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A Prospective Study of Centralization of Lumbar and Referred Pain: A Predictor of Symptomatic Discs and Anular Competence

Donelson, Ronald MD*; Aprill, Charles MD†; Medcalf, Robert PT, Dip MDT‡; Grant, William EdD§

Author Information

From the *Institute for Spine Care, Department of Orthopedic Surgery, SUNY Health Science at Syracuse, Syracuse, New York, †Magnolia Diagnostics, New Orleans, Louisiana, ‡Novacare Outpatient Rehabilitation Division, Atlanta, Georgia, the §Department of Family Medicine, SUNY Health Science Center at Syracuse, New York.

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Address reprint requests to: Ronald Donelson, MD; Institute for Spine Care; 550 Harrison Center; Syracuse, NY 13202

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Abstract

Study Design. The presence or absence of rapidly centralizing, peripheralizing, or abolishing low back and radiating pain, as identified during a McKenzie mechanical lumbar assessment of patients with chronic lumbar pain, was compared prospectively with discographic pain provocation and anular competency.

Objectives. To evaluate any relation between the responses of centralization and peripheralization with discographic findings.

Summary of Background Data. Centralization of referred pain has been reported as a very common occurrence during McKenzie assessment and treatment. Patients whose pain centralizes have been shown to achieve superior treatment outcomes. A dynamic internal disc model has been hypothesized as an underlying mechanism for centralization that has not been studied previously.

Methods. Patients with chronically disabling low back pain who were referred for discography underwent preliminary blinded McKenzie clinical assessment and were categorized into three groups by their pain response. Patterns, or lack thereof, of pain response were then compared with blinded discographic pain

provocation and anular findings.

Results. During the McKenzie assessment, the referred pain of 50% centralized with 74% having positive discograms, of which 91% had an intact anulus. The pain of 25% peripheralized only (would not centralize); 69% of these had positive discograms, but only 54% had an intact anulus. The distal pain of 25% did not respond at all, and only 12.5% of these had positive discograms.

Conclusion. The McKenzie assessment process reliably differentiated discogenic from nondiscogenic pain ($P < 0.001$) as well as competent from an incompetent anulus ($P < 0.042$) in symptomatic discs and was superior to magnetic resonance imaging in distinguishing painful from nonpainful discs.

The Quebec Task Force Report stated: "There is so much variability in making a diagnosis that this initial step (i.e. clinical assessment) routinely introduces inaccuracies which are then further confounded with each succeeding step in care," adding that the resulting terminology used for diagnosis "is the fundamental source of error. Faced with uncertainty, physicians become inventive."³² Confusion further increases with the belief by far too many patients, providers, and payors that hightech imaging, by providing anatomic detail, is the standard for establishing a diagnosis. However, the high rates of false positive ^{4,14} and false negative ^{16,38} findings speak to the inadequacies of these studies in identifying the pain-generating lesion in the majority of cases.^{3,32}

Sources of pain commonly refer laterally in the low back, into the buttock, down the leg, and into the foot. Pain confined to the back, buttock, or thigh generates nearly as many theories of origin as the diversity of health care providers who treat these conditions. Once pain has "peripheralized" to the distal leg and foot, however, diagnostic opinion across all health disciplines converges, and intervertebral disc herniation is commonly concluded.

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Centralization and Directional Preference

A clinical phenomenon known as "centralization," first described by McKenzie,²⁰ occurs commonly [6,7,8,9,12,18](#) during the mechanical assessment of patients with low back pain, using repeated end-range lumbar test movements. The most distal extent of the referred or radicular pain, even if the pain has only spread as far as the lateral back, rapidly recedes toward and/or to the lumbar midline ([Figure 1](#)). Midline pain can also rapidly abolish under these same testing circumstances, by a single direction of repeated end-range movements.

