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ORIGINAL PAPER

Persistent radiculopathy after surgical treatment for lumbar disc herniation: causes and treatment options

Ashley Rogerson[1] · Jessica Aidlen[2] · Louis G. Jenis[2,3]

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Abstract

Purpose Lumbar disc surgery is a common procedure in the USA. It is frequently performed with good or excellent results in most patients. This article reviews common causes of persistent radiculopathy after surgical intervention.

Methods We performed an extensive review of the literature as well as applying our own experience.

Results Common causes of persistent leg pain following operative intervention include re-herniation, epidural fibrosis, biochemical/physiologic changes in the nerve root, and psychosocial issues.

Conclusions Patients with persistent leg pain after surgical treatment of lumbar disc herniation can pose a challenging clinical problem. Summary of these topics and available treatment options are reviewed.

Keywords Chronic radiculopathy · Lumbar disc herniation · Prevalence

Introduction

Lumbar radiculopathy, or "sciatica," is commonly caused by lumbar disc herniation. Lifetime prevalence of low back pain associated with sciatica is roughly 10%. Fortunately, the majority of cases are short-lived and studies have shown only 1.6% lifetime prevalence of sciatica lasting greater than two weeks [1, 2]. The majority of lumbar disc herniations involve the L4–5 or L5–S1 levels [3, 4]. Despite the favourable natural history of lumbar radiculopathy or sciatica due to lumbar disc herniation, lumbar discectomy is still a commonly performed procedure with roughly 180,000–200,000 cases performed annually in the USA [5–7]. In the absence of cauda equina syndrome or progressive neurologic deficit, the majority of lumbar disc surgery is performed on an elective basis when leg pain persists despite at least six weeks of non-operative treatment.

Success rate of lumbar disc surgery has been quoted as high as 92–98% in some studies [8]. Patients treated surgically tend to have better functional outcomes and pain scores in the short-term, but by two to four year follow-up, statistical significance is lost and results of operative and non-operative treatment are equivalent [3, 9]. Other studies have shown higher failure rates after operative intervention. Kayaooglu et al. [10] found an 11.8% re-operation rate in their series of 715 patients. A meta-analysis by McGirt et al. [11] showed a 14% incidence of short-term return of back or leg pain following lumbar disc surgery. Seven- to 20-year follow-up showed satisfactory results in only 64% of patients in one study [12]. Poor outcome following lumbar disc surgery can fall into two categories: (1) a failure to relieve symptoms starting in the immediate post-operative period or (2) a recurrence of sciatica/radiculopathy after a pain-free interval. Causes for immediate failure are numerous and include operation at the wrong level, inadequate decompression, unrecognized segmental instability, retained extruded/sequestered disc fragment, extraforaminal nerve compression, and polyneuropathy [13]. In this article, we will review the common causes of *recurrent* leg pain following lumbar disc surgery along with current available treatment options.

✉ Louis G. Jenis
ljenis@partners.org

[1] Department of Orthopaedic Surgery, Tufts Medical Center, Boston, MA 02111, USA

[2] Department of Orthopedic Surgery, Division of Spine Surgery, Newton Wellesley Hospital, Newton, MA 02462, USA

[3] Newton Wellesley Hospital, 2014 Washington Street, Newton, MA 02458, USA

Recurrent disc herniation

Recurrent disc herniation is defined as a disc herniation occurring at the same level, either contralateral or ipsilateral side, following a pain-free interval of at least six months post-operatively [14]. Studies have shown about a 5–20% incidence of recurrent herniation [13–15]. Multiple studies have looked into patient factors associated with recurrent lumbar disc herniation and the findings have been consistent throughout multiple studies. Clinical risk factors for recurrent herniation include male sex, younger age, active smoking, and occupational lifting [11, 16, 17].

Carragee et al. [17] found that annular competence and type of herniated disc fragment were related to outcome. Patients with a large annular defect were more likely to have a re-herniation (27%) and re-operation (21%), while patients with no annular defect and no extruded fragment were more likely to have persistent sciatica (38%). Suk et al. also found a higher rate of re-herniation following an index operation for a contained disc which required iatrogenic annulotomy in order to remove the disc fragment [13]. A recent study by Li et al. [16] showed that preservation of disc height, more sagittal facet joint orientation, and facet tropism may be biomechanical risk factors associated with recurrent disc herniation.

