Management of Symptomatic Lumbar Degenerative Disk Disease

Abstract
Symptomatic lumbar degenerative disk disease, or discogenic back pain, is difficult to treat. Patients often report transverse low back pain that radiates into the sacroiliac joints. Radicular or claudicatory symptoms are generally absent unless there is concomitant nerve compression. Physical examination findings are often unremarkable. Radiographic examination may reveal disk space narrowing, end-plate sclerosis, or vacuum phenomenon in the disk; magnetic resonance imaging is useful for revealing hydration of the disk, annular bulging, or lumbar spine end-plate (Modic) changes in the adjacent vertebral bodies. The use of diskography as a confirmatory study remains controversial. Recent prospective, randomized trials and meta-analyses of the literature have helped expand what is known about degenerative disk disease. In most patients with low back pain, symptoms resolve without surgical intervention; physical therapy and nonsteroidal anti-inflammatory drugs are the cornerstones of nonsurgical treatment. Intradiskal electrothermal treatment has not been shown to be effective, and arthrodesis remains controversial for the treatment of discogenic back pain. Nucleus replacement and motion-sparing technology are too new to have demonstrated long-term data regarding their efficacy.

Approximately 70% to 85% of adults will be affected by low back pain (LBP) at some point during their lifetimes.\textsuperscript{1,2} Numerous anatomic sites can be responsible for the pain, and accurate diagnosis is often difficult. Degenerative disk disease (DDD), internal disk disruption, lumbar disk herniation, and facet joint arthritis, as well as intra-abdominal pathology, are all potential causes of LBP.

Patients with DDD or discogenic back pain can present with a constellation of symptoms that range from benign LBP to excruciating back pain with lower extremity symptoms. Risk factors for LBP, such as jobs requiring heavy lifting, use of a jackhammer or machine tools, or the operation of motor vehicles, have been identified in the literature.\textsuperscript{3} Continued degeneration of the affected disk can lead to secondary problems such as degenerative spondylolisthesis, lumbar stenosis, and facet arthrosis.

Clinical Presentation
The signs and symptoms in a patient with discogenic back pain can vary. Patients will typically report trans-
verse LBP that radiates down into the sacroiliac region. Symptoms of lower extremity claudication are generally absent unless concomitant lumbar stenosis is also present. Radicular complaints generally are absent unless there is a disk herniation or foraminal stenosis.

The physical examination of a patient with primarily discogenic LBP is often unremarkable. Back pain may be reproduced on palpation of the lumbar or lumbosacral spine. The range of motion of the lumbar spine may be limited. Pain usually is worsened with flexion and lessened with extension. Pain with extension of the back may herald facet joint disease. The gait may be antalgic, and transitions from one position to the next may be guarded. Straight leg raise and other tests for radicular signs are rarely positive.

The physical examination should also include assessment of the abdomen and lower thorax. Intra-abdominal pathology such as renal stones, aortic aneurysm, pancreatic problems, and tumors can manifest as back pain. A detailed history should be done to elicit red flags such as unexpected weight loss, night pain, night sweats, fevers, and urinary or gastrointestinal signs such as blood in the urine or stool. Discogenic back pain remains primarily a diagnosis of exclusion.

### Imaging Studies

#### Radiographic Evaluation

Upright plain radiographs are the initial study of choice. Anteroposterior (AP) and lateral views may be helpful in the diagnosis, including flexion-extension imaging if there is concern for spondylolisthesis. The radiographs should be analyzed for signs of osteophytes, foraminal narrowing, end-plate sclerosis, disk space narrowing, and vacuum phenomenon within the disk. Much like magnetic resonance imaging (MRI) scans, plain radiographs can show degenerative changes in asymptomatic patients. Vigilance should be maintained for abnormalities that may indicate a more serious problem, such as a fracture or metastasis, and intra-abdominal pathologies.
Magnetic Resonance Imaging

