



The evidence-based approach for surgical complications in the treatment of lumbar disc herniation

Robert Harper¹ · Eric Klineberg¹

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Abstract

Purpose The purpose of this article is to review the evidence-based approach for surgical complications following disc herniation.

Methods A search of the primary English literature was conducted for research examining the outcomes and complications of surgical discectomy. Special regard was given to high-quality prospective randomized studies.

Results The most commonly reported complications of surgical treatment of disc herniation are included in this review. Medical complications, and surgical complications including infection, durotomy, neurological injury, symptomatic re-herniation, and revision surgery are defined and systematically reviewed in detail for incidence, evaluation, and management.

Conclusion This article provides the clinician and surgeon with a review of the evidence-based evaluation and management of surgical complications following disc herniation, offering best practice guidelines for informed discussions with patients in shared decision-making.

Keywords Disc herniation · Lumbar microdiscectomy · Complications · Durotomy · Re-herniation

Introduction

Lumbar disc herniation (LDH) is a common problem encountered in the clinical spine practice. Non-operative treatment is the mainstay of initial management of LDH. More than 90% of patients will improve with conservative care, and surgery is rarely indicated before six weeks after onset of symptoms in the absence of cauda equine syndrome [1]. Despite overall good results for non-operative management of LDH, surgery is an important modality for patients that fail conservative treatment. Lumbar discectomy is the most commonly performed spine surgery [2, 3]. This procedure has an excellent track record in the treatment of LDH. In the eight year follow up of patients in the Spine Patient Outcomes Research Trial (SPORT), Lurie et al. found superior outcomes in both primary and secondary measures in surgically treated patients in the as-treated analysis compared to those whom were treated conservatively for LDH. These benefits of surgery last up to

eight years [4]. Despite the effectiveness of lumbar discectomy in the management of LDH, the procedure is not without risks. In a meta-analysis of complications in lumbar discectomy, Shriver et al. found overall complication rates of 12.5%, 13.3%, and 10.8% for open microdiscectomy, microendoscopic discectomy (MED), and percutaneous microdiscectomy respectively in their analysis of 42 studies [5]. The purpose of this article is to provide the evidence-based data on the identification and evaluation of the surgical complications of disc herniation.

Factors affecting complications

Surgical training, and therefore the surgical specialty, may affect the rate of complications in discectomy. Esfahani et al. sampled the NSQIP database to analyze whether surgical specialty had any impact on lumbar discectomy complications [6]. They found that orthopaedic surgeons and neurosurgeons were similar in all post-operative outcomes and complications, except for higher rate of blood transfusions for orthopaedic surgeons (0.3 vs 0.1%) and longer operative times for neurosurgeons (83.7 vs 72.5 min). Although these values may be statistically significant, they do not appear to be clinically

✉ Robert Harper
raharper@ucdavis.edu

¹ Department of Orthopedic Surgery, University of California Davis, 4860 Y Street Suite 3700, Sacramento, CA 95817, USA

significant. There were no significant differences in complications including; mortality, readmission, or rates of re-operation. Others have pursued whether the operative setting contributes to complications. Pugley et al. used the NSQIP database to compare 30-day complications rates between inpatient and outpatient single-level lumbar discectomy. They found an overall higher complication rate in the matched inpatient cohort when compared with outpatient (5.4 vs 3.5%) [7]. They included wound, pulmonary, neurological, cardiac, haematological complications, along with urinary tract infection (UTI) and return to OR within 30 days. The inpatient cohort however may suffer from selection bias, as the indication for admission may have been the complication. Others have questioned whether traditional open versus minimally invasive techniques affect overall complications. Shriver et al. found no difference in overall complication rates between open microdiscectomy versus minimally invasive within specific domains: reoperation, disc recurrence, wound complications, haematoma, nerve injury, medical complications, durotomy, or surgical errors [5].

