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REVIEW ARTICLE

Current concepts for lumbar disc herniation

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Abstract

Purpose To present the pathophysiology, biology, clinical presentation, diagnosis, and current treatment options for lumbar disc herniation.

Methods A thorough literature search was undertaken in PubMed and Google Scholar to summarize the current knowledge and future perspectives on lumbar disc herniation.

Results Several changes in the biology of the intervertebral disc are thought to contribute to disc herniation; nevertheless, the exact inciting event leading to disc herniation is yet to be discovered. Non-operative treatments have stood the test of time as the first-line treatment for most patients with lumbar disc herniation; however, operative treatment remains the current gold standard, with minimally invasive endoscopic microdiscectomy techniques showing best results with respect to postoperative pain and function.

Conclusions The exact event leading to disc herniation remains unclear. Non-operative treatments should be the first-line treatment for most patients with lumbar disc herniation. Operative treatment remains the current gold standard, with minimally invasive endoscopic microdiscectomy techniques showing best results with respect to postoperative pain and function. Regenerative medicine is promising.

Keywords Intervertebral disc · Lumbar spine · Disc herniation · Disc diseases

Introduction

Low back pain is extremely common, being experienced by approximately 70% of people at some point in their life [1]. Sciatica (low back-related leg pain) is one of the commonest variations of low back pain; approximately 5% of males and 2.5% of females will experience sciatica at some time in their lifetime [2]. Nonetheless, low back pain and sciatica represent symptoms rather than specific diagnoses, and within the vast differential, the most common source is intervertebral degeneration leading to degenerative disc disease and lumbar disc herniation [2, 3].

Lumbar disc herniation with the presence of sciatica represents a historically well-known disease. The process of understanding it has been rather long, passing from the beliefs of early societies that supernatural demonic forces would vex individuals with crippling pain, to the more naturalistic and critical view of the ancient Greeks (Hippocrates) and Egyptians who suspected a relationship between lumbar spinal pathology and leg symptoms, up to the early twentieth century, where the concept of disc herniation was introduced by Georg Schmorl [4]. Currently, according to the recommendations of the combined task forces of the North American Spine Society, the American Society of Spine Radiology and the American Society of Neuroradiology, "herniated disc" is the best general term to denote displacement of disc material and localized displacement of nucleus, cartilage, fragmented apophyseal bone, or fragmented annular tissue beyond the intervertebral disc space [5].

Pathophysiology

The nucleus pulposus (NP; the inner element of disc) is a site of collagen secretion and contains numerous proteoglycans (PG) that facilitate water retention, creating hydrostatic pressure to resist axial compression of the spine; it is primarily

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composed of type II collagen that accounts for 20% of its overall dry weight. In contrast, low amount of PG are found in the annulus fibrosus (AF: the outer element of disc) that is composed of primarily concentric type I collagen fibres, accounting for 70% of its dry weight [6–9]. When compressive forces are applied across the disc space, the pressure within NP is increased, leading to a more flatten-shaped nucleus that pushes against the circumferential positioned annular fibers and places them under tension. In this setting, the AF disperses stresses and maintains the NP within the center of the disc [10]. If the AF is disorganized, the soft nucleus can be pushed through and becomes herniated [11]. To be considered herniated, disc material must be displaced from its normal location and not simply represent an acquired growth beyond the edges of the apophyses, as is the case when connective tissues develop in gaps between osteophytes or when annular tissue is displaced behind one vertebra as an adaptation to subluxation. Herniation, therefore, can only occur in association with disruption of the normal AF or, as in the case of intravertebral herniation (Schmorl node), a defect in the vertebral body end plate [5]. Afterwards, the disc may be "protruded," "extruded," "sequestrated," or even "migrated".

