

The role of repeated end-range/pain response assessment in the management of symptomatic lumbar discs

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Abstract

Background context: The selection of appropriate patients for lumbar disc surgery is a challenging task involving a highly variable, multifactorial decision process complicated by a lack of reliable, validated clinical signs and imaging findings. Recently, multiple studies have demonstrated the reliability and diagnostic utility of a standardized form of spinal assessment using repeated end-range test movements while monitoring patterns of pain response (McKenzie assessment).

Purpose: It is the aim of this article to evaluate the utility of this assessment system and its literature support in the selection of candidates for surgery for disc-related pain.

Study design and methods: A literature review.

Results: Most patients under consideration for lumbar disc surgery, when examined using this form of dynamic mechanical spinal evaluation, based on patients' patterns of pain response to standardized repeated end-range lumbar test movements and positions, fall into one of three subgroups: 1) a reversible condition, 2) an irreversible condition or 3) an unaffected condition. Reversible conditions in acute to chronic low back and/or leg pain are recoverable, often rapidly so, using nonoperative self-care dictated by the patient's assessment findings. The elicitation of pain "centralization," an improvement (favorable change) in pain location in response to repetitive end-range testing, typically occurring with only one direction of test movement(s), predicts a high likelihood of successful response to conservative care, even in the presence of neurologic deficits. Irreversible conditions are characterized by symptom aggravation by all directions of testing, including the absence of the centralization response, predicting a poor response to nonsurgical care. In those whose pain is unaffected with similar testing, evidence indicates the pain is likely nondiscogenic. A dynamic disc model has been described as a possible model for these varying pain responses. Insight into annular integrity of symptomatic discs is also provided using this repeated end-range/pain response (McKenzie) assessment.

Conclusions: As described, the literature supports the use of a repeated end-range/pain response assessment (dynamic mechanical evaluation) in obtaining diagnostic and therapeutic information in patients with low back and leg pain. This may contribute to improving the selection process of surgical patients. © 2003 Elsevier Science Inc. All rights reserved.

Keywords:

Lumbar; Intervertebral disc; Low back pain; Sciatica; Surgery; Diagnosis; McKenzie; Centralization; Directional preference

Introduction

In general, two broad clinical categories of disc pathology are recognized: radicular pain resulting from lumbar

disc prolapse and axially dominant pain, thought by many to be caused by a painful internal disc abnormality (eg, annular fissuring or instability). An anatomic diagnosis of compressive prolapse can be made with confidence in only a small percentage of patients with clinical manifestations of nerve root compression and confirmatory imaging. In the far more common nonradicular patients with low back pain, making a reliable anatomic diagnosis is much more difficult because of limited understanding of pain mechanisms and lack of clinical and diagnostic skills and technologies. Various diagnostic techniques have been described [1–9] with vari-

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able reports of sensitivity and specificity leading to significant variation among medical specialists and allied health practitioners in how a diagnosis for patients with low back pain is made [10].

Although the phrase “exhausting conservative care” is often stated to be a prerequisite to considering surgical intervention, the variability in assessment and the lack of evidence that any particular form of conservative care has been shown to be effective in the treatment of discogenic pain introduces a multidimensional variable into the decision-making process. For patients not responding to the various forms of nonoperative care, when a “disc” diagnosis is then made, there is a fivefold difference in the rate of disc surgery reported in the United States [11]. Various forms of surgery are also carried out. This wide variation related to spinal surgery decisions reflects these large differences in the patient selection process.

Diagnosis and surgical decision making for radicular pain is fairly precise, and surgical outcomes are favorable for relief of the radicular pain. Nevertheless, in light of good long-term outcomes with nonoperative treatment in this group [12,13], the decision of whether to operate on compressive lumbar disc disease carries its own challenges in the context of what patients’ preferences would be for surgical versus nonsurgical care [14]. Meanwhile, with highly variable rates of success reported after surgery for axial low back pain related to noncompressive lumbar disc disease [1,15–20], surgical selection criteria are obviously in need of refinement.

No one clinical finding or physical sign has been shown to be pathognomonic of discogenic pain. However, several studies have suggested that pain location and, in particular, the changes in pain location in response to repeated end-range loading/pain response tests may be useful for both diagnosis and treatment [21–27]. Specifically, there is a clear suggestion that such repetitive end-range/pain response spinal testing, as described by McKenzie [28] (Fig. 1), may evaluate the presence or absence of discogenic pain and, therefore, be useful in clinical decision making [22,29].