Medical complications

As lumbar discectomy is often an elective procedure, and generally performed in younger patients, medical complications are uncommon. Although patients tend to be relatively healthy, there does exist a risk for pulmonary embolism (PE), deep vein thrombosis (DVT), pneumonia, UTI, myocardial infarction (MI), and other medical complications in this operative cohort. Esfahani et al. demonstrated a low incidence of medical complications for neurosurgeons and orthopaedic surgeons with rates of 0.3% UTI, 0.2% PE, 0.2% DVT, and 0.2% and 0.1% pneumonia, respectively, for 30-day complication rates between specialties of 7464 patients who underwent lumbar discectomy [6]. Pugely et al. found similarly low incidence of medical complications in their comparative study of 30 day complications of discectomy in the inpatient and outpatient setting of 4310 patients taken from the NSQIP database. In the inpatient setting, they measured a 0.45% rate of DVT, 0.34% PE, 0.19% pneumonia, 0.04% stroke, and 0.11% myocardial infarction (MI). In the outpatient setting, there was a 0.18% rate of DVT, 0.06% PE, 0.12% pneumonia, with no strokes or MI. There was a statistically significant higher rate of urinary tract infection (UTI) (1.2 vs 0.3%) and blood transfusions (0.75 vs 0.12%) in the matched inpatient cohort compared to the outpatient. Although the mortality rate of discectomy is vanishingly rare, there was a 0.04% inpatient and 0.06% outpatient mortality rate in the Pugely study within 30 days of discectomy [7] and 0.1% mortality rate among the neurosurgery cohort in the Esfahani study [6].

Infection

Wound complications such as superficial or deep infection are also rare following lumbar discectomy. Pugely et al. found overall wound complications of 1.88% in the inpatient setting and 1.21% in the outpatient setting [7]. There does appear to be an advantage to outpatient discectomy with regard to deep wound infection rates within the study. The incidence of deep wound infection was statistically lower in the outpatient setting with rate 0.18% compared to rate of 0.6% in the inpatient setting. There was no statistical difference in superficial infections between the two groups, with rates of 0.98% inpatient and 0.85% outpatient respectively. Perhaps hospital colonization or need for hospitalization due to medical comorbidity is responsible for that small increase in risk of deep infections. In 7464 patients sampled from the NSQIP data base, Esfahani et al. found overall wound complications rates of 1.1% for both neurosurgeons and orthopaedic surgeons [6]. Infection rates were 0.6% superficial and 0.2% deep for neurosurgeons and 0.5% superficial and 0.4% deep for orthopaedic surgeons. There was no statistical difference between the specialties. Shriver et al. found wound complications rates of 2.1% for open discectomy and 1.2% for MED without further definition of complications type [5]. Hamdan et al. reported on 35 patients with disc space infections following discectomy over a ten year period [8]. The authors found an incidence of 2.2%. Twenty-nine patients (82.9%) were treated with operative debridement, and all patients recovered fully by nine months.

Durotomy

Incidental dural tear is the most common intra-operative complication of discectomy. The reported incidence of incidental dural tear in primary discectomy varies from 1.3 to 3.5% [9–13]. Tears should generally be repaired immediately with suture or fibrin glue. Dural tear carries a risk of fistula, meningitis, arachnoiditis, or epidural abscess. Dural tear, even with repair, may lead to poorer outcomes. In ten year follow up of microdiscectomy patients with incidental durotomy, Saxler et al. demonstrated functional limitations due to back pain, increased rates of reoperation, and longer time to return to work [9]. Others have not found any long-term differences in outcome. In the SPORT cohort, Desai et al. did not find any outcome differences in the 3.1% of 799 patients with an intra-operative dural tear that underwent a first time discectomy [12]. They did, however, demonstrate significant differences in operative times (139 vs 74.7 minutes), increased blood loss (288.8 vs 57.4 ml), and longer hospital stay (2.5 vs 0.9 days) in patients that had durotomy. Revision microdiscectomy is a known risk factor for intra-operative dural tear. Inada et al. found in their retrospective

review of 382 patients who underwent microdiscectomy, that the rate of dural tear was significantly higher in revision surgeries at 16.7% vs primary microdiscectomy at 1.3% [10]. In a study of the Swedish Spine Register, Stromqvist et al. showed that revision microdiscectomy nearly doubled the durotomy risk from 2.7% in primary disc surgery to 5% in revision surgery [11]. In a multi-centre study in the UK, Tafazal et al. found a 13.2% rate of dural tear among 106 revision microdiscectomies [13].