Disc protrusion is present if the greatest dimension between the edges of the disc material presenting beyond the disc space is less than the distance between the edges of the base of that disc material that extends outside the disc space. The base is defined as the width of the disc material at the outer margin of the disc space of origin, where disc material displaced beyond the disc space is continuous with the disc material within the disc space. Disc extrusion is present when, in at least one plane, any one distance between the edges of the disc material beyond the disc space is greater than the distance between the edges of the base of the disc material beyond the disc space. Disc sequestration is a subtype of extrusion where no continuity exists between the disc material beyond the disc space and that within the disc space. Disc migration is extruded disc material that is displaced away from the site of extrusion, regardless of continuity with the disc [5]. For disc herniation to occur, the nucleus must be fluid enough or "dynamic". Therefore, older individuals with dehydrated discs are less prone to herniation, whereas younger patients that have a well-hydrated nucleus are more likely to herniate [11].

Biology

Several changes in the biology of the intervertebral disc are thought to contribute to disc herniation, nevertheless the exact inciting event leading to disc herniation is yet to be discovered [11]. Some authors believe that an acute traumatic episode leads to displacement of the disc, although this is most likely related to force imparted onto a previously degenerated disc that has developed a focal AF weakness [11]. However, the traumatic cause of disc herniation has been questioned scientifically, particularly with the increased availability of genetic information [12]. Degenerative changes that weaken the AF facilitate herniation of NP material; these changes can result from reduced water retention in the NP [8, 13, 14], increased percent of type I collagen in the NP and inner AF [15], degradation of collagen and extracellular matrix (ECM) materials [16], and upregulation of systems of degradation such as apoptosis, matrix metalloproteinase (MMP) expression, and inflammatory pathways [6, 17]. A recent pilot study showed that there is a linear direct correlation between the expression of aquaporin-1 (AQP1; transmembrane protein responsible largely for water molecule transport across the membrane) and the T2 signal intensity in patients' MRIs, thus implying that a decreased AQP1 expression leads to decreased water content in the intervertebral discs [18].

A field of ongoing research is the single-nucleotide polymorphisms that are associated with intervertebral disc degeneration. It is hypothesized that up to 74% of disc degeneration is due to genetic factors [17], and a plethora of genes encoding structural proteins (collagen I, IX, and XI), structural support proteins (vitamin D receptors), cytokines (interleukin-1a and interleukin-6), matrix metalloproteinases (MMP-1, MMP-2, MMP-3, MMP-9, MMP-14), apoptotic factors (tumour necrosis factor [TNF]-related apoptosis-inducing ligand and caspase-9), growth factors (growth differentiation factor 5), and pain mediators (cyclooxygenase 2) have been found to contribute in the aetiology of disc degeneration and herniation [17].

Nonetheless, disc herniation does not arise only in aged or degenerated discs; the cases of disc herniation that cannot be attributed to degeneration can be attributed to spinal overloading [6]. Specifically, it has been implied that in some patients a more focal degenerative process in the AF along with a relatively healthy state of the NP, can lead to fissuring of the AF and extrusion of the pressurized NP tissue [19, 20]. Recent scientific evidence from caprine lumbar spines showed that prolonged static axial overloading primes the lumbar intervertebral disc for posterolateral herniation that may be the basis of low back pain and herniation in people leading a sedentary and sitting life style [20].

The idea of low-grade bacterial infection leading to disc degeneration and herniation may sound new, however, it has been introduced almost two decades ago [21]. Although previous investigators have attributed the presence of microorganisms in intraoperative disc specimens to contamination rather than true infection [22–24], the presence of bacteria in discs has been confirmed; reports showed the presence of bacteria ranging from 13.5 to 45% of disc material obtained from surgery [21, 25–29]. Coscia et al. [28] reported a significant association of disc herniation with bacterial outgrowth; in 169 intra-operative disc specimens they found that 20% of discs were positive for *P. acnes* (45% of cultured discs), and 18% of discs were positive for coagulase-negative