With a consistent re-herniation rate of 5–20% in the literature, surgeons have tried altering their surgical technique to prevent future re-herniation. O'Connell et al. [18] first described the technique for aggressive discectomy by removing the herniated fragment with subsequent curettage of the remaining disc. This technique differs from a limited discectomy which involves removing only the herniated fragment with little violation of the disc space [18]. In an extensive literature review and meta-analysis of 54 studies by McGirt et al. [11], the authors found that patients undergoing aggressive discectomy had higher rates of back pain in long-term follow-up but fewer episodes of recurrent herniation compared to limited discectomy. Though there is no standardized surgical technique, more aggressive discectomy essentially amplifies degeneration of the disc and disc space collapse to whatever degree the native disc is removed. This can result in chronic low back pain due to degenerative disc disease (DDD) and facet arthropathy, and may also result in symptomatic foraminal or lateral recess stenosis. Currently, there is no consensus on aggressive versus limited discectomy, and it is up to the surgeon's discretion to determine how much disc material to remove.

There are clear clinical and anatomic risk factors (i.e., annular incompetence) for re-herniation demonstrated in the literature. Careful review of the MRI pre-operatively and open discussion about the intraoperative findings may help mitigate patient expectations and guide post-operative activity restrictions. Two studies by Carragee et al. [19, 20] recommended that most patients do not need any post-operative activity restrictions following lumbar discectomy. The re-operation rate and recurrent herniation rate were 5.3% and 11.2%, respectively, which is similar to the rates previously quoted in the literature [20]. However, in some cases of re-herniation, a patient can recall a specific trauma, i.e., heavy lifting, which precipitated the recurrent herniation [17]. If patients are found to have a large annular tear, either iatrogenic or de novo from the disc herniation, limiting activities that increase the risk of re-herniation, i.e., heaving lifting, twisting, or contact sports, may help decrease the chance of re-herniation.

Little information exists regarding acute re-herniation less than six months after index procedure. It is the authors' opinion that acute re-herniation is best addressed by early revision discectomy prior to formation and maturation of epidural fibrosis which may make revision surgery more difficult and increase risk of incidental durotomy or nerve root injury.

When a re-herniation does occur, the results of a secondary disc surgery, or revision discectomy, have been shown to have similar success rates [10, 13]. Operative time for revision surgery was found to be significantly longer than the index procedure (88.9 versus 66.8 min) in a study by Suk et al. [13]. Recognizing both patient risk factors and intra-operative findings such as large annular defects can help counsel patients about their individual risk of re-herniation.

Epidural fibrosis

Epidural fibrosis is thought to occur to some extent after every laminectomy procedure, usually between six weeks and six months post-operatively [21]. Scarring around the thecal sac and nerve roots following lumbar disc surgery can tether the nerve root, thus eliciting a pain response during everyday activities. Epidural fibrosis can be differentiated from recurrent disc herniation by utilizing MRI with gadolinium contrast [22, 23]. Epidural fibrosis appears hypo- or isointense on T1-weighted sequences with immediate, homogenous enhancement upon contrast administration. Fibrosis will also appear hyperintense on T2-weighted sequences relative to the intensity of the intact annulus. Prolapsed or extruded disc fragments are hypo- or isointense in comparison to the intact annulus on all sequences. Occasionally, a recurrent herniation will demonstrate early peripheral enhancement after contrast administration [13, 22–24].

Nucleus pulposus contains a high concentration of phospholipase A2 (PLA2), which is a pro-inflammatory molecule that activates the arachidonic acid cascade and is thought to be involved scar tissue formation. Lumbar disc surgery itself may increase exposure of the nerve root to PLA2 by incising the annulus and removing nucleus pulposus material. The inflammatory cascade will persist even after the offending disc has been surgically removed, promoting scar formation [21].