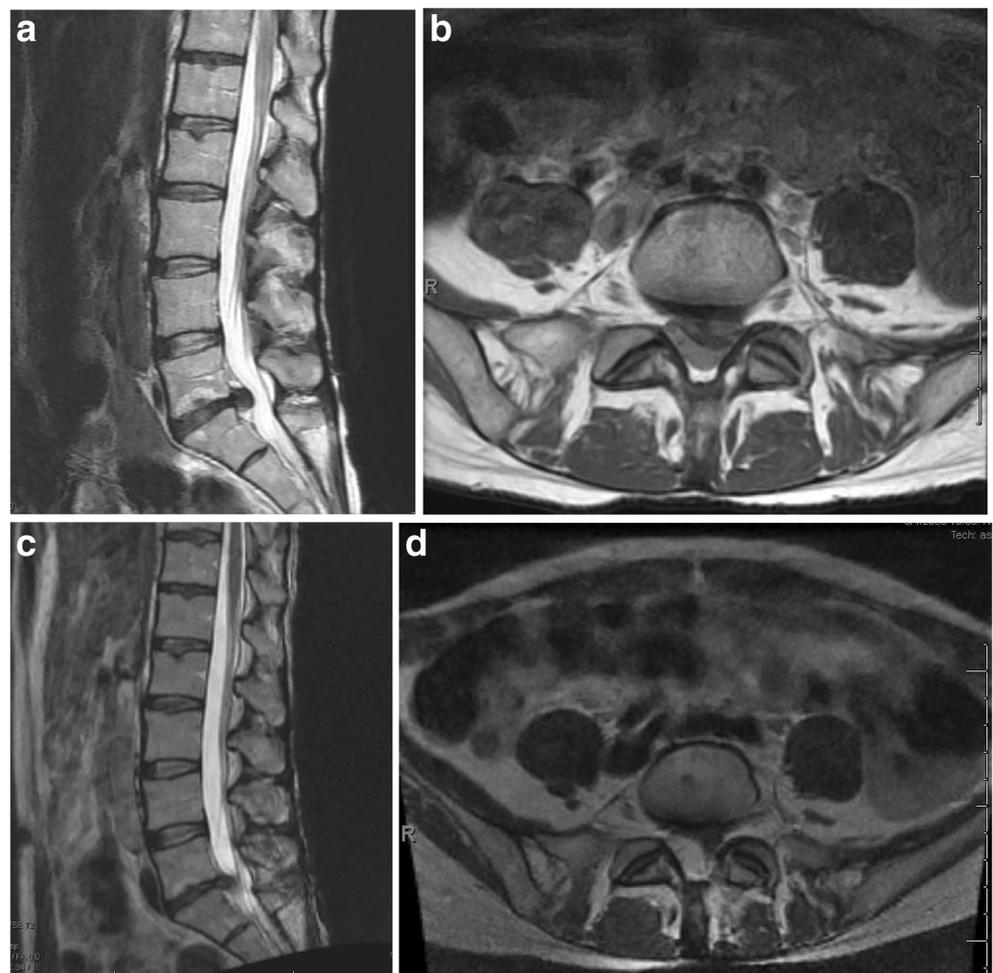
Nerve injury

Nerve injury is an uncommon complication following lumbar discectomy. In a meta-analysis of 19 studies, Shirver et al. found nerve injury rates of 2.6% for open discectomy, 0.9% for MED, and 1.1% for percutaneous techniques [5]. In their RCT of annular closure device for discectomy, Thome et al. experienced only one nerve root injury associated with implantation of the device [14]. Pugely et al. found an overall 0.15% peripheral nerve injury rate in their inpatient cohort, with no injuries in their outpatient cohort [7].