Figure
1

During this standardized mechanical assessment ([Figure 2](#)), the most common direction of lumbar testing that centralizes pain (directional preference) is extension,^{8,20} whereas a smaller group will centralize only with laterally directed movements (sidegliding).^{9,20} It is a much smaller group whose pain will centralize and abolish with lumbar flexion only.^{8,20}

Figure
2

In addition, once centralized to the midline and then often abolished with additional end-range exercises, the pain commonly remains so, even after the centralizing end-range movements or positioning cease and the motion segments have returned to their mid-range position. However, movements or positioning in the opposite direction of bending often reproduce and/or re-peripheralize the pain (directional vulnerability) ([Figure 1](#)), which can then be recentralized/abolished with return to the original, beneficial patient directional movements.

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Dynamic Internal Disc Model

The mechanism and identity of the pain source has been left to speculation in patients whose pain can be centralized. In his 1981 text, McKenzie proposed that the direction of bending that centralizes the pain precisely corresponds with the direction in which disc nuclear content has abnormally migrated, generating referred symptoms by mechanically stimulating the anulus or nerve root.²⁰ As long as the anulus and the hydrostatic disc mechanism are intact, however, an offset load on the disc in the lesion-specific direction of spinal bending can apply a reductive force on the displaced nuclear content, directing it toward its original central disc location. Such a reduction of displacement would alleviate stress on the symptom-generating anulus and/or nerve root, thereby

centralizing and/or abolishing the pain, and identifying the patient's (or lesion's) "directional preference."

For displaced nuclear content that is symptom-producing to respond to an asymmetric load in a reductive/pain-centralizing fashion, the hydrostatic mechanism must be functional, and the nucleus must be contained within an intact anular envelope. However, if no centralizing direction is found during spinal testing, and if multiple directions of testing only peripheralize the distal pain, this dynamic internal disc model theorizes that the annulus is incompetent and the hydrostatic mechanism nonfunctional. If true, this would be the basis of why patients with extruded discs were noncentralizers/peripheralizers when assessed mechanically.⁷

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Diagnostic Disc Injection

Provocation discography is a test for discogenic pain and provides direct information about nuclear morphology and the status of the nuclear envelope.¹² There is no other way to reliably establish whether a disc is painful. Diagnostic criteria for discogenic pain have been established.²² Reliability of disc injection to accurately define anatomy has been demonstrated in cadaveric studies.¹¹ Under optimal conditions in the cadaveric spine, disc injection is superior to magnetic resonance imaging (MRI) for the detection of anular fissures communicating with the nucleus.³⁷

The reliability of pain response occurring during discography has been questioned.²⁴ Opponents of discography generally refer to the work of Holt.^{5,13} Thorough review of this study has summarily refuted the data on methodologic grounds.³¹ The experiment has been replicated in a stringently designed, carefully executed study. Under controlled conditions, Walsh et al found that lumbar discs do not hurt during injection and distention in asymptomatic individuals.³⁵

Postinjection computed tomography (CT) scanning provides an axial view of the injected discs. Patterns of radial and concentric anular fissures are more clearly defined in this plane. Computed tomography discography has revealed a greater degree of organization of these fissures than had been realized previously. Vanharanta et al ³⁴ and then Monetta et al ²³ reported that pain production at discography correlates directly with the extent of

anular disruption.

It is not possible to conclude that discography, performed objectively even in the hands of an expert, is the gold standard in diagnosing symptomatic discs. Though invasive and, therefore, limited in its use, it is the best assessment we currently have.

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Study Overview

This prospective, blinded study of patients with chronic low back pain seeks to evaluate the existence of a relation between patterns of pain response (i.e., centralization, peripheralization) during a clinical, mechanical assessment and the pain provocative and anular competence findings of discography. Our hypothesis, consistent with the dynamic internal disc model, specifies that: 1) pain that centralizes is discogenic and arises only from discs whose anulus is intact; 2) pain that peripheralizes only is also discogenic, but arises from discs whose anulus is no longer functionally competent; and 3) referred pain whose location cannot be changed rapidly with repeated end-range testing is not discogenic.

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Methods

The survey population consisted of 63 patients, 41 men and 22 women. All complained of low back pain, with varying degrees of lower extremity pain and altered sensation. Average age was 39.6 years (SD 11.1 years). All patients' symptoms were present for more than 3 months, with a median duration of 15.3 months (SD 12.2 months).