It is the purpose of this article to review the current literature regarding the usefulness of this form of dynamic spinal assessment, particularly related to the identification of discogenic pathology. Of special interest is the ability of this method to define the potential “reversibility” of symptoms related to pain-generating disc pathologies.

Current surgical selection criteria and outcomes

To maximize success in surgical outcomes, proper patient selection is mandatory and must be based on accurate diagnosis. The evaluation process is multifactorial, comprised of the history, physical examination and isolation of a discrete anatomic lesion that correlates with clinical findings.

In cases of lumbar disc herniation with radiculopathy, both the diagnosis and surgical decision are very strongly influenced by findings on clinical examination. In patients

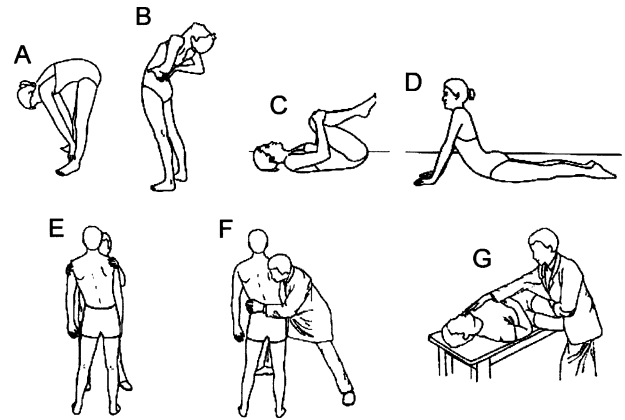


Fig. 1. Standing and recumbent directional lumbar test movements performed repeatedly to the patient’s available end-range: (A) Flexion while standing. (B) Extension while standing. (C) Flexion while lying. (D) Extension while lying. (E) Side-gliding while standing. (F) Side-gliding with over-pressure. (G) Flexion-rotation with overpressure. During testing, changes in patient’s pain location are continuously monitored in order to identify a directional “preference” (pain centralizes or is abolished) and directional “vulnerabilities” (pain is produced or peripheralizes). A direction of testing that centralizes or abolishes pain is continued and defines a patient’s direction of treatment, and those directions that produce or peripheralize pain are temporarily avoided.

with a positive straight-leg-raising maneuver, a history of radicular pain, positive nerve root findings based on neurological deficits and objective demonstration of concordant pathology (eg, computed tomography or magnetic resonance imaging [MRI] findings of herniated nucleus pulposus [HNP]), one can confidently make the diagnosis of compressive disc pathology and treat it surgically with a high chance of a successful outcome [12,30–32]. The presence of a positive Lasegue maneuver has been shown to correlate most strongly with the likelihood of a good clinical outcome [33].

In the setting of disc disease and axial pain only, the picture is far less clear. Based on the inability of conventional imaging techniques to identify such symptomatic levels [34,35], lumbar discography has become more prevalent. Discography remains controversial [36,37]. Although many studies have reported utility [1,6,38–44], more recent articles point out the importance of proper technique and recognition of possible confounding variables, such as psychological or occupational distress [37].

Given the variability inherent in the diagnostic process, a logical place to investigate process improvement for surgical outcome is in patient selection. An identical surgical procedure performed on 100 patients with a success rate of only 60% can be 100% successful if the 60 successful and 40 unsuccessful outcomes can be predicted preoperatively. Thus, in patients with low back pain, critical surgical selection questions remain: are there any findings that implicate the disc as the underlying source of pain and, if so, are there indicators that the disorder will recover satisfactorily or not without surgery?

“Directional” patterns of pain response: four randomized controlled trials

At least four randomized controlled trials (RCTs) have thus far investigated the interesting relationship between the direction of spinal loading with the distal extent and/or intensity of low back and leg pain [45–48]. This consideration is relevant to this topic, because the authors of two of these articles related specific symptom responses directly to disc pathology [45,46], and the extent of distal spread of leg pain is often viewed as reflective of the severity of the disc pathology.