Re-herniation

The incidence of post-operative recurrent LDH following discectomy varies widely in the reported literature, from as low as 1% to as high as 25% (Fig. 1) [15, 16]. There are multiple risk factors that contribute to the prevalence of recurrent disc herniations. In a multi-centre cohort, McGirt et al. performed post-operative imaging on patients following lumbar discectomy [17]. They found an overall rate of symptomatic re-herniation of 10.2%. Factors associated with symptomatic re-herniation requiring surgery included a greater residual mean annular defect (46 ± 18 vs 32 ± 14 mm²) and lower percentage of disc volume removed (13 vs 28%). The researchers found that annular defect greater than 54 mm² showed an 18% incidence of re-herniation. There was a 12% incidence of asymptomatic disc re-herniation that did not require additional surgery. Carragee et al. characterized herniations by annular defect and morphology based on intra-operative findings [18]. They classified disc herniations into four categories. Type 1 are free fragments with a fissure in the annulus fibrosus, type 2 are free fragments with a defect in the annulus fibrosus, type 3 are contained fragments without an annular tear, and type 4 are contained, without a free fragment. The

Fig. 1 **a, b** 50F with large left-sided paracentral disc herniation with effacement of the thecal sac and compression of the S1 nerve root. She had a significant left lower extremity radiculopathy. She was treated with left minimally invasive hemi-laminotomy and microdiscectomy with resolution of her symptoms at her first post-operative visit. **c, d** Left-side paracentral disc herniation in the same patient 2 years after initial microdiscectomy. There is S1 nerve root displacement and thecal sac effacement, with left leg radiculopathy. She desired conservative management and was treated with epidural injections and time with eventual resolution and excellent clinical outcome



overall re-herniation rate for all groups was 8.9%. However, for the group with a type 1 fissure group, the rate was 1.1%, for the type 2 defect, the rate was 27.3%, for the type 3 contained group 9.5%, and for type 4 no fragment group, the rate was 12.5%. A notable clinical finding in this study was the high rate of recurrent or persistent sciatica in the type 4 no fragment group (37.5%) despite a low rate of documented re-herniation (12.5%). Wera et al. reported on 259 disc herniations treated with subtotal discectomy [19]. They had overall lower rates of reoperation for each Carragee type than in the original study. For Carragee type 1 herniations, the reoperation rate was 1.6% (versus 1.1% in Carragee's paper), the rate was 3.3% (versus 21.2%) in type 2, 9.6% (versus 4.8%) in type 3, and 4.6% (versus 6.3%) in type 4. Their data suggest that more aggressive discectomy in patients with a large annular defect discovered at surgery may be protective against re-herniation. Aggressive discectomy is not without consequence, as Watters et al. demonstrated a 19–36% increase in low back pain [20]. Given the association of large annular defect with increased risk of re-herniation, annular closure devices (ACDs) have been developed to prevent recurrence while allowing for a more limited discectomy. Thome et al. performed RCT in patients with an annular defect greater than 6 mm undergoing lumbar discectomy. [14] Patient who received ACD had

statistically significant lower rate of symptomatic re-herniation (12 vs 25%) in 550 patients followed over two years. Carragee et al. found rates of symptomatic re-herniation of 27% in patients with annular defects greater than 6 mm [18], indicating that ACD may have a role for patients with significant annular defects during discectomy. Other factors associated with recurrent herniation include the presence of lumbosacral transitional vertebrae (LSTV) and hypermobility of the affected segment. Shin et al. reported on a series of 119 patients following discectomy at L4–L5 [21]. The authors found that 52.4% of the 21 patients with recurrent disc herniation had LSTV in their series. In addition, mean sagittal range of motion on flexion-extension radiographs was 11.68 ± 4.24 degrees in patients with recurrent herniation compared to 9.04 ± 3.65 degrees in patients without recurrence.