Staphylococcus (40% of cultured discs). Similarly, a recent systematic review showed that the median percentage of culture positive spinal disc material samples was 22%, with a pooled estimate of the proportion with positive culture being 34%; *P. acnes* was also the most prevalent microorganism (45% of cultured discs) followed by coagulase-negative staphylococci (14% of positive cultures) [30]. The study however, identified moderate evidence for a relationship between bacterial presence and low back pain or disc herniation, and modest evidence for causation, while no differentiation was found between contamination and infection [30]. Therefore, the question contamination or infection of discs has to be answered, in addition to the clarification of the exact mechanism by which *P. acnes* induces disc degeneration, herniation, or Modic changes.

Disc inflammation leads to disc degeneration or herniation by local chronic inflammation and production of inflammatory factors. Recently, Yuan et al. [31], quantified a series of cytokines and neutrophils in *P. acnes*-positive and bacteria-free disc specimens. They showed that latent infection of *P. acnes* was associated with chronic inflammation in degenerated intervertebral discs, as increased levels of cytokines and accumulation of neutrophils were evident in *P. acnes*-positive discs, especially in the samples that showed visible bacteria in histology [31]. Moreover, the significantly increased levels of cytokines were more indicative of the original growth of *P. acnes* in degenerated intervertebral discs rather than contamination [31]. Rajasekaran et al. [32] used proteomics (LC–MS/MS) to identify even at femtomole levels proteins that reflect bacterial presence as well as dynamic host defense responses, and 16S rDNA analyses (PCR) to authenticate presence of bacteria in the discs. PCR confirmed the presence of *P. acnes* in 18 of 22 disc samples, while LC–MS/MS identified molecules (host defense response proteins) that are expressed only during host–pathogen reaction. The authors concluded a highly compelling evidence for the tissue having infection [32], and proposed a hypothesis, unifying the mechanical and infective hypothesis, where endplate breaks and low grade infection both can lead one to each other, accelerating inflammation, and leading eventually to disc degeneration and herniation [32].

Clinical presentation and diagnosis

The primary signs and symptoms of lumbar disc herniation include radicular pain, sensory abnormalities, and weakness in the distribution of one or more lumbosacral nerve roots [6, 30, 33]. Patients report increased pain when sitting, which is known to increase disc pressure in nearly 40% of cases [32]. The affected dermatome varies based on the level of herniation as well as the herniation type: in paracentral herniations, the transversing nerve root is affected, while in far lateral herniations, the exiting nerve root is affected. Pain that is relieved with sitting and forward flexion is more consistent with lumbar spinal stenosis, as the latter motion increases disc pressure by 100–400% [6]. Physical examination should include a complete neurologic assessment, and sciatic or femoral nerve root tension tests including the Lasègue (classic, rebound, crossed and differential), Braggard, flip, Deyerle, Mendel-Bechterew, Fajersztajn, and Milgram tests. In a questionnaire survey among spine surgeons [34], the classic Lasègue test (straight leg raising test) and neurological evaluation for muscle weakness were most frequently performed by 92.9% and 94.0% of the responders, respectively. The crossed leg raising test, on the other hand, was the least performed technique with 36.1% stating that they either "sometimes" or "never" assessed it [34].

The Lumbar Disc Herniation with Radiculopathy Work Group of the North American Spine Society's (NASS) Evidence-Based Guideline Development Committee [35] recommended manual muscle testing, sensory testing, and classic and crossed Lasègue test as the gold standard for clinical diagnosis of lumbar disc herniation (grade of recommendation: A). The Committee found insufficient evidence to make a recommendation for or against the use of the cough impulse test, Bell test, hyperextension test, femoral nerve stretch test, slump test, lumbar range of motion, or absence of reflexes in diagnosing lumbar disc herniation with radiculopathy (grade of recommendation: I). A recent meta-analysis concluded that initial screening by the classic Lasègue test in conjunction with three of the following four symptoms in a nerve root distribution is sufficient for clinical diagnosis of lumbar disc herniation with radiculopathy: dermatomal pain, sensory deficits, reflex deficits, and/or motor weakness [36].