The role of epidural fibrosis as a post-operative pain generator is debated in the literature. Ross et al. [25] showed that

patients with extensive peridural scar were 3.2 times more likely to experience recurrence of radiculopathy. Other studies have not found similar results [26, 27]. Re-operation for epidural fibrosis is generally ineffective unless there is also a mechanical compression on the symptomatic nerve root [27]. As previously stated, the best results of revision surgery have been seen in cases of recurrent disc herniation [10, 13]. When the surgical findings showed epidural fibrosis alone, good or excellent results were only seen in 42% of patients compared to 82.4% in the re-herniation patients [10, 13].

Treatment efforts for epidural fibrosis have mainly involved prevention of scar formation. Techniques to decrease epidural fibrosis formation, such as application of free fat grafts, synthetic grafts (i.e., Dacron, silastic membrane), and intra-operative topical steroids have all been studied in both humans and animals with mixed results [21]. Ensuring proper haemostasis prior to wound closure is thought to decrease epidural fibrosis [28, 29]. Medical treatment options for chronic nerve root-mediated leg pain will be discussed in the following section.

Biochemical changes in the lumbar nerve root

Early studies showed consistent histologic changes in spinal nerve roots after operatively treated cases of sciatica due to lumbar disc herniation. Lindahl and Rexed [30] found histologic evidence of perineural hyperplasia and inflammatory reaction in the biopsied nerve roots at the time of surgery. This was among the first studies demonstrating histologic changes within the nerve root associated with radiculopathy due to disc herniation, suggesting that radicular pain due to disc herniation is due to more than just a mechanical compression of the nerve root. It is now commonly accepted that radiculopathy or sciatica due to lumbar disc herniation is caused by two underlying mechanisms: direct mechanical compression of the nerve root by the herniated disc material and biochemical irritation from the nucleus pulposus resulting in a change in the normal physiology, or "sensitization" of the nerve root [31].

Kayama et al. [24] demonstrated a significantly decreased nerve conduction velocity after lumbar disc incision in a canine model. Histologic analysis of the nerve roots eight weeks later also showed evidence of increased size and density of capillaries in the nerve roots adjacent to the incised discs. This study suggests that in complete absence of mechanical compression, introduction of nucleus pulposus material alone may cause symptoms of sciatica [24]. Additional animal studies have shown marked decrease in pain/thermal stimulation thresholds as well as inflammatory changes within the nerve root with exposure to nucleus pulposus [31–33]. Interleukins, nitric oxide, TNF alpha, and matrix metalloproteinases have all been implicated in sensitizing the nerve root when exposed to nucleus pulposus [34–36].

Regardless of whether a patient undergoes operative treatment for lumbar disc herniation, persistent leg pain can occur as a result of neural and neurovascular compression [37]. This can lead to chronic neuropathic pain. If subsequent MRI does not demonstrate re-current disc herniation or perineural fibrosis, then persistent sciatica or radiculopathy may be a result of chronic physiologic changes and demyelination of the nerve root. These changes in nerve root structure and function can evoke spontaneous discharges from the dorsal root ganglion resulting in persistent leg pain [38, 39].

Without evidence of mechanical compression of a nerve root, revision lumbar disc surgery is not a first-line treatment option [27]. In some cases of chronic radiculopathy following lumbar disc herniation, it is difficult to differentiate the cause of persistent leg pain as it may be due to structural changes in the nerve root, chronic inflammation or radiculitis, formation of epidural fibrosis, or some combination of these factors. The efficacy of lumbar epidural steroid injections (LESI) as a treatment for acute cases of radiculopathy due to lumbar disc herniation and radiculitis has been well studied [40–44]. Transforaminal epidural injections are used to target a specific nerve root, whereas interlaminar injections will diffuse within the epidural space to affect multiple nerve roots. Commonly, these injections are a solution of local anaesthetic and steroid. LESI have been shown to significantly decrease leg pain compared to placebo or local anaesthetic alone; however, in most studies, these effects are short-lived and focused on acute cases of radiculopathy [8, 40–44]. A study by Manchikanti et al. [44] looked at patients with 6 or more months of low back and extremity pain due to disc herniation without previous lumbar surgery. Eighty-six percent of patients receiving LESI achieved improvement in pain and functional status; however, they required on average four injections per year [44]. Despite the lack of abundant research into use of LESI for cases of chronic leg pain, this procedure can potentially serve both diagnostic and therapeutic purposes in persistent leg pain after LDH. It is important to counsel patients that one LESI will not likely be a permanent solution for their leg pain and that they may require multiple injections.