Reoperation

Meta-analysis found 7.1% mean (4.8%–10.1%) reoperation rates for lumbar disc herniation after open discectomy and mean 3.7% reoperation (2.1–6.2%) for MED with variable lengths of follow up [5]. There have been several studies with large patient

Fig. 2 a, b Axial and sagittal images of a 20-year-old male with a large central L5-S1 disc herniation. There is thecal sac effacement and displacement of the bilateral S1 nerve roots. He had predominantly right-sided radiculopathy. He was treated with bilateral hemi-laminotomy and microdiscectomy with resolution of symptoms at 1 month post-operative. c, d Axially and sagittal images of same patient 8 years after the index procedure with recurrent disc extrusion at the L5-S1 space with left-sided S1 nerve root displacement. He developed resultant left-sided radiculopathy. He was treated with revision L5-S1 microdiscectomy with satisfactory clinical results at 1 month post-operative



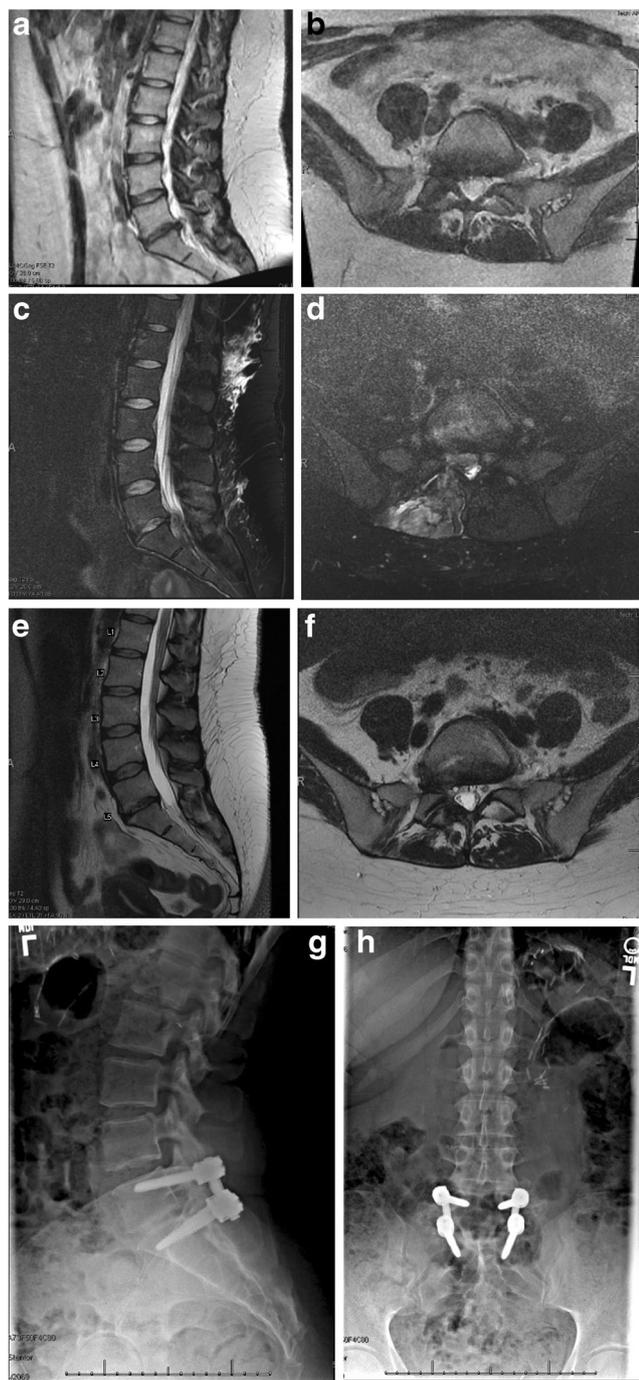


Fig. 3 **a, b** Thirty-six-year-old female with severe right lower extremity radiculopathy and L5-S1 disc herniation that extends from paracentral to posterolateral foramen. She has compression of both the descending S1 nerve root and the exiting L5 nerve root on the left side. She underwent right-sided hemi-laminotomy and microdiscectomy. She had excellent resolution of leg pain at 4 weeks post-operative. **c, d** At 6 weeks, the patient bent over to pick up an object and had return of radicular symptoms. MRI demonstrated a massive recurrent herniation. She underwent revision L5-S1 microdiscectomy with satisfactory clinical results at 4 weeks post-operative. **e, f** Two years after revision L5-S1 microdiscectomy, the patient presented again with right-sided radiculopathy. MRI showed repeat lateral foraminal disc herniation with L5 and S1 nerve root compression. **g, h** The patient underwent uncomplicated L5-S1 TLIF. She had resolution of her right-sided radicular pain following the surgery and excellent clinical result

follow up of 6274 patients from the database, there was a 12.2% reoperation rate at four years. In the same study, 38.4% of patients that underwent re-exploration discectomy within two years of the index procedure went on to eventually require a lumbar fusion. Kim et al. analyzed the Korean national health insurance database for 47,316 patients who underwent surgery for LDH [24]. They included all modalities, including microdiscectomy, MED, nucleolysis, laminectomy, and fusion. There was overall reoperation rate of 13.9%. Microdiscectomy had reoperation rate of 13.8% and MED had reoperation rate of 12.4% at five years. There is some controversy regarding