Radiographs are the first imaging modality for the work-up of the patients with low back pain, and should be obtained only after several weeks (6–12 weeks) in the absence of neurological compromise [6]. In addition to standard anteroposterior (AP) and lateral views, flexion and extension views has been recommended to be obtained in order to evaluate the role of spinal instability in the patient's symptoms [6]. Compensatory scoliosis, narrowed intervertebral space and presence of traction osteophytes are findings suggestive of lumbar disc herniation.

Magnetic resonance imaging (MRI) is the most commonly ordered test to evaluate patients with sciatica, with a diagnostic accuracy of 97% and high inter-observer reliability [6, 35]. Often, MRI is performed prior to radiographs; however, in a meta-analysis of 20 studies evaluating the MRI of asymptomatic people, the reported disc abnormalities at any level were reduction in signal intensity (20–83%), disc bulges (10–81%), disc protrusion (3–63%), disc extrusion (0–24%), disc narrowing (3–56%), and AF tears (6–56%) [37, 38]. Therefore, MRI should not be ordered at initial presentation of patients with a suspected acute disc herniation without

symptoms and signs of neurological compromise; these patients frequently improve after a six week course of physical therapy and medication, and MRI is likely an unnecessary financial and utilization burden in the initial presentation [37, 38]. Additionally, over time both symptomatic and asymptomatic disc herniations will decrease in size in MRI, while the finding of disc disease in MRI does not correlate with the likelihood of chronic pain or the future need for surgery [37, 38]. A herniated disc on imaging studies must be correlated with objective clinical findings, otherwise it may be presumed to be an asymptomatic herniation. In contrast, in patients with a history and clinical findings consistent with lumbar disc herniation with radiculopathy, MRI is recommended as an appropriate noninvasive test to confirm the presence of lumbar disc herniation (grade of recommendation: A) [35]. Recently, the use of open MRI-G-scan that allows the acquisition of lumbosacral spine images not only in the supine but also in the upright position has been shown useful for the detection of hidden protrusions and/or herniated discs already present in the supine position [39]. Diffusion tensor imaging (DTI) MRI has been widely used to image the central nervous, but it has been also proven useful for the evaluation and visualization of peripheral nerves, such as detecting microstructural changes in the nerve roots in patients with disc herniation [6, 40–42]. In particular, significant changes in the quantitative diffusion values of the DTI MRI were indicative of damaged nerve microstructure in patients with lumbar discs herniation and radiculopathy [42].

Advances in axial imaging and computed tomography (CT) including multidetector CT (MDCT) have brought the diagnostic level of CT to be nearly equal to that of MRI [43]. Specifically, in patients with a history and clinical findings consistent with lumbar disc herniation with radiculopathy, CT scan, myelography, and/or CT myelography are recommended as appropriate tests to confirm the presence of lumbar disc herniation as an alternative to MRI (Grade of recommendation: A) [35]. For instance, in cases where MRI is not available or possible such as in patients with pacemakers, claustrophobia and/or intractable back pain, a CT myelography could be performed. The drawbacks include an invasive technique that requires the assistance of a trained radiologist, and risk for complications including post-spinal headache, radiation exposure, and meningitis [6].