In the first study, Spratt et al. [46] document that those patients with low back pain and dynamic flexion/extension radiographic findings of spondylolisthesis, retrolisthesis or normal sagittal translation, randomized to an extension treatment strategy of both bracing and end-range exercises, experienced significantly greater pain relief than those randomized to a comparable flexion strategy. Based on this beneficial pain response to extension common to all three radiographic subgroups, the investigators concluded that the pain source was likely unrelated to the radiographic findings and more likely to be discogenic.

In contrast, the second RCT by Snook [45] et al. hypothesized “that a source of chronic, non-specific low back pain is in the intervertebral disc, and that the specific lesion is internal disc disruption” based on two concepts: the frequent occurrence of radial fissures extending into the innervated outer third of the annulus [2,49–52] and evidence of an increased risk of lumbar disc injury related to forward bending in the morning [53,54]. Not only is there an increased fluid content in the disc after a night of recumbency [55–57] but, in a more pressurized state, the lumbar discs are more vulnerable to posterior prolapse with flexion loading [58–60].

The authors then investigated the effects of meticulous avoidance of positions and movements involving lumbar flexion in the first morning hours in a group of volunteers with chronic low back pain. At 1 year, significant improvements in pain-free days and disability resulted. At 3 years, 62% still reported voluntary performance of these same morning flexion-avoidance self-care strategies motivated by even further significant increases in the number of pain-free days [61]. The authors’ premise that flexion avoidance relieved noxious stimuli to the posterior annulus, although not proven by this study, was strongly supported by the data.

In a third RCT, Williams et al. [47] showed significant improvement in acute low back and leg pain, as well as pain centralization (see below), in patients who were assigned to a lordotic rather than a kyphotic sitting posture during a 48-hour period. Although the authors did not speculate on the anatomic source of the pain, they did point out a direct relationship between the degree of “noxious” loading and the extent of pain referral [4], reporting that subjects’ Quebec Task Force classification [50] rapidly improved as their lower extremity pain “centralized” [21,28,62] and/or was abolished over 48 hours with the use of the lordotic sitting posture.

The fourth RCT reported on 145 patients with “nonspecific” low back pain, with or without leg symptoms, who underwent a single assessment session consisting of repeated end-range flexion and extension/pain response tests, performed while standing and recumbent. Like the other three studies, the majority reported that flexion testing caused an increase in intensity of both their midline and distal-most pain and/or an increase in the distal extent of their leg symptoms (“peripheralized” their pain) [48]. Further analysis revealed that 47% of the entire study group reported a clear decrease in both central and peripheral pain with only one, never with both, direction of testing. Whereas a small but noteworthy subgroup improved with flexion (15%) while worsening with extension, 85% improved with extension testing and worsened with flexion, consistent with the findings of the other three RCTs described above. Rather than these two opposing directional subgroups reflecting different pain-generating structures, the authors suggested that a single structure with directionally reversible mechanical characteristics (the disc?) might be responsible [48].

Centralization of pain

During assessment, pain radiating from the low back, whether into the buttock, thigh or distally to the foot, may be induced to retreat from its most distal location to the point where only low back pain persists; ultimately, the midline pain is eliminated as well. This pattern of pain response was first described by McKenzie [28,62] (1980), who applied the term “centralization” to this phenomenon (Fig. 2).

This centralizing pattern of symptom recovery from sciatica resulting from disc prolapse is in reality quite familiar to patients and physicians. Specifically, the leg pain routinely reduces or “retreats” to the back and is abolished be-

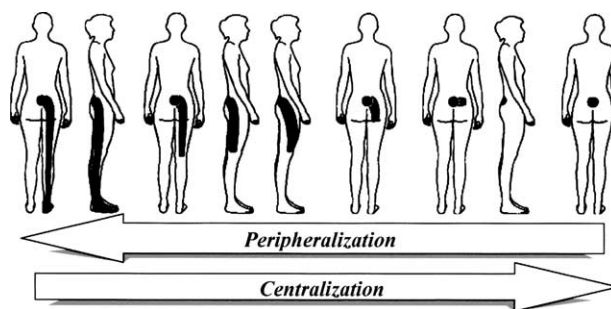


Fig. 2. “Centralization” is the progressive retreat of pain arising from the lumbar spine in a proximal direction, retreating back toward or completely to the lumbar midline. The initial pain might have spread only asymmetrically across the back or may radiate all the way to the foot. Alternatively, “peripheralization” is an increase in the extent of distal radiation of pain arising from the lumbar spine. These two patterns of pain response are commonly exposed during the performance of the repeated end-range testing illustrated in Fig. 1. Centralization is indicative of improving the underlying pain source, and peripheralization indicates it is being aggravated further.

fore the disappearance of the back pain. However, for centralization to be purposely induced within single or multiple clinical assessment sessions by identifying the patient-specific direction of beneficial spinal loading suggests that, first, discrete mechanical pathology exists and, second, that it remains rapidly reversible using patient-generated spinal loading forces.