the optimal operative intervention following re-herniation. For many, revision discectomy is the treatment of choice for recurrent herniations (Fig. 2). Papadopoulos et al. found equivalent outcomes for leg and buttock numbness or pain in 26 patients undergoing revision discectomy for re-herniation when compared to 30 matched controls [25]. In a ten year follow up study of 51 patients following revision discectomy for recurrent disc herniation, Guo et al. found good to excellent results in 36 patient (70.6%) [26]. They found that increased length of symptoms after the primary surgery, a history of an injury and the presence of fibrosis or scar were associated with failure (defined as fair to poor results) after reoperation. Fusion surgery can provide definitive treatment for recurrent disc herniation (Fig. 3). Chen et al. reported 86.1% excellent to good results in 43 patients who underwent transforaminal lumbar interbody fusion (TLIF) for recurrent disc herniation [27]. Gillard et al. sought to determine whether less invasive spine surgery (LISS) procedures affect fusions rates in TLIF following failed disc surgery [28]. The authors could not find any difference in fusions rates when comparing those who had LISS to matched open controls.

populations that investigate the rate of reoperation after lumbar discectomy with follow up greater than four years. Keskimäki et al. examined 25,359 patients in the Finnish Hospital Discharge Register for rates of reoperation after lumbar discectomy [22]. They found a rate of 12.3% reoperations at 4.1 years with 18.9% probability for reoperation by Kaplan-Meier method at nine years. In a Level III retrospective study analyzing a national insurance database of 13,654 patient records, Heindel et al found a reoperation rate of 3.95% at three months after single-level discectomy [23]. In longer-term

Conclusion

Lumbar discectomy for LDH is an established and effective treatment for symptomatic patient that have failed conservative treatment. With knowledge of the evidence-based incidence of complications, the spine surgeon can provide patients

with current information for the purposes of effective shared decision-making.

Compliance with ethical standards

Conflict of interest Eric Klineberg MD declares personal fees from Depuy Synthes, personal fees from Stryker, personal fees from K2M, personal fees from Springer, personal fees from Trevena, personal fees from Allosource, grants and personal fees from AO Spine, personal fees from Medicea, outside of the submitted work.

Robert Harper MD declares that he has no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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