International Journal of Innovative Research in Medical Science (IJIRMS)
Volume 08, Issue 03, March 2023,
https://doi.org/10.23958/ijirms/vol08-i03/1652

Review article

Comparing Surgical Interventions for Recurrent Lumbar Disc Herniation: A Literature Review

Dr. Yusuf Sharaf [*1], Dr. Mohamed Albaqali [2], Dr. Fareed Saloom [3], Dr. Abdulla Hasan [4] Dr. Yakub Sayyad[5]

[1]Spine Department, Asharaf Spine Center, Manama, Bahrain.
[2]Orthopedic Department, AlKindi Hospital, Manama, Bahrain.
[3]Orthopedic Department, Alsharaf Center, Manama, Bahrain.
[4]Medical Department, International Medical Center, Manama, Bahrain.
[5]Clinical Research, Shifa Clinic, Chikhli, Pune 412114, Maharashtra, India.

*Corresponding author: Yusuf Sharaf; *dr.yousif.sharaf@gmail.com*

Received 23 February 2023; Accepted 20 March 2023; Published 21 March 2023

Abstract

The recurrence of lumbar disc herniation (LDH) is a common complication that can occur after primary discectomy. Various factors contribute to the recurrence of LDH, including patient-related, surgical, and biomechanical factors. Despite attempts to determine the best surgical techniques and patient selection criteria, there is inconsistent evidence that some factors increase the likelihood of recurrence. Repeat discectomy has been shown to be a safe and effective surgical option for recurrent LDH cases that do not respond to non-operative management. However, selecting the most suitable surgical intervention, such as endoscopic or conventional discectomy with or without instrumented fusion, can be difficult. Factors such as presenting symptoms, previous surgeries or re-herniations, radiographic instability, sagittal or coronal deformity, and surgeon experience should all be considered when making this decision. Further comparative clinical investigations are needed to establish the best surgical method.

Keywords: ***Lumbar disc herniation, recurrence, endoscopic discectomy, transforaminal lumbar interbody fusion and stabilization.***

Introduction

Lower back pain (LBP) is a frequently reported health problem worldwide, accounting about 80% of people experiencing it at least once during their life. This condition is highly prevalent and can cause significant disability, resulting in an annual cost of over $100 billion in the United States alone. Degenerative disc disease and lumbar disc herniation (LDH) are the leading causes of LBP, accounting for a large proportion of cases. The lumbar area's L4-L5 and L5-S1 regions are the most commonly affected locations, with approximately 95% of disc herniations occurring there [1].

Previous large-scale studies have shown that surgical treatment of LDH can provide short-term benefits, but the value of this approach in the medium to long term is uncertain [2,3]. A study conducted in Finland compared non-operative treatment with microdiscectomy for LDH [4]. It revealed no significant difference between the two groups regarding 2-year measurements such as Oswestry Disability Index ODI score and health-related quality of life HRQoL. However, the study did find that leg pain improved significantly after six weeks, and patients reported higher treatment satisfaction after two years. The most noteworthy finding of the study was that microdiscectomy for L4-5 LDH led to better patient-reported outcomes compared to non-operative treatment, including subjective work ability, ODI, and HRQOL scores, as indicated by subgroup analysis [4].

Recent studies have defined multiple factors associated with successful outcomes following discectomy for LDH. Several factors were found to impact preoperative outcomes, including more severe leg pain before surgery, improved mental health condition, shorter duration of symptoms, younger age, higher levels of physical activity before surgery, and severe LBP before surgery. However, the study did not find any significant association between postoperative outcomes and the presence of motor deficit, vertebral level or side of herniation, gender, or type I modic changes [5-7]. When compared to open discectomy, there was an association between an endoscopic discectomy and reduced operation duration and lower blood loss. However, there is no significant increase in overall complications, reoperation rates, or wound infection among patients who undergo endoscopic discectomy as a group [8].