Over the last decade, centralization and directional preference have been widely investigated. Interexaminer reliability in identifying centralization has been shown to be high [63]. Of further importance, centralization is commonly elicited during this form of dynamic assessment in acute patients, that is, in 73% to 89% [21,23,25,26]. Two studies also reported centralization was elicited in 45% to 50% of patients with chronic low back pain [22,24], whereas 52% of another cohort with sciatica and neurological deficit recovered full lumbar motion and eliminated all pain within 5 days of commencing extension treatment directed by this form of lumbar testing [29]. Five other observational cohort studies compared treatment outcomes between the centralizing and noncentralizing subgroups [21,23–26], all reporting that centralizers experienced significantly better outcomes than noncentralizers. The predictive value of this form of pain pattern classification was also shown to be significantly stronger than 22 other independent baseline variables, including psychosocial factors [27].

It is the strength of this literature that prompted Denmark's Low Back Pain Clinical Guidelines panel to assign the McKenzie assessment methods their highest recognition for scientific literature support [64].

A dynamic internal disc model and internal disc pain

Multiple cadaveric [65–67], discographic [68] and MRI [69] studies document posterior migration of nuclear content in response to anterior disc loading associated with lumbar flexion, as well as the oppositely directed anterior nuclear migration in response to extension loading. Considering that the annulus has nociceptors within its outer third [52,70] and has been identified as a common source of low back pain [71], it is plausible that pain that worsens with flexion may be related to an increase in mechanical noxious stimuli on the posterior annulus resulting from both annular tension and posterior migration of nuclear contents resulting from the anteroposterior pressure gradient set up across the disc by the anterior loading that occurs with lumbar flexion [22,28,45,60]. This pain-generating mechanism might be operative in many of the subjects in all four RCTs cited earlier [45–48].

Thus far, only one study has investigated how these repeated end-range lumbar tests might apply a spinal loading effect that changes pain known to be generated from symptomatic lumbar discs [22]. This study is worthy of a more thorough review. The authors compared the pain response findings of this form of mechanical examination with discographic findings, in particular whether the repeated end-range examination findings could differentiate discogenic

from nondiscogenic pain, as well as determine the state of annular competence in symptomatic discs. The authors postulated a dynamic internal disc model similar to that proposed by McKenzie [28] whereby an offset load applied to the disc in a symptom- and fissure-specific direction of spinal bending would apply a reductive force or load onto displaced nuclear content, redirecting it back toward its more physiologic central location. Such a reduction would require an intact, competent annulus and a functioning hydrostatic mechanism. The symptom-generating annulus and/or nerve root are consequently mechanically decompressed, resulting in a lessening of nociceptive stimuli and the centralization of pain. Again, the direction of spinal testing that elicits this beneficial pain response is referred to as the patient's "directional preference."

Based on this disc model, patients whose pain centralized during their mechanical assessment would be expected to have positive discography with a competent annulus based on a lack of contrast leakage and a positive injection pressure. Patients whose pain peripheralized during this mechanical testing would also be expected to have positive discography but with an incompetent annulus and nonfunctioning hydrostatic mechanism, that is, dye leakage and a lack of injection pressure buildup. Further, those whose pain could not be affected in any way (no change in pain location or intensity) with any of the mechanical testing/loading would be anticipated to have negative discography.

With both discography and this repeated end-range loading examination assessing patients' symptom response, it is logical to infer that the directional loading examination selectively loads various annular areas of a symptomatic disc using a standardized sequence of directional tests, whereas discography fills and pressurizes, that is, internally loads, the disc creating a mechanical or chemical stimulus to afferents in the outer layers of the annulus, accessing those layers through a symptomatic fissure.