Recent data on nerve conduction studies have shown that there is only fair to insufficient evidence to support their use in lumbar disc herniation. Only cross-sectional imaging is considered the diagnostic test of choice in disc herniation with radiculopathy, while the use of NCS should be limited to confirm the presence of comorbid conditions [35]. More specifically, somatosensory-evoked potentials are suggested only as an adjunct to cross-sectional imaging to confirm the presence of nerve root compression, but are not specific to the level of nerve root compression or the diagnosis of lumbar disc herniation with radiculopathy [35]. Similarly, fair evidence exists regarding electromyography (EMG), NCS and F waves that are suggested to have limited efficacy in the diagnosis of lumbar disc herniation with radiculopathy, and although H reflexes can be helpful in the diagnosis of an S1 radiculopathy, they are not specific to the diagnosis of lumbar disc herniation [35]. Motor-evoked potentials, extensor digitorum brevis reflex, thermal quantitative sensory testing, and liquid crystal thermography studies have shown insufficient evidence for a recommendation for or against their use in the diagnosis of lumbar disc herniation with radiculopathy [35].

Non-operative treatment

Non-operative treatment is the first-line treatment for most patients with lumbar disc herniation [6, 44]. It aims primarily at pain reduction using drugs, physical therapy/exercises, spinal manipulation, traction (manual or mechanical), epidural steroid injections, as well as other not particularly widespread modalities such as bracing, electrical stimulation, transcutaneous electrical stimulation, acupuncture, herbal supplementation, and bee-venom pharmacopuncture [6, 35].

Drugs

NSAIDs have the principal role in pain management of disc herniation, although, in the acute setting, short-term narcotic use such as a single dose of a morphine-derivative analgesic can be useful. In the acute setting, a tapering dosage regimen of oral steroids can be helpful in decreasing inflammation-generated pain from nerve root irritation [11]. Muscle relaxants are also frequently prescribed, and in spite of what implied by the drug class name, these medications have more significant sedative effect rather than direct muscular effect [11]. Truly antispasmodic medications such as baclofen or cyclobenzaprine can have a more direct effect on muscle spasms [11]. Various other regimens have been proposed, such as single infusion of IV glucocorticosteroids, 5-hydroxytryptamine receptor inhibitors, gabapentin, agmatine, and sulfate amitriptyline [45–48]; however, the 2014 NASS guidelines [35] does not make a recommendation for or against the use of any of the above, due to lack of sufficient evidence. Similarly, tumor necrosis factor alpha (TNF-α) inhibitors (adalimumab, infliximab) are not suggested to provide benefit in the treatment of lumbar disc herniation (fair evidence, level II studies) [35, 49]. Of these biological agents, the transforaminal injection of etanercept (TNF-α inhibitor) achieved significant three to six month improvement in both worst leg pain and worst back pain scores in a placebo controlled randomized trial; however, there was no dose-dependent response associated with this injection nor a comparison population to corticosteroid injections [50].

Physical therapy/exercises

Traditionally, physical therapy has been thought to improve symptoms related to lumbar disc herniation, with a high effectiveness on sciatica [34]. However, recent data are quite opposite [51–53]. In a 2010 prospective randomized controlled trial by Thackeray et al. [52], the therapeutic outcomes of physical therapy after selective nerve root blocks and of selective nerve root blocks alone in people with low back pain and sciatica due to disc herniation are studied. The authors concluded that physical therapy interventions were no more beneficial than nerve root blocks alone [52]. Six years later, Thackeray et al. [53], using data from the Spine Patient Outcome Research Trial (SPORT), evaluated the profile of patients who received physical therapy and those who did not, among patients receiving non-operative treatment within six weeks of enrollment. They showed no difference in the outcomes between the two groups within the first six weeks, while compared with other non-operative treatments standard care physical therapy was not associated with a significant difference in pain, disability, or need for surgery within one year [53]. A recent systematic review that included all treatment strategies for sciatica did not support the effectiveness of physical therapy [51]. The NASS work group suggested that there is no reliable evidence to make a recommendation for or against the use of physical therapy/structured exercise programs as stand-alone treatments; however, it was the work group's opinion that a limited course of structured exercise is an option for patients with mild-to-moderate symptoms from lumbar disc herniation with radiculopathy [35].