MRI is the imaging study of choice for DDD because it offers unparalleled detail of the status of the disk. A disk that appears normal on MRI is unlikely to be a pain generator and should prompt a search for another cause of back pain. Characteristics that should be examined on MRI are disk height, the presence or absence of annular tears, signs of degeneration (eg, decreased signal on T2-weighted images), and end-plate changes (Figures 1 and 2). MRI scans should be interpreted with caution. Boden et al\(^8\) found that almost 30% of asymptomatic individuals with no history of LBP had disk abnormalities. Seven-year follow-up of these patients demonstrated that MRI abnormalities were not predictive of the development or duration of LBP. Jensen et al\(^9\) found that more than half of asymptomatic patients had evidence of disk bulges on MRI scans. These findings were further supported by Jarvik and colleagues\(^3,10\) in preliminary and follow-up studies of a Veterans Affairs patient cohort. They initially found that in asymptomatic patients (pain-free ≥4 months), disk height was decreased in 56%, moderate to severe desiccation was present in 83%, and one or more disk bulges were present in 64%.\(^9\) At 3-year follow-up, self-reported depression was the strongest predictor of subsequent back pain, and disk protrusions were associated with a lower risk of subsequent back pain.\(^10\)

The high-intensity zone (HIZ), as described by Aprill and Bogduk,\(^11\) is an MRI finding seen on T2-weighted spin-echo images. It is an increased signal intensity seen in the posterior anulus of the disk. The HIZ was seen in 28% of patients who underwent MRI for LBP, and the authors found that it was a specific indicator of a painful internal disk disruption. However, the significance of the HIZ has been questioned in a recent study, and the continued low sensitivity with regard to pain reproduction limits its usefulness.\(^12\)

End-plate changes that are associated with DDD have been well characterized by Modic et al.\(^1\) The authors broke down the changes seen on different MRI sequences and correlated them with histopathologic findings. Type I changes are decreased signal intensity on T1-weighted images, with increased signal intensity on T2-weighted images. This corresponded in the study to areas of degeneration, increased reactive woven bone, and vascularized granulation tissue. Type II changes demonstrate increased signal intensity on T1-weighted images and isointense or slightly increased signal on T2-weighted images. The histologic specimens from the disks in the study showed replacement of hematopoietic elements with fat and evidence of chronic repetitive trauma. Type III changes are manifested by decreased signal intensity on both T1- and T2-weighted imaging and correspond to advanced degeneration with replacement of the fat with sclerotic bone, along with end-plate (Modic) changes at the L5-S1 interspace\(^5\) (Figure 3).

Diskography

Diskography is the only imaging method that involves direct stimulation of the disk. Although its effectiveness and reliability have come into question, it still is considered by some to be a useful tool in assisting in the diagnosis of discogenic back pain. To be considered reliable, diskography is conducted and assessed in four ways: low-pressure injection (including volume of fluid); abnormal disk morphology, as demonstrated with dye extravasation out to or through the anulus; subjective reproduction of the patient’s pain at the injected level; and no or minimal subjective pain response when adjacent (control) levels are injected.\(^13\) For a diskogram to be positive, the patient’s pain must be reproduced at low pressure/volume injection at the concordant disk. Dye extravasation through the anulus further validates the study. An increase in the patient’s pain with injection of an adjacent control disk brings the results of the study into question. The main limitation of diskography is its reliance on subjective pain responses from the patient.

The use of diskography to assess LBP in asymptomatic or mildly symptomatic patients has been extensively studied.\(^14-21\) Patients who have previously undergone lumbar diskectomy, regardless of symptoms, will have similar results with diskography on the operated level.\(^16\) Derby
et al\textsuperscript{13} found that pain tolerance was significantly lower \((P < 0.05)\) in the patient population than in the control group. They also found that asymptomatic disks can be made painful, but usually the pain is mild and requires high-pressure injection to elicit.