This study sample consisted of 63 patients referred for lumbar discography mostly by surgeons who thought they were potential surgical candidates [22]. All had therefore failed their provider's version of "exhausting conservative care." MRI revealed disc degeneration but without root compression. Immediately before discography, patients were examined using this form of repeated end-range/pain response assessment with 50% reporting a single direction of testing that centralized their pain, indicating that their pain generator was likely reversible. Another 25% reported a worsening or peripheralization with all directions of testing, and the remaining 25% reported no effect on either their pain intensity or location with any direction of testing.

Consistent with the authors' hypothesis and dynamic internal disc model, the majority of patients in both the centralization and peripheralization groups subsequently had positive discograms (74% and 69%, respectively) with 91% of the centralization group versus only 54% of the peripheralization group having an intact annulus ($p < .042$), again consistent with the proposed model. In sharp contrast, only

12.5% of the “no effect” group had a positive discogram ($p < .001$). So the centralizing or peripheralizing symptom responses occurred most commonly in patients with discogram-positive pain, with the difference being the presence or absence of a competent annulus.

Considering the strong evidence for good outcomes for centralizers using the indicated nonsurgical self-care [21,23–26], it becomes very difficult to justify disc surgery in those whose pain centralizes during this form of mechanical assessment, regardless of symptom duration and all the other failed forms of conservative care. These numerous studies all indicate that the centralization pain response indicates the pain-generating lesion remains “reversible” or recoverable and speaks to the benefits of including this particular assessment technique as a routine part of clinicians’ efforts to “exhaust conservative care” preoperatively.

Role of mechanical assessment in radicular pain

As noted previously, mechanical therapy may not play a central role in the treatment of every neurocompression syndrome (radiculopathy, or stenosis) but should at the very least be valuable in a diagnostic sense. Provocation of leg pain in extension, for example, in the case of fixed bony foraminal stenosis does not necessarily imply annular incompetence, but rather dynamic nerve compression within the foramen. Likewise, the flexion preference displayed by patients with neurogenic claudication resulting from spinal stenosis reflects an attempt to perform an internal decompression and is essentially independent of the dynamic disc model. This is not, however, to imply that there is no benefit in using this form of assessment in patients with referred pain apparently resulting from nerve compression. The benefit again lies in the ability of this methodology to test the reversibility of both the symptoms and the commonly associated loss of range-of-motion related to the pathology. The simultaneous correction of both pain and motion loss would strongly suggest that both the pain generator and the movement inhibition are related to a single, reversible lesion, likely disc [29; van Helvoirt H, Donelson R, Aprill C; A rapid non-surgical recovery of chronic sciatica and neurologic deficit: a case report; unpublished] and not fixed neurocompression.

A provocative case report documents the rapid reversal of pain and full recovery in a patient with chronic, severe sciatica, neurologic loss, a lateral list and marked reduction in lumbar motion who was scheduled for lumbar disc excision [van Helvoirt H, Donelson R, Aprill C; A rapid non-surgical recovery of chronic sciatica and neurologic deficit: a case report; unpublished]. Using this form of directional repeated end-range/pain response assessment, the patient’s directional preference was identified when her pain centralized with prone laterally bent positioning and lumbar extension. With subsequent treatment based on these examination findings, recovery was rapid, complete, and surgery was avoided. Additionally, by the diligent application of the

very relevant exercises and posture strategies, the patient was also able to prevent all but one minor subsequent episode over 3 years of follow-up, despite many frequent prior episodes.

Similarly, Kopp et al. [29] published a retrospective observational study in 1986 calling attention to the prognostic and therapeutic value of determining whether a patient with lumbar disc prolapse and neurological deficits exhibited a “directional preference,” although only the extension direction was tested. Sixty-seven military personnel with pain radiating to the calf or foot with at least one significant physical sign of nerve root irritation (positive straight leg raises, motor weakness, dermatomal sensory loss or reflex change) and marked reduction in extension range of motion were hospitalized for surgical consideration because of the severity of their pain and/or failure to respond to outpatient care. All were then tested with end-range extension loading, performed in the prone position (Fig. 1, D), while their symptom response was monitored. Those whose peripheral pain did not worsen with this extension testing ($N=35$, 52%) were then instructed to perform extension exercises frequently, but only as tolerated, over the next few days. Of these 35, 34 (97%) recovered, 33 within 5 days, and all avoided surgery. The pain of the remaining 32 (48%) peripheralized with the initial testing and was unresponsive to any subsequent form of conservative care. All underwent diagnostic imaging and 30 (91%) underwent disc surgery. Demographic data indicated no difference between these surgical and nonsurgical groups regarding age, symptom location or neurological findings. The authors themselves postulated that this extension treatment was in keeping with a disc nuclear reversal model, as well as the earlier work of Nachemson [72] characterizing the pressure within lumbar discs during extension (normalized to a standing position) as substantially lower than during a relative loss of lumbar lordosis.