In addition to epidural injections, medical management is a treatment option for chronic radiculitis. Gabapentin (Neurontin) and pregabalin (Lyrica) are two widely used medications for treatment of neuropathic pain. Dolgun et al. [37] found that early administration of either gabapentin or pregabalin for acute postoperative neuropathic pain was beneficial in preventing conversion to chronic pain at one year follow up.

Psychosocial aspects of failed back surgery syndrome

Failed back surgery syndrome (FBSS) has been a topic of debate and research for decades. The cause of poor outcome after

lumbar disc surgery is often multifactorial. There is not always a clear correlation between the degree of clinical symptoms and radiographic findings. Psychosocial issues, organic causes (i.e., re-herniation), surgical indications, and surgical technique can all potentially contribute to persistent back or leg pain. The Minnesota Multiphasic Personality Inventory (MMPI), a tool widely used by psychologists who work with chronic pain patients, has been widely used in the study of FBSS. Multiple studies have shown that certain aspects of the MMPI, specifically depression, hysteria, and hypochondriasis, are correlated with fair or poor results following lumbar surgery [45, 46]. Herron [45] used the MMPI to show that the psychological profile of a patient is not static, and there may be changes with response to chronic pain. In his study, patients with a poor surgical result had an increase in depression, hysteria, and hypochondriasis on MMPI [45]. Coskun et al. [26] looked at the relationship of epidural fibrosis, disability, and psychological factors as factors that influence pain after lumbar disc surgery. They used the MMPI to assess personality characteristics of patients who underwent lumbar disc surgery. The authors did not find a relationship between the degree of epidural fibrosis and poor surgical outcome. They did find a positive correlation between certain portions of the pre-op MMPI and poor surgical outcome, specifically in patients who scored high on hypochondriasis, hysteria, conversion, and somatization [26]. Work by Hasenbring et al. [47] found that a combination of somatic, psychological, and social parameters should be used to best predict the intensity of pain following lumbar disc surgery at multiple post-operative intervals; again indicating that surgical outcome is multifactorial [47].

Lumbar disc herniation is a common diagnosis among Worker's Compensation claims [48–50]. Compared to the general population, lumbar disc surgery in the Worker's Compensation population has been shown to be less successful with regard to both clinical outcome and time to return to work [48–50].

Psychosocial issues and secondary gain cannot be overlooked when managing patients with persistent radiculopathy after lumbar disc surgery. Optimal management of these patients has yet to be determined. Clear indications and goals of surgery should always be discussed with patients and documented prior to going forward with an operation.

Conclusion

It is important for spine surgeons to carefully scrutinize all pre-operative imaging, including advanced studies such as MRI or CT myelogram in addition to dynamic radiographs, to identify all potential sites of nerve root compression and to recognize segmental instability. Confirmation of appropriate operative level with intra-operative fluoroscopy and meticulous decompression by identifying and removing sequestered disc fragments and performing a partial medial facetectomy if necessary will optimize the patient for a good surgical outcome after the index procedure.

If leg pain recurs post-operatively, the surgeon must consider the timing and progression of the patient's symptoms. If there is a pain-free interval for several weeks or months post-operatively, then the most likely cause of leg pain is a recurrent disc herniation. Proper diagnosis of the underlying pathology is important prior to proceeding with treatment. MRI with gadolinium should be obtained to evaluate for recurrent herniation or epidural fibrosis. Re-herniations have a favourable outcome with revision surgery. ESI and medical treatment are treatment options for epidural fibrosis or chronic radiculitis. It is important to conduct a thorough review and have an understanding of any psychosocial factors that may be contributing to chronic or recurrent pain symptoms. Multidisciplinary pain management programs can be beneficial for patients with recurrent leg pain, especially if there is no clear indication for revision surgery.

Compliance with ethical standards

Conflict of interest The authors declare that they have 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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