Carragee et al\textsuperscript{14} found that asymptomatic patients who have undergone posterior iliac crest bone grafting procedures often have concordant pain (50\%) with disk injection. Annular disruption (grade III) was found to be significant \((P < 0.05)\) for pain reproduction as well. The authors further found that the rate of false-positive diskograms in asymptomatic patients with comorbidities (chronic neck/arm pain or somatization disorder) was significantly higher. They concluded that a false-positive rate can be low in diskography in patients without chronic pain and with normal psychometric testing.\textsuperscript{15}

Further investigation found a 25\% rate of positive pain provocation with low-pressure injections in patients without chronic LBP.\textsuperscript{16} Carragee et al\textsuperscript{17} found that the presence of an HIZ did not reliably predict the presence of a symptomatic disk disruption. Twenty-four percent of asymptomatic patients in their study had HIZs. Positive diskograms in these patients were found to be statistically similar to those of control subjects (69.2\% asymptomatic versus 72.7\% symptomatic). All patients in the study with HIZ and abnormal psychometric testing had a positive diskogram, while only half with normal psychometric testing and HIZ had positive diskograms.

Patients with positive diskograms may not always benefit from surgery. Smith et al\textsuperscript{22} retrospectively looked at 25 patients with positive diskograms who did not undergo surgical intervention. At a mean follow-up of almost 5 years, 17 (68\%) of the patients had improved, 2 (8\%) were unchanged, and 6 (24\%) had worsened. Psychiatric disease was present in four of the six who worsened. Other researchers have found poor results in two-level fusions and in almost half (47\%) of single-level fusions for diskogram-concordant back pain.\textsuperscript{23} In another study correlating diskography to surgical fusion, only 13 of 30 patients (43\%) in the discogenic back pain group met the criteria for “minimal acceptable outcome,” while 29 of 32 (91\%) in the spondylolisthesis group did.\textsuperscript{24}

Diskography remains a controversial diagnostic tool. To ensure the highest likelihood of success, it should include control levels (usually one on each side of presumed symptomatic disks), and the examination should be provocative, with patient interaction, and should include injection pressure monitoring and postinjection computed tomography to assess for dye extravasation. It has been shown that abnormal psychometric testing positively skews diskography results. Diskography should be used as a confirmatory test and not as an outright diagnostic tool.

**Treatment**

**Nonsurgical**

Approximately 90\% of individuals with LBP will have resolution of their symptoms within 3 months, with or without treatment; most will have cessation of discomfort within 6 weeks.\textsuperscript{1} With this type of natural history, the initial treatment of all patients with LBP without a neurologic emergency should be nonsurgical. Kirkaldy-Willis and Farfan\textsuperscript{25} divided the degenerative cascade into three stages: temporary dysfunction, unstable, and stabilization. The authors found that the transition through the stages often happens over a 20- to 30-year period, and the condition often stabilizes later in life as the disk space collapses and becomes more stiff. The authors believed that patients in the first two phases would respond primarily to conservative care. When the last phase was reached, surgery was more likely to be performed more for reasons of nerve root irritation than LBP.

Physical therapy, with strengthening of core muscle groups (both abdominal wall and lumbar musculature), has demonstrated positive effects in patients with discogenic pain.\textsuperscript{15} Educating patients on better body mechanics, in terms of lifting with the legs instead of the back, lessens the strain placed on the lumbar region. A more recent literature review advocated mobilization or activity in the treatment of LBP as opposed to bed rest.\textsuperscript{26} Exercise has been shown to improve function and decrease pain in adult patients with chronic LBP.\textsuperscript{27} Chiropractic manipulation has been shown to be beneficial for the treatment of acute LBP and equivalent to physical therapy in this group of patients.\textsuperscript{28,29} The benefits of spinal manipulation have not been seen in patients with chronic LBP.\textsuperscript{13} Cochrane literature reviews\textsuperscript{30,31} have found that back schools demonstrate effectiveness in short- and intermediate-term settings in relation to LBP and return-to-work status in comparison with spinal manipulation, exercises, advice, and placebo.

Flexion (Williams) versus extension (McKenzie) exercises have long been used to treat LBP. A recent literature review found that the McKenzie method of evaluating and categorizing patients was highly successful.\textsuperscript{32} The authors found that the McKenzie method produced better short-term results than did nonspecific guidelines and equal results to those of stabilization or strengthening protocols. A direct comparison
of the two methods showed no difference between the two groups except that sagittal mobility improved faster with flexion exercises. The use of braces for either prevention or treatment of LBP has been shown in a recent review to be ineffective, although patient compliance was a concern of the authors.

Recent trends in the treatment of LBP have centered on a multidisciplinary approach. The disciplines usually include a physical dimension and a combination of one or more of the following: social, occupational, and psychological. Guzmán et al undertook a review of 10 trials (1,964 patients) that used multidisciplinary rehabilitation for the treatment of chronic LBP. The trials all had control groups receiving usual care, nonmultidisciplinary treatment, or no treatment. Intensive (>100 hours), multidisciplinary biopsychosocial rehabilitation produced greater improvements than did nonmultidisciplinary, less intensive programs.

There is a long history of treating LBP with medication. The use of narcotics over the long term should be avoided because of concerns about addiction, altered cognition in older patients, and interaction with other medications. The use of nonsteroidal anti-inflammatory drugs (NSAIDs) for the treatment of LBP was the subject of a Cochrane review. The authors reviewed 51 trials with 6,057 patients and found that NSAIDs are effective for short-term symptomatic relief in patients with acute back pain. No specific NSAID was found to be more efficacious than any other. The same group also reviewed the use of muscle relaxants in patients with LBP and found that their use was effective but cautioned about their side-effect profile. The use of antidepressants in the treatment of chronic LBP has become more common. Staiger et al reviewed 22 trials and found that both tricyclic and tetracyclic antidepressants produced symptom reduction in this patient population, whereas selective serotonin reuptake inhibitors did not.

**Surgical**

**Intradiskal Electrothermal Therapy**

The role of intradiskal electrothermal therapy (IDET) in the treatment of discogenic back pain remains controversial. The lack of any long-term studies (>2 years) precludes meaningful analysis of the data. Although complication rates for this procedure are very low, so too is its documented efficacy. Freeman et al, in a randomized, double-blind, controlled trial, showed no difference between the group undergoing IDET and the group undergoing the sham procedure, with no improvement in either group. The use of IDET in the treatment of discogenic back pain remains controversial, and without good, long-term results, a recommendation for its use cannot be given.

**Epidural Injection**

Spinal epidural injection therapy has also been used to treat discogenic back pain. A recent review of the literature showed that no good studies exist to support the use of transforaminal epidural steroid injections in the treatment of LBP and that caudal epidural steroid injections resulted in only short-term relief. Both facet blocks and medial branch neurotomy with regard to surgical results after lumbar fusion. Workers’ compensation has been found to have an overall negative effect on patient outcomes. In a study by Franklin et al, 67.7% of patients receiving workers’ compensation in Washington state reported worse back pain after surgery, with 55.8% feeling
that their quality of life was worse or no better. DeBerard et al\textsuperscript{47} conducted a similar study of patients receiving workers’ compensation in Utah and reported inconsistent results. They did conclude that certain preoperative risk factors predestined the patient to poorer outcomes: number of prior low back operations, household income (low) at the time of injury, age at the time of surgery (older being worse), and litigation.

LaCaille et al\textsuperscript{49} found that tobacco use, depression, and litigation were predictors of poor outcome in patients undergoing interbody fusion, despite an 84% fusion rate. Hägg et al\textsuperscript{50} and the members of the Swedish Lumbar Spine Study Group found that patients with depressive symptoms and LBP improved when treated nonsurgically, while low disk height and low level of neuroticism (ie, muscular tension, somatic anxiety, guilt, and psychasthenia) were predictors of improvement with surgical intervention. The same group found that surgical candidates with chronic LBP differed from symptom-free control patients in having higher rates of general morbidity, tobacco use, and depressive symptoms.\textsuperscript{51} However, surgical candidates did not differ in such characteristics from nonsurgical patients with chronic LBP.\textsuperscript{51}

Additionally, a solid posterolateral fusion does not preclude that intersegmental motion from contributing to continued pain.\textsuperscript{52,53} Weatherly et al\textsuperscript{52} reported on five patients who underwent anterior lumbar interbody fusion (ALIF) in the setting of a solid posterolateral fusion and found a decrease in pain and increase in function in all five. Barrick et al,\textsuperscript{53} in a cohort of 18 patients with discographically confirmed painful disks, found significant decreases in the Oswestry Disability Index (ODI) ($P = 0.04$) and Numerical Rating Scale ($P < 0.001$) pain scores.

The Swedish Lumbar Spine Study Group has done much to enrich the knowledge of the efficacy of lumbar fusion in the setting of discogenic back pain. In 2001 the group found that fusion for DDD results in superior outcomes relative to standard nonsurgical care.\textsuperscript{54} Also, using an incremental cost-effectiveness ratio, the group showed that lumbar fusion, although initially more expensive, may in the long run be a cheaper form of treatment than nonsurgical care. All of the treatment effects in that study were found to be in favor of surgery.\textsuperscript{54} Finally, the group compared three types of fusion in the lumbar spine: posterolateral, posterolateral with instrumentation, and circumferential. The investigators found that the highest fusion rate was garnered by the circumferential group (91%), followed by the posterior instrumented (87%) and the noninstrumented (72%) groups\textsuperscript{55} (Figure 4). However, the higher fusion rates came with higher rates of complications (31% in the circumferential group) and more significant use of resources in the instrumented groups in the form of operating time, blood transfusion, and length of hospital stay postoperatively. The investigators found that all of the techniques significantly reduced pain and decreased disability in their cohort but that there was no disadvantage in using the “least demanding surgical technique.”

**Motion-sparing Technology**

The complication of adjacent segment disease is a well-known clinical entity in spine surgery.\textsuperscript{55,56} A recent study on the lumbar spine showed a 27.4% incidence of adjacent segment disease, requiring further surgery at an average of 6.7 years.\textsuperscript{55} The resultant concern has contributed to the development of motion-sparing technology. The basic premise is that if motion is preserved at the diseased segment, then degeneration at adjacent segments may be retarded or possibly halted. Motion-sparing technology encompasses an array of techniques.
surgical procedures, including posterior soft-tissue stabilization procedures; posterior metallic, synthetic, or polymer rods; nucleus pulposus replacement; injection of disks with biochemical polymer compounds; and total disk arthroplasty (TDA). However, at this time, only TDA is approved for discogenic back pain.

**Total Disk Arthroplasty**

TDA is another option for the treatment of DDD. It is designed to temper the problem of adjacent-segment disease so as to be an alternative to spinal fusion. Its primary indication is in patients with axial back pain caused by DDD (Figure 5). TDA was recently approved in the United States for the treatment of isolated discogenic back pain without instability. The contraindications for disk replacement surgery are numerous because all other possible pain generators need to be ruled out to have a successful outcome. Exclusion criteria for lumbar TDA are stenosis, facet arthritis, spondylolysis or spondylolisthesis, radiculopathy secondary to herniated disk, scoliosis, osteoporosis, obesity, chronic steroid use, pregnancy and previous lumbar fusion, infection, and fracture.

The most studied TDA device in the United States is the SB Charité III (DePuy Spine, Raynham, MA). It is an unconstrained total disk replacement designed so that the device has an instant axis of rotation, closely mimicking that of the native intervertebral disk. Higher surgical volume has been found to be beneficial in patient outcomes. Surgeons and hospitals that performed more TDAs (high-enrolling group) showed significantly shorter hospital stays and operating times and lower complication rates, as well as significantly fewer device failures and cases of neurologic deterioration. Additionally, correct placement of the prosthesis on radiographic evaluation leads to improved flexion/extension range of motion and better functional outcomes. Comparison of results of TDA to ALIF with Bagby and Kuslich (BAK) cages has been shown to be equivalent. Guyer et al showed similar significant improvements in both visual analog scale (VAS) scores (TDR, 57.7%; BAK cage, 60.4%) and in ODI scores (TDR, 53.6%; BAK cage, 53.7%) with similar complication rates, for a group of 144 patients (100 TDR, 44 ALIF) in their US Food and Drug Administration trial. These results were supported by McAfee and colleagues in a study of 60 patients with SB Charité TDR versus ALIF with BAK cages. Both studies concluded that TDR is a reasonable alternative to fusion for discogenic pain. In further evaluation by these groups, TDR was shown to give better disk height.

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**Figure 5**

A, Sagittal T2-weighted MRI scan of a 47-year-old man showing severe disk height loss at the L5-S1 interspace. Note the end-plate (Modic) changes in both the L5 and S1 lumbar vertebrae. Postoperative anteroposterior (B) and lateral (C) plain radiographs taken following lumbar disk replacement with the ProDisc-L (Synthes, West Chester, PA).
restoration and less subsidence than ALIF with BAK cages. Finally, the Food and Drug Administration trial of the SB Charité III TDR did show two economic parameters that were found to be significantly better ($P < 0.05$) in the TDR cohorts: shorter hospitalization and a lower rate of reoperations.

Bertagnoli and colleagues have published data on the ProDisc-L (Synthes, West Chester, PA) TDR. They have shown in prospective studies, in both single- and multilevel TDAs, that patient-centered outcomes were significantly improved.VAS scores and ODI scores improved significantly by 3 months, with patient satisfaction >90%, and these improvements were maintained at 2 years ($P < 0.001$). The investigators also showed that TDA can be used to address adjacent segment disease after posterior lumbar fusion; significant improvements were noted in VAS and ODI, with patient satisfaction scores above 85% at 2-year follow-up ($P < 0.001$). Delamarter et al showed short-term improvements in VAS and ODI scores in a cohort of 53 patients when TDA was compared with anteroposterior fusion (360° fusion). These significant ($P < 0.05$) improvements disappeared by 6 months postoperatively, and this study received criticism for its use of 360° fusion for the comparison group. Zigler et al found an overall significant ($P = 0.0341$) success rate in favor of TDA over circumferential fusion. Hannibal et al showed no difference in outcome between one- and two-level ProDisc-L application at 2-year follow-up. Shim et al compared SB Charité with ProDisc-L TDRs and found no difference between the two in terms of outcomes. However, the authors did find a high rate of index-level facet degeneration and adjacent-level disk degeneration in both the SB Charité (36.4% and 19.4%, respectively) and ProDisc-L (32% and 28.6%, respectively).

Reported complications of TDA leading to failure of the prosthesis have been shown primarily to involve facet joint degeneration, subsidence, and adjacent-level disease. Case reports of fractures of the vertebral body have been reported, as well. McAfee et al reported on their experience with the SB Charité artificial disc and found an 8.8% reoperation rate, compared with a 10.1% reoperation rate in the lumbar fusion control group. The primary reason for removal of the TDA device was device migration (18 of 24 [75%]). Of the 24 prostheses, 22 were removed without incident (91.7%), and 7 (29.2%) were revised with another SB Charité TDA. However, there was a higher incidence of vascular injuries in the reoperation group (16.7%) compared with the primary implantation group (3.4%). Another 14 patients in the TDA group required posterior instrumented fusion for persistent LBP (2.4%).

**Summary**

DDD has a multifactorial etiology. Initial degeneration of the disk results in a cascade of events that eventually may lead to chronic LBP. It is necessary to correctly identify patients with true discogenic pain, and it is imperative that all other sources of pain be excluded before performing surgery for discogenic back pain. In carefully selected patients, successful outcomes can be attained with surgical intervention. The role of TDA is still to be defined in the affected population. Long-term studies may elucidate whether TDA is the appropriate treatment in selected patients. Until that time, arthrodesis remains the best surgical option in a carefully selected patient population.

**References**

**Evidence-based Medicine:** References 16-18, 36, 40, 45, 54, 59-63, 67, and 68 are level I randomized controlled trials or prospective studies. References 4, 6-10, 12, 14, 15, 19, 21, 24, 26-32, 34, 35, 37-39, 41-43, 46, 50, 51, 56, 58, 69, and 70 are level II randomized controlled trials or retrospective studies. References 1-3, 5, 11, 20, 22, 23, 33, 47-49, 52, 53, 57, 64-66, and 71-73 are level III case-control studies or level IV case series. References 25 and 44 are level V expert opinion.

Citation numbers printed in **bold type** indicate references published in the past 5 years.

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38. Fritzell P, Hagg O, Wessberg P, Nordwall A, Swedish Lumbar Spine...