Patients were drawn largely from metropolitan New Orleans, with many interurban and some interstate referrals. All were referred for discography by neurosurgeons, orthopedists, or physiatrists. Referrals were based on continued pain sufficiently severe to warrant invasive testing, failure of a variety of conservative care programs, and one or more MRI studies without compelling surgical indications. The majority of patients were experiencing pain below the knee. None had neurologic deficits. The majority (69.9%) were not working as a result of their back pain. Insurance coverage was divided between worker's compensation (42.8%), medical/legal (30.1%), and private self-pay (27.1%).

All patients had been evaluated by lumbar MRI, some with myelography and postmyelography/CT. All scans were reviewed by the discographer before disc injection.

Patient entry into the study was dictated by scheduling. Consecutive patients scheduled for discography on days the study therapists were available at the radiology practice were enrolled in the study. Patients with a history of prior lumbar surgery, including chemonucleolysis, were excluded.

Mechanical Evaluation and Classification. Upon each patient's arrival at the radiology clinic for their scheduled diagnostic injection, demographic information was obtained, as well as informed consent regarding the preliminary McKenzie mechanical assessment. All patients then underwent a standardized mechanical evaluation, as described by McKenzie,²⁰ including multiple directions of loaded and unloaded repeated end-range lumbar spinal testing ([Figure 2](#)).

Each patient was examined by one of five therapists who participated in the study. To maximize their level of clinical competence and effectiveness in the McKenzie assessment process, all five were Diplomats in Mechanical Diagnosis and Therapy, having completed a sequence of four postgraduate courses presented by the McKenzie Institute, passing a credentialing examination, and successfully completing a 10-week Diploma program. In addition, all were faculty members of the McKenzie Institute, USA.

The first 40 patients were all examined by one therapist (RM), representing the pilot portion of this study. The study was then expanded to include 4 other therapists who evaluated the remaining 23 subjects. Each therapist was blinded to all previous medical records and images of each patient and used only their clinical skills of history-taking and mechanical examination of the patient. This consisted of repeated end-range lumbar test movements to determine the effect on the patient's pain location.

One of three effects on pain was identified during each patient's mechanical assessment and then recorded by the therapist: 1) rapid centralization of the referred pain or abolition of pain, if only low back pain (Centralizers), 2) no centralization, but peripheralization of pain in one or more directions (Peripheralizers), and 3) no

change in the distal-most pain location or intensity (No Change).

Diagnostic Disc Injection. Immediately after this mechanical evaluation, patients underwent lumbar discography by a single investigator (CA) blinded to the findings of the mechanical assessment. A standardized technique was used,¹ with an extrapedicular approach from the side opposite the dominant pain. The lowest two lumbar discs were studied initially, because all patients suffered from pain in the lumbosacral region. Additional levels were included if pain was centered above the lumbosacral junction or if there was an abnormality noted on screening MRI (anular fissure, reduced T2 signal). A minimum of two discs and as many as four levels were studied, including one control level, in all patients.

Contrast was slowly instilled into each disc, with the volume recorded. Resistance to injection was characterized as poor, fair, or firm. Endpoint characteristics of sustained or unsustained resistance were recorded. Frontal and lateral radiographs were obtained at endpoint. If there was no resistance after injection of 3.0 ml, or if pain response occurred at a low volume, injection was continued under fluoroscopic visualization, with spot filming during injection. Nucleograms were graded as normal (organized) or abnormal (disorganized with endplate disruption and/or anular fissures). Poor resistance to injection coupled with contrast spreading through the anulus to the epidural/perineural or peridiscal space was interpreted as complete anular disruption and the hallmark of noncontained pathology. Firm resistance was interpreted as an intact outer anulus, contained pathology, even if contrast material leaked from the disc at peak injection pressure.

During disc injection, each patient was assessed for pain response by the discographer and a second observer. In addition to spontaneous verbalization, secondary signs (grimace, withdrawal, moaning) and physiologic changes (increase in pulse rate) were recorded. If a pain response was induced, the patient was queried regarding the character, distribution, and intensity of the pain with reference to primary symptoms. Responses were graded as no pain, similar pain, exact pain reproduction, or atypical pