G, Abbas J, Stein D, May H, Masharawi Y, et al. The lumbar lordosis in males and females, revisited. PLoS One 2015;10:e0133685.
58. Jin LY, Song XX, Li XF. The role of estrogen in intervertebral disc degeneration. Steroids 2020;154:108549.
59. Kobayashi Y, Ogura Y, Kitagawa T, Yonezawa Y, Takahashi Y, Yasuda A, et al. Gender differences in pre- and postoperative health-related quality of life measures in patients who have had decompression surgery for lumbar spinal stenosis. Asian Spine J 2020;14:238-44.
60. Vlassoff C. Gender differences in determinants and consequences of health and illness. J Health Popul Nutr 2007;25:47-61.