Two points from this study are especially noteworthy in light of subsequently published literature. First and most obvious, a large percentage of patients with compelling clinical evidence of nonrecovering compressive disc disease rapidly reversed their course using treatment determined by their pain response to directional lumbar testing. Secondly, because extension was the only direction tested, there may well have been additional patients who would have had an equally favorable response if they had been evaluated with other directions of testing (eg, lateral-left, lateral-right testing, rotation or flexion; Fig. 1). Although not as well documented in the scientific literature, these other directions reportedly can also elicit the same beneficial centralizing response and recovery [28,48,73,74].

Interexaminer reliability

The value of any clinical test is fundamentally based on its interexaminer reliability. For this form of repeated end-range assessment, Spratt et al. [75] reported strong reliabil-

ity, noting that this form of assessment provided useful diagnostic information and was helpful in identifying the most efficacious form of physical therapy for patients with nonspecific low back pain. Fritz et al. [63] also showed high reliability between examiners in determining the presence or absence of the centralization pain response, and Razmjou et al. demonstrated strong reliability between well-trained clinicians in categorizing patients into a standard classification scheme based on these pain responses to test movements [76]. Other studies have provided further support for the reliability of this form of assessment [26,77,78]. Larger patient samples with larger numbers of trained and untrained examiners are needed in future reliability studies.

Nonoperative treatment

In the absence of cauda equina syndrome, neoplasm or infection, nonoperative care is the rule for the initial treatment of both radicular and axial syndromes. Unfortunately, the literature is not clear on the efficacy of the various regimens, but most patients with a suspected disc herniation should be treated nonoperatively for at least a month [79]. Commonly used treatments include analgesics, nonsteroidal anti-inflammatory and muscle-relaxing medications, spinal manipulation and rapid return to normal activities while avoiding both bed rest and exercise in the acute periods [79]. Unfortunately, no specific physical therapy routine has been demonstrated as more efficacious than another with regard to shortening the duration of acute symptoms.

As discussed, mechanical assessment using repeated end-range/pain response directional testing [28] has received significant attention in the literature as a useful diagnostic tool. For most patients, including up to 50% of patients with chronic low back pain [22,24,29], directional characteristics can be found that reproducibly either ameliorate or aggravate a patient's clinical symptoms. For those who demonstrate a directional preference, the treatment recommended is self-evident, consisting of that specific direction of end-range exercises and appropriate symptom-driven posture strategies [45–47]. That the largest subset contains those whose symptoms respond beneficially to extension-directed care, with temporary avoidance of flexion [28,48], is also in keeping with all four RCTs described earlier [45–48] and patients' and clinicians' common anecdotal experience. These studies, plus the work of Nachemson [72] demonstrating a higher intradiscal pressure in sitting, all suggest a plausible explanation for the commonly observed clinical occurrence of patients with discogenic pain reporting increased pain with sitting. However, until randomized controlled outcome studies are performed on these pain response-determined subgroups, rather than on patients classified only as having nonspecific back pain, measuring the efficacy of any treatment will continue to be problematic [80,81]. No published RCT has yet investigated this form of care in patients with sciatica.