Epidural steroid injections

A meta-analysis that included all treatment strategies for sciatica concluded that epidural injections were superior to intradiscal injections, percutaneous discectomy, traction, physical therapy/exercises, radio frequency treatment, and chemonucleolysis in terms of overall response or overall recovery [51]. With pain as the outcome, epidural injections showed significantly superior results when compared to placebo; when considering overall recovery as the outcome of interventions, there was a statistically significant improvement following epidural injections compared with placebo or standard treatment [51]. According to recent guidelines, there is good evidence (level I) in favor of contrast-enhanced fluoroscopy-guided transformaninal epidural steroid injections for short-term (2–4 weeks) pain relief in a proportion of patients with lumbar disc herniation with radiculopathy [35, 54]. Interlaminar epidural steroid injections may also be considered for the treatment of lumbar disc herniation, although with a poor quality evidence to support their use [35, 55]. Additionally, the existing evidence is unreliable to recommend for or against the effectiveness of one injection approach (interlaminar, transforaminal, or caudal) over another in the delivery of epidural steroids [35, 56]. Moreover, there is no evidence with respect to the optimal frequency or quantity of injections, neither sufficient data for their 1-year efficacy [35]. If to be used, current evidence indicates that performing injections in the lateral decubitus position provides patients with better relief at follow-up compared to prone positioning [57].

Alternative medicine

There is a wide spectrum of choices ranging from spinal manipulation and traction to acupuncture and complementary medicine (bee-venom pharmacopuncture and herbal supplementation) for patients who are not interested for conventional treatments [58, 59]. A Korean study suggested that acupuncture, herbal medicine with a variety of herbs, bee-venom pharmacopuncture and Chuna therapy (Korean spinal manipulation) represent safe alternatives to conventional treatment for lumbar disc herniation; according to their findings, patients showed five year improvement in pain, functional disability, quality of life, and neurological impairment [59]. However, it is quite certain that there is great bias in this series, due to lack of a control group, and the inherent high spontaneous resorption rate (above 60%) of disc hernias that may be responsible for the study's good results [6]. Traction therapy presented satisfying short-term outcome according to Isner-Horobeti et al. [58], with decreased opiate consumption and reduced disability scores noted for the patients. However, the rather small sample size (17 patients) and the extremely brief follow-up period (2 weeks) do not allow for recommendations. Spinal manipulation has been proved an option for pain relief in patients with lumbar disc herniation with radiculopathy, however, also with poor evidence [35, 60].

Regenerative medicine

The ideal treatment for intervertebral disc degeneration should aim to resolve nociceptive disc pain, slow, or reverse catabolic metabolism within the disc, and to restore partially or completely disc tissue [61]. These issues have been attempted to be dealt with by promising novel therapies including gene therapy, tissue engineering, cell-based therapy and growth factor delivery [61]. As up to 74% of disc degeneration is hypothesized to result from genetic causes, anabolic factors such as TGF-b, BMP-2, BMP-7, or IGF-1, and gene regulators such as SOX-9 and LMP-1 have showed to modulate the metabolic activity of disc cells, increasing proteoglycans disc content [62]. Therefore, if gene expression of disc cells was to be modified in a way that anabolic factors and gene regulators would be produced, gene therapy could play a role in the management of disc degeneration and herniation [61]. Tissue engineering approaches such as suitable scaffolds for stem cells or growth factors have been tested in vitro and

in vivo with promising results [63, 64]. Preclinical studies of gene therapy approaches showed several side effects, making necessary the development of safer systems of transfection and transduction prior to clinical application, while preclinical studies of tissue engineering techniques are cost-effective and still far from possible clinical application [61].

Stem cell therapy or autologous growth factor injection is more attractive due to low harvest site morbidity, favourable modulation of cells, and easier clinical application [61]. In fact, Basso et al. [61], reviewed clinical trials of regenerative medicine approaches for disc degeneration, and found four studies with mesenchymal stem cell (MSC) intradiscal injection (47 patients) [65–68] and three studies with platelet-rich plasma (PRP) injection (57 patients) [61, 69, 70]. No adverse effect or complications following intradiscal injection of MSCs and PRP occurred, while an improvement in clinical scores was demonstrated in all studies [61, 65–70]. However, with the exception of Tuakli-Wosornu et al. [70], who performed a prospective double-blind randomized controlled study [autologous PRP group vs contrast agent group (control)], randomized clinical trials analyzing MSCs and PRP are missing. More powered high-quality studies are necessary to confirm the promising preclinical and clinical preliminary results for regenerative medicine approaches to assist in the non-operative management of intervertebral disc disease.

Interventional spinal procedures

Intradiscal ozone therapy for lumbar disc herniation is a cost-effective and rather safe procedure, with a complication rate estimated around 0.1% [71–73]. Good results have been reported both in the short- and long-term (5–10 years) with a success rate ranging from 70 to 90%, and a significant herniation volume reduction in up to 96% of cases [74–76]. It can be combined with peri-ganglionic and epidural steroid/anaesthetic injection, producing a cumulative effect enhancing the overall outcome of treatment [71, 73]. Plasma disc decompression/nucleoplasty, intradiscal high-pressure saline injection, and percutaneous electrothermal disc decompression [35] have also been reported for selected cases such as contained disc herniations (plasma decompression) or extrusions and sequestrations (saline injection) [77–80]. However, these studies provide level IV therapeutic evidence, and there is still insufficient data regarding its use in disc herniation with radiculopathy [35].

Operative treatment

Altered bladder function and progressive muscle weakness/progressive neurological deficits are the only absolute indications for lumbar discectomy, which are nevertheless rare and most commonly associated with cauda equina syndrome [11, 81]. The relative indications for surgery vary among surgeons and patients, and discectomy, in its many shapes and forms, can produce symptomatic relief only in appropriately selected patients [11]. The heterogeneity regarding this matter is shown in a recent survey among 817 spine surgeons, where severity of pain and/or disability (55.3%) was considered to be the most import indication for surgery, followed by failure of conservative treatment (50.6%), typical radiculopathy with neurological deficits (43.0%), and duration of complaints (36.2%) [34]. The extent of disc herniation and patients' preferences were less important indications [34]. Ideal timing for operative treatment is also a matter of great importance, but similarly an agreement cannot be easily reached; 46.1% of surgeons regard a period of four to eight weeks of conservative treatment as the minimum period before deciding to perform surgery, 23% of surgeons regard a period of eight to 12 weeks, 11.3% a period greater than 12 weeks, and 19.5% of surgeons perform surgery within four weeks of conservative treatment with a fifth of them performing surgery within two weeks [34]. In general, the typical indication for surgery is to provide more rapid relief of pain and disability in the minority of patients whose recovery is unacceptably slow after a minimum period of conservative treatment of six to 12 weeks [11, 81]; imaging identification of compressive pathology that is concordant with the patient's physical signs and symptoms is definitely a prerequisite [11].

Various operative techniques have been described for disc herniation including open discectomy (paracentral approach, and Wiltse approach for far lateral herniation), mini-open discectomy, microdiscectomy, and percutaneous endoscopic lumbar discectomy via interlaminar, transforaminal, posterolateral, and transiliac approaches [6, 82–85]. In all cases, discectomy has proved a reliable treatment provided the surgical indications, patients' selection and associated abnormalities such as spinal instability and canal narrowing, and technique are respected, as re-operations are always difficult [85].

Open vs. endoscopic discectomy

Open discectomy was initially introduced in 1929 and later modified in 1938 to the technique practiced today; it is regarded since then as a standard operative treatment for lumbar disc herniation [86, 87]. In 1977, the microscope was introduced in the procedure, further refining the procedure into a minimally invasive open microdiscectomy [86–88]. In the last decades, various endoscopic techniques were developed to perform discectomy under direct view and local anaesthesia [89]; the use of an endoscope, endoscope sheath, and cannula assembly, a working channel scope, or use of an oval cannula has been reported in the literature in the 1990s [86], while full endoscopic transforaminal and intralaminar operations under continuous visualization were more recently described [90, 91].