Discectomy for LDH is linked with several significant complications. The incidence of dural tears after LDH was between 1 and 17%, with a higher risk in older patients, those who are obese, and those undergoing revision procedures [9]. Additional complications that may arise include postoperative infection (occurring in 1-5% of cases), deterioration of functional status (seen in 4% of cases), and nerve root injury (occurring in 0.2% of cases) [10,11]. Numerous factors have been recognized as risk factors for recurrent herniation, such as disc sequestration, disc height index before surgery, disc protrusion, advancing age, trauma, smoking, longer sick leave duration, workers' compensation, more severe preoperative symptoms, and the presence of diabetes [1,12,13]. Minimizing the risk factors for recurrence is crucial as there is a considerable rise in perioperative complications associated with revision LDH discectomy. The present narrative review aimed to

examine research investigating the recurrence of LDH and to identify factors and features linked to this condition.

Methodology

To identify all relevant studies on the effectiveness of surgical interventions for recurrent LDH, a comprehensive search was conducted using MESH terms in three electronic databases, including PubMed, Google Scholar, and Medline. In addition, reference lists were manually searched of the extracted articles to ensure that all relevant studies were included. We used keywords and Boolean operators. The search strategy included terms such as "recurrent lumbar disc herniation," "surgical interventions," "microdiscectomy," "laminectomy," "discectomy," "fusion," and "artificial disc replacement".

The inclusion criteria included papers published in English comparing surgical interventions for recurrent lumbar disc herniation conducted in the last 15 years, while exclusion criteria were studies that do not involve human participants or a comparison of at least two different surgical interventions in addition to editorials, or letters to the editor. Title and abstract screening, followed by full-text screening.

Recurrent lumbar disc herniation

The definition of recurrent lumbar disc herniation (rLDH) varies in literature, with some defining it as the appearance of a herniation at the same primary herniation level (same or opposite side), accompanied by a painless interval of six months at least following the initial intervention. Others consider recurrent herniation to be (although less commonly defined) the occurrence of herniation at a different level after the initial surgery [14,15].

Previous literature has shown that the LDH recurrence rate ranges from 5- 15% [16]. Numerous studies have attempted to identify the cause of this recurrence, which is thought to be linked to various surgical techniques. The most commonly known surgical technique is a discectomy, which offers several approaches, including simple one discectomy, percutaneous endoscopic discectomy (which may be interlaminar, transforaminal, or minimally invasive transforaminal interbody fusion). Moreover, the recurrence of LDH is closely related to the learning curve for specialists [13,17-19].

Several risk factors were found to be associated with disc herniation recurrence. A recent systematic review examined the existing literature concerning the risk factors linked to rLDH. Various potential risk factors for rLDH have been studied, such as gender, age, presence or not of diabetes, body mass index (BMI), smoking status, type of LDH, and occupational work, among others. Nevertheless, pooled estimates from the systematic review revealed that among these factors, only being a smoker, having disc protrusion, and having diabetes were predictors of rLDH. Regarding gender, a detailed examination of various study locations revealed that Asian males had a higher probability of experiencing rLDH. Furthermore, when the subgroup analysis was conducted based on surgical procedures, it was found that male patients who underwent minimally invasive surgery were more susceptible to developing rLDH. The authors speculated that smokers undergoing minimally invasive surgery were more at risk of rLDH [13]. In addition to these factors, it is important to consider possible complications after surgery and other relevant issues [15,20].

Recurrent herniation can cause severe pain and disability and often require additional surgery following the initial operation, making it a crucial factor in determining the success of postoperative care. Moreover, this complication imposes a considerable burden on the healthcare system. Studies show that the cost of managing patients with rLDH varies significantly, with the mean cost per patient requiring revision surgery being $39,386. In contrast, those managed conservatively cost, on average $2315 in each case [21]. Therefore, identifying patients at higher risk of recurrent herniation and adopting the best management activities are essential to reduce disease-related costs and health problems.

Discectomy

McGirt et al. discovered that intraoperative debulking might also play a role in rLDH. Specifically, a correlation was discovered between a higher probability of re-herniation and larger annular defects and a smaller percentage of disc removal during the primary surgery. In contrast, more aggressive removal resulted in accelerated disc height loss. The researchers' systematic review indicated that although limited discectomies may result in shorter operation duration, faster functional recovery, and similar functional status after six months, they were associated with higher rates (8.7%) of recurrent herniation compared to aggressive discectomy (3.3%). The task, therefore, is to strike a balance between preserving disc height and lowering re-herniation risk [21,22].