Mechanical basis for selecting surgical candidates: a proposal

As noted previously, "directional preference" is common in many patients with nonspecific low back pain [21–27,29,45–48,82]. It also correlates well with earlier intradiscal pressure measurements [72] and many biomechanical disc studies [53,54,65–67,69,83–87], strongly suggesting that the disc specifically is being assessed with this repeated end-range/pain response assessment. Given the excellent recoveries documented for these patients [21,23–27,82], the ability to identify the rapid recovery capability in those with known disc pain [22,29; van Helvoirt H, Donelson R, Aprill C; A rapid non-surgical recovery of chronic sciatica and neurologic deficit: a case report; unpublished], even those with neurogenic symptoms [29; van Helvoirt H, Donelson R, Aprill C; A rapid non-surgical recovery of chronic sciatica and neurologic deficit: a case report; unpublished], adds a great deal to our understanding and management of low back pain. Assessing the refractoriness of both "nonspecific" low back pain and sciatica is a valuable feature of this form of assessment. Given that centralization commonly occurs even in populations with chronic low back pain [21,22,24], symptom duration alone does not indicate refractoriness to appropriate conservative care.

Regardless of what diagnostic label(s) may have been previously applied, it is both logical and evidence-based that patients in whom centralization occurs will experience a good recovery with appropriate nonoperative care and should therefore rarely be surgical candidates. On the other hand, patients in whom centralization cannot be achieved and pain peripheralizes with all test movements are of particular interest, because a successful nonoperative outcome is much less likely. They often have pain below the knee as well as neurologic deficits [29]. Although many will centralize and recover [29], only peripheralizing pain with all directions of testing suggests either directionally irreversible nerve root compression or painful internal disc pathology [22,29], likely with annular incompetence [22]. Suffice it to say that the findings of a repeated end-range/pain response examination can assist in determining the likelihood of disc pathology, determine whether the pathology will reverse with some direction of mechanical loading or require surgical intervention.

A final note of caution must be sounded. Although the lumbar intervertebral disc is a very common symptom generator in patients with chronic low back pain, it is not the only one. Pain provocation and relief have been reported with diagnostic injections of both sacroiliac and facet joints and, occasionally, in more than one of these locations [8,9,88,89]. Thus, in order to interpret the results of positive discography and predict the results of surgical intervention, such as arthrodesis, one must be cognizant that additional symptom generators may exist and need to be considered. In the context of the McKenzie repeated end-range/pain response examination, pain produced by facet and sacroiliac

pathologies neither centralizes nor peripheralizes, although other response patterns may occur during the assessment [5]. This is distinct from the larger subset whose pain either centralizes or peripheralizes with various directions of end-range loading tests and who may have positive discographic findings [5,22].

Summary

In patients with nonspecific low back pain, response to a repeated end-range/pain response lumbar evaluation may provide information that is diagnostic, therapeutic and prognostic. Regardless of the duration of each patient's pain, the elicitation of pain centralization predicts a higher likelihood of successful response to conservative care using the directional findings of the evaluation and indicates that a lumbar disc is the likely source of that pain. The literature to date supports that the so-called "dynamic internal disc model" is clinically appropriate in this setting of low back pain. Annular integrity may also be determined using this form of assessment.

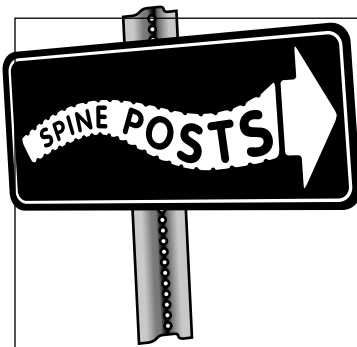
Given their favorable prognosis with nonoperative care, it is strongly suggested that patients who exhibit the centralization phenomenon should not undergo surgical treatment without a trial of directional treatment, focused on both exercises and postural strategies. Conversely, patients who have pain provoked or peripheralized with all directions of mechanical testing are more likely to have an irreversible disc lesion, involving either nerve root compression or annular fissuring, and are more likely surgical candidates. In the absence of compressive nerve root pathology on advanced imaging (eg, MRI), the majority of these "peripheralizers" would be expected to have positive discography with annular incompetence [5,22]; in this subset, intradiscal treatment or arthrodesis may be appropriate.

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Thirty Years Ago in Spine . . .

An engineer, Sir Godfrey Newbold Hounsfield, described, in 1973, his work on computer-assisted tomography or computerized axial tomography, also known as computed tomography. In 1979, he became the first engineer to be awarded a Nobel Prize for

Medicine. His work is honored by the name of units of measurement of pixels—Hounsfield numbers.

In the same year, Paul Christian Lauterbur presented a method of imaging tissues by use of nuclear magnetic resonance.

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