Various studies and meta-analyses have been published during the last decades comparing and analyzing the different surgical procedures, in an attempt to determine the superiority of one technique over another [87–89, 92–96]. Cong et al. [89] analyzed randomized controlled clinical trials (nine studies, 1092 patients) comparing endoscopic with open discectomy for the treatment of symptomatic lumbar disc herniation; patient satisfaction status was significantly better in endoscopic group, while no significant difference was found regarding the complication rate, and primary beneficial clinical outcomes. The length of hospital stay was significantly shorter, and the blood loss volume was significantly lower in the endoscopic group, while no difference was found in the operating time, recurrences rate, and re-operation rate [89]. Ruan et al. [96] in another meta-analysis compared percutaneous endoscopic lumbar discectomy with open microdiscectomy for lumbar disc herniation (seven studies, 1389 patients). Function was not different between groups, complication and re-operation rates, although both higher in the endoscopic group, were not significantly different between groups; however, operating time and hospital stay were significantly higher in the open microdiscectomy group [96]. Li et al. [87] analyzed randomized and non-randomized controlled clinical studies (seven studies, 1301 patients) comparing standard discectomy procedures (open discectomy, partial laminectomy, hemilaminectomy and open microdiscectomy) with endoscopic discectomy. Pain score after surgery, post-operative mean disability period, operating time, blood loss, and hospital stay were significantly higher in the discectomy group, while complication, recurrence and re-operation rates were not different between groups [87]. Phan et al. [95] in a large meta-analysis (23 studies, 28,487 patients) compared endoscopic discectomy and microendoscopic discectomy with open discectomy and found a higher rate of patients' satisfaction, less post-operative pain and shorter hospital stay for endoscopic procedures, without any difference with respect to complication, recurrence and reoperation rates between the groups [95]. Feng et al. [93] published a Bayesian-framework network meta-analysis of randomized clinical trials (29 studies, 3146 patients) to compare seven operative treatments for patients with lumbar disc herniation. They found best success and complication rate for endoscopic discectomy, and best re-operation rate for standard open microsurgical discectomy [93].

In 2018, four meta-analyses have been published so far, comparing discectomy techniques. Li et al. [94] published a meta-analysis (10 studies, 804 patients) to compare microendoscopic discectomy with conventional microdiscectomy. They found no difference between the two techniques with respect to any of the examined variables [94]. Ding et al. [92] in another meta-analysis (17 studies, 1390 patients) compared fenestration discectomy with percutaneous transforaminal endoscopic discectomy. They found no difference with respect to post-operative pain and complications; however, operating time, blood loss, and hospital stay were significantly lower in the percutaneous transforaminal endoscopic discectomy group [92]. Similar results were reported by Zhang et al. [88] and Alvi et al. [86] in respective meta-analyses (nine studies, 1527 patients [88]; 14 studies, 1707 patients [86]); a significant difference was found only for hospital stay for endoscopic discectomy groups, without any differences in pain, complication, and re-operation rates at short and long term.

Conclusion

Lumbar disc herniation is a common entity that causes symptoms of sciatica and possible foot pain, numbness, or weakness. The exact event leading to disc herniation remains unclear. Non-operative treatments with drugs, spinal manipulation, physical therapy/exercises, epidural steroid injections, and possibly alternative treatments should be the first-line treatment for most patients with lumbar disc herniation; however, there is not a strong evidence for the effect of these treatments. Regenerative medicine is promising. Operative treatment remains the current gold standard, with minimally invasive endoscopic microdiscectomy techniques showing best results with respect to post-operative pain and function, without any difference with respect to complications and re-operations compared to the standard discectomy techniques.

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