Percutaneous endoscopic lumbar discectomy (PELD)

This has recently gained significant popularity as a substitute for open lumbar discectomy (OLD) in managing LDH. PELD offers several advantages over OLD, such as performing surgery under local anaesthesia and its ability to cause minimal harm to adjacent muscle and bone tissues, thereby promoting speedy recuperation in patients. Although the scope of PELD was initially restricted to specific lesions, based on their location and advancement, recent technological advances and the development of new tools have helped to overcome these limitations [23]. A recent meta-analysis found similar reoperation and recurrence rates between the two surgical methods [23]. This result is consistent with two earlier reports [24,25]. However, one study suggested that PELD had a higher recurrence and reoperation rate than the alternative procedure [26]. Typically, in cases of recurrence or reoperation, there is a residual disc fragment or accompanying stenosis [27]. Therefore, determining appropriate indications and developing surgical skills proficiency is crucial to minimize such complications.

Microendoscopic discectomy (MED)

Is a minimally invasive surgical procedure used to treat LDH? However, the advantage of this method may be outweighed by the risk of early postoperative recurrence. In a study conducted on 344 patients who underwent MED, 10.8% of the cases reported rLDH. The study's authors reported that the recurrence and reoperation ratios for LDH following MED were similar to those of traditional discectomy. In addition, over 50% of the recurrence instances were observed during the initial postoperative period. Individuals with LDH that had migrated caudally experienced a considerably higher recurrence rate than those with non-migrated or rostrally migrated LDH [28]. Previous evidence reported a 1-21% recurrence rate at one year when utilizing the MED approach [29]. It is crucial to prevent a second surgery for patients undergoing MED, as repeated decompression increases the risks and complications compared to decompression/fusion [13,30]. An earlier study demonstrated that higher BMI and elevated post-surgery Oswestry disability index ODI following microdiscectomy were significantly linked to a higher rLDH risk within a year [29].

Management of rLDH

Managing postoperative recurrent LDH is a matter of debate among surgeons due to multiple factors, resulting in considerable disagreement between 22 - 69%. While the literature on this topic mainly comprises case series or reviews with limited evidence, comprehensive data analysis suggests that repeat surgery is currently considered the standard treatment for recurrent LDH. Various surgical options for treating rLDH, including repeat discectomy, using conventional or minimally invasive techniques. Additionally, instrumented spinal fusion can be performed in conjunction with these procedures. Surgeon's preference, presence of symptoms or axial LBP, instability or deformity in radiographic images, and the

number of previous herniations should all be considered when determining the best approach [31].

Revision discectomy

The outcomes of revision surgery for rLDH were the subject of various investigations, with varying results. Although some recent reports have demonstrated results similar to primary discectomies, earlier evidence showed no significant difference and even worse outcomes after revision discectomy [21]. In an early prospective analysis conducted by Cinotti et al., comparing 26 revision microdiscectomies for ipsilateral rLDH versus primary discectomies. The authors evaluated patient-reported outcomes using a non-validated 100-point clinical outcome assessment and showed that after revision discectomies results were comparable to those following primary discectomies (85% and 88%). Yet, it should be noted that the sample had patients with comorbidities (epidural fibrosis and foraminal stenosis), which might have influenced the findings [32]. To control for these mixed populations, Suk et al. defined rLDH as disc herniations confirmed by MRI at the same level after a period of pain-free intervals exceeding six months. The study included 28 patients who had undergone revision OLD following an index open discectomy. Both procedures yielded similar outcomes as there were no significant differences observed in the pain-free interval, length of stay, or clinical improvement measured by the visual analog scale (VAS) scores. However, the authors noted that the length of surgery for revision surgeries was longer than that for primary surgeries [33].

According to Patel et al., outcomes after primary discectomy and revision surgery were comparable in a sample of 30 cases who underwent both procedures for single-level LDH. Both primary and revision surgeries significantly improved outcome scores for all patients, with both having similar results [34]. Numerous authors suggest that repeat discectomies can be a suitable treatment option for an rLDH causing radicular symptoms. However, the following section will explore the need for instrumented fusion in patients.

Revision discectomy without fusion raises several concerns. One concern is the possibility of underlying instability that caused the rLDH in the first place. Concerns are rising also that revision discectomy may further contribute to instability. During revision discectomy, surgeons may need to remove extra lamina and facets to obtain a clear view of normal tissue planes and avoid accidental durotomy and neural damage [35].

A systematic review evaluated the effectiveness of PELD for rLDH. According to controlled studies in the review, PELD requires less time and blood loss during surgery than OLD, as the need to remove muscle, ligament, and lamina is significantly reduced. Furthermore, avoiding epidural scarring in the previous OLD access site may result in a longer surgical procedure and increased blood loss. These observations imply that PELD is a less invasive surgical option for treating rLDH. Shorter operative times, less blood loss, and shorter hospital stays may benefit patients in multiple ways. There are two potential benefits of a shorter hospital stay and a faster return to work for patients with rLDH. While the economic impact of these benefits has not been assessed, they could still provide advantages. Additionally, rLDH patients tend to be older and have more medical conditions, making shorter operation times and reduced blood loss beneficial in reducing postoperative complications and promoting a faster recovery [36].

The Oswestry Disability Index ODI improvement was found to be 60.9% (40.7% to 75%), and the MacNab score was 75.77% (60% to 95%). A meta-analysis concluded that both PELD and OLD methods achieved similar functional recovery at final follow-up, indicating that both procedures effectively treat rLDH by achieving adequate decompression and removing recurrent herniated disc materials. One prominent reason PELD is preferred by spine surgeons is its lower complication rate of 4.89% (with a range of 0 to 9.76%). The risk of dural injury during repeat discectomy is primarily influenced by the surgical approach, the techniques employed to manage scar tissue, and the surgeon's experience with the procedure. Percutaneous endoscopic transforaminal discectomy (PETD) was found to have the lowest incidence of dural injury at 0%, while percutaneous interlaminar endoscopic discectomy PEID had a range of 0 to 4.9%. PETD involves a posterolateral approach to reach the disc while avoiding the scarred area from previous surgeries. This technique minimizes the risk of nerve root injury or dural tear and reduces the chances of cerebrospinal fluid (CSF) leakage. Moreover, even in cases of dural tears during the procedure, the transmuscular working channel collapses after the removal of the instrument, further reducing the risk of CSF leakage [36].

Instrumented Fusion

Although some surgeons recommend repeating discectomy alone, others advocate fusion procedures with or without minimally invasive techniques. Current guidelines suggest that repeat discectomy is appropriate for individuals with rLDH, whereas fusion may be considered for those with substantial deformity, instability, or concomitant axial LBP [37]. Incorporating instrumented fusion can potentially increase stability and counterbalance segmental movement at the level that is affected [38]. According to Dower et al., patients who underwent discectomy alone (79.5%) and those who received discectomy with fusion (77.8%) demonstrated similar rates of satisfactory outcomes [39]. However, patients who underwent fusion (60.1%) showed significant improvements in back pain scores compared to those who underwent isolated discectomy (47.2%), underscoring the potential advantages of fusion in cases suffering from back pain before the surgery.

Posterolateral fusion (PLF) is the primary method of achieving fusion in cases of rLDH. In a retrospective study by Fu et al., patients with isolated rLDH who underwent simultaneous disc excision and PLF achieved excellent or good clinical outcomes in 83.3% of cases. In comparison, 78.3% of those undergoing revision discectomy alone had similar outcomes. The study found no significant differences in intraoperative blood loss, surgery duration, or length of stay between the two groups, indicating comparable outcomes for discectomy with or without fusion in patients without associated pathology or instability [40].

Chen et al. investigated the effectiveness of transforaminal lumbar interbody fusion (TLIF) in managing rLDH. TLIF offers several advantages, such as minimal dissection of the dural sac and low risk of postoperative radiculitis, due to the dissection through unscarred tissue [41]. In a recent study, two groups of patients were compared: those who received revision discectomy alone (Group A) and those who underwent revision discectomy with TLIF and instrumentation (Group B). In Group A, complications occurred in 32.73% of cases, whereas Group B had a lower rate of 28%. Further analysis revealed that Group A had eight cases of re-recurrence (7.27%) and three instances of postoperative instability (2.73%). In contrast, Group B did not experience any re-recurrence or postoperative instability. However, the two groups had no significant statistical difference regarding dural tear, disc space infection, and superficial wound infection. Although there was a slightly higher incidence of neurological deficit in Group A, it was not statistically significant. In Group B, a single patient with persistent pain and mobility issues required additional surgery because of disc space infection. Group A experienced significantly higher postoperative low back and radicular pain than Group B ($P < 0.05$). Conversely, the fusion group necessitated significant blood transfusions in 44% of cases. The two groups differed significantly regarding intraoperative blood loss, duration of operation, postoperative hospital stay, and total procedure cost, with Group A having significantly lower values than Group B [42].

At present, no unanimous agreement was made concerning the number of repeat herniations required before considering instrumented fusion at the affected level. Repeating discectomy is the most common surgical intervention for the first-time recurrence if LBP or radiographic instability is absent. As the number of

surgeries increases, the chances of inducing or exacerbating segmental lumbar instability also rise due to the need for more aggressive facetectomies and dissection to visualize the neural foramen [38]. As the frequency of recurrent herniations increases, the willingness to include instrumented fusion declines. In a survey conducted by Mroz et al. with 2560 Orthopedic and neurological surgeons, most surgeons preferred to use revision microdiscectomy alone for a first-time recurrence, regardless of region, specialty, fellowship training, or practice type. When managing a second-time recurrence previously treated with a microdiscectomy, there was considerable disagreement in the preferred approach among surgeons. According to the survey conducted, there was a 69% probability of disagreement between surgeons [31].

Conclusion

Recurrent lumbar disc herniation is a frequent complication after initial discectomy. Various reported risk factors include modifiable patient-related, surgical, and biomechanical factors. While identifying the optimal surgical technique and candidate has been emphasized. Although there is contradictory evidence regarding the factors that actually elevate the risk of recurrence, repeat discectomy seems to be a reliable and efficient surgical option for patients with recurrent lumbar disc herniation (rLDH) who did not respond to non-operative treatment. However, the challenge now is to determine the appropriate surgical intervention, such as endoscopic or conventional discectomy, with or without instrumented fusion, based on factors such as presenting symptoms, history of previous surgeries or re-herniations, radiographic instability, sagittal or coronal deformity, and surgeon experience. Further comparative trials are required to identify the most suitable surgical treatment.

Declarations

Ethics approval and consent to participate

Not applicable

List of abbreviations

Lower back pain: LBP
Lumbar disc herniation: LDH
Health-related quality of life HRQoL
Oswestry Disability Index ODI
Recurrent lumbar disc herniation: rLDH
Open lumbar discectomy: OLD
Percutaneous endoscopic lumbar discectomy: PELD
Visual analog scale: VAS
Percutaneous endoscopic transforaminal discectomy: PETD

Data Availability

Not applicable

Conflicts of Interest

All authors declare no conflict of interest. There are no conflicting relationships or activities.

Funding Statement

This study did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors' contributions

YS confirms responsibility for the study conception and design, data collection, interpretation of results, and manuscript preparation. MA, FS, AH did all interpretation, writing of the manuscript. YKS contributed to the final writing of the manuscript. All authors have critically reviewed and approved the final draft and are responsible for the manuscript's content and similarity index.

References

[1] Amin RM, Andrade NS, Neuman BJ. Lumbar Disc Herniation. Curr Rev Musculoskelet Med 2017;10(4):507–16.
[2] Weinstein JN, Tosteson TD, Lurie JD, Tosteson ANA, Hanscom B, Skinner JS, et al. Surgical vs Nonoperative Treatment for Lumbar Disk Herniation. JAMA 2006;296(20):2441–50.
[3] Atlas SJ, Deyo RA, Keller RB, Chapin AM, Patrick DL, Long JM, et al. The Maine Lumbar Spine Study, Part II. 1-year outcomes of surgical and nonsurgical management of sciatica. Spine (Phila Pa 1976) 1996;21(15):1777–86.
[4] Osterman H, Seitsalo S, Karppinen J, Malmivaara A. Effectiveness of microdiscectomy for lumbar disc herniation: a randomized controlled trial with 2 years of follow-up. Spine (Phila Pa 1976) 2006;31(21):2409–14.
[5] Oba H, Takahashi J, Tsutsumimoto T, Ikegami S, Ohta H, Yui M, et al. Predictors of improvement in low back pain after lumbar decompression surgery: Prospective study of 140 patients. J Orthop Sci 2017;22(4):641–6.
[6] Tschugg A, Lener S, Hartmann S, Wildauer M, Löscher WN, Neururer S, et al. Preoperative sport improves the outcome of lumbar disc surgery: a prospective monocentric cohort study. Neurosurg Rev 2017;40(4):597–604.
[7] Wilson CA, Roffey DM, Chow D, Alkherayf F, Wai EK. A systematic review of preoperative predictors for postoperative clinical outcomes following lumbar discectomy. Spine J 2016;16(11):1413–22.
[8] Phan K, Xu J, Schultz K, Alvi MA, Lu VM, Kerezoudis P, et al. Full-endoscopic versus micro-endoscopic and open discectomy: A systematic review and meta-analysis of outcomes and complications. Clin Neurol Neurosurg 2017; 154:1–12.
[9] Puvanesarajah V, Hassanzadeh H. The True Cost of a Dural Tear: Medical and Economic Ramifications of Incidental Durotomy During Lumbar Discectomy in Elderly Medicare Beneficiaries. Spine (Phila Pa 1976) 2017;42(10):770–6.
[10] Kotil K. Closed Drainage versus Non-Drainage for Single-Level Lumbar Disc Surgery: Relationship between Epidural Hematoma and Fibrosis. Asian Spine J 2016;10(6):1072–8.
[11] Murphy ME, Hakim JS, Kerezoudis P, Alvi MA, Ubl DS, Habermann EB, et al. Micro vs. macrodiscectomy: Does use of the microscope reduce complication rates? Clin Neurol Neurosurg 2017; 152:28–33.
[12] Shin BJ. Risk factors for recurrent lumbar disc herniations. Asian Spine J 2014;8(2):211–5.
[13] Huang W, Han Z, Liu J, Yu L, Yu X. Risk Factors for Recurrent Lumbar Disc Herniation. Medicine (Baltimore) 2016;95(2): e2378.
[14] Yaman ME, Kazancı A, Yaman ND, Baş F, Ayberk G. Factors that influence recurrent lumbar disc herniation. Hong Kong Med J 2017;23(3):258–63.
[15] Swartz KR, Trost GR. Recurrent lumbar disc herniation. Neurosurg Focus 2003;15(3): E10.
[16] Yin S, Du H, Yang W, Duan C, Feng C, Tao H. Prevalence of Recurrent Herniation Following Percutaneous Endoscopic Lumbar Discectomy: A Meta-Analysis. Pain Physician 2018;21(4):337–50.
[17] Ajiboye RM, Drysch A, Mosich GM, Sharma A, Pourtaheri S. Surgical Treatment of Recurrent Lumbar

Disk Herniation: A Systematic Review and Meta-analysis. Orthopedics 2018;41(4): e457–69.
[18] Goker B, Aydin S. Endoscopic Surgery for Recurrent Disc Herniation After Microscopic or Endoscopic Lumbar Discectomy. Turk Neurosurg 2020;30(1):112–8.
[19] Staartjes VE, de Wispelaere MP, Miedema J, Schröder ML. Recurrent Lumbar Disc Herniation After Tubular Microdiscectomy: Analysis of Learning Curve Progression. World Neurosurg 2017; 107:28–34.
[20] Hao L, Li S, Liu J, Shan Z, Fan S, Zhao F. Recurrent disc herniation following percutaneous endoscopic lumbar discectomy preferentially occurs when Modic changes are present. J Orthop Surg Res 2020;15(1):176.
[21] Shepard N, Cho W. Recurrent Lumbar Disc Herniation: A Review. Global Spine J 2019;9(2):202–9.
[22] McGirt MJ, Eustacchio S, Varga P, Vilendecic M, Trummer M, Gorensek M, et al. A prospective cohort study of close interval computed tomography and magnetic resonance imaging after primary lumbar discectomy: factors associated with recurrent disc herniation and disc height loss. Spine (Phila Pa 1976) 2009;34(19):2044–51.
[23] Kim M, Lee S, Kim HS, Park S, Shim SY, Lim DJ. A Comparison of Percutaneous Endoscopic Lumbar Discectomy and Open Lumbar Microdiscectomy for Lumbar Disc Herniation in the Korean: A Meta-Analysis. Biomed Res Int 2018; 2018:9073460.
[24] Schaffer JL, Kambin P. Percutaneous posterolateral lumbar discectomy and decompression with a 6.9-millimeter cannula. Analysis of operative failures and complications. J Bone Joint Surg Am 1991;73(6):822–31.
[25] Goald HJ. Microlumbar discectomy: follow-up of 477 patients. J Microsurg 1980;2(2):95–100.
[26] Cheng J, Wang H, Zheng W, Li C, Wang J, Zhang Z, et al. Reoperation after lumbar disc surgery in two hundred and seven patients. Int Orthop 2013;37(8):1511–7.
[27] Kambin P. Arthroscopic microdiscectomy. Arthroscopy 1992;8(3):287–95.
[28] Matsumoto M, Watanabe K, Hosogane N, Tsuji T, Ishii K, Nakamura M, et al. Recurrence of Lumbar Disc Herniation after Microendoscopic Discectomy. J Neurol Surg A Cent Eur Neurosurg 2012;222–7.
[29] Dobran M, Nasi D, Paracino R, Gladi M, Costanza MD, Marini A, et al. Analysis of risk factors and postoperative predictors for recurrent lumbar disc herniation. Surg Neurol Int 2019; 10:36.
[30] Meredith DS, Huang RC, Nguyen J, Lyman S. Obesity increases the risk of recurrent herniated nucleus pulposus after lumbar microdiscectomy. Spine J 2010;10(7):575–80.
[31] Mroz TE, Lubelski D, Williams SK, O'Rourke C, Obuchowski NA, Wang JC, et al. Differences in the surgical treatment of recurrent lumbar disc herniation among spine surgeons in the United States. Spine J 2014;14(10):2334–43.
[32] Cinotti G, Roysam GS, Eisenstein SM, Postacchini F. Ipsilateral recurrent lumbar disc herniation. A prospective, controlled study. J Bone Joint Surg Br 1998;80(5):825–32.
[33] Suk KS, Lee HM, Moon SH, Kim NH. Recurrent lumbar disc herniation: results of operative management. Spine (Phila Pa 1976) 2001;26(6):672–6.
[34] Patel MS, Braybrooke J, Newey M, Sell P. A comparative study of the outcomes of primary and revision lumbar discectomy surgery. Bone Joint J 2013;95-B(1):90–4.
[35] Hlubek RJ, Mundis GM. Treatment for Recurrent Lumbar Disc Herniation. Curr Rev Musculoskelet Med 2017;10(4):517–20.
[36] Li X, Hu Z, Cui J, Han Y, Pan J, Yang M, et al. Percutaneous endoscopic lumbar discectomy for recurrent lumbar disc herniation. Int J Surg 2016;27:8–16.
[37] Wang JC, Dailey AT, Mummaneni PV, Ghogawala Z, Resnick DK, Watters WC, et al. Guideline update for the performance of fusion procedures for degenerative disease of the lumbar spine. Part 8: lumbar fusion for disc herniation and radiculopathy. J Neurosurg Spine 2014;21(1):48–53.
[38] Greenleaf RM, Harris MB, Bono CM. The Role of Fusion for Recurrent Disk Herniations. Seminars in Spine Surgery 2011;23(4):242–8.
[39] Dower A, Chatterji R, Swart A, Winder MJ. Surgical management of recurrent lumbar disc herniation and the role of fusion. J Clin Neurosci 2016;23:44–50.
[40] Fu TS, Lai PL, Tsai TT, Niu CC, Chen LH, Chen WJ. Long-term results of disc excision for recurrent lumbar disc herniation with or without posterolateral fusion. Spine (Phila Pa 1976) 2005;30(24):2830–4.
[41] Chen Z, Zhao J, Liu A, Yuan J, Li Z. Surgical treatment of recurrent lumbar disc herniation by transforaminal lumbar interbody fusion. Int Orthop 2009;33(1):197–201.
[42] Ahsan K, Khan SI, Zaman N, Ahmed N, Montemurro N, Chaurasia B. Fusion versus nonfusion treatment for recurrent lumbar disc herniation. J Craniovertebr Junction Spine 2021;12(1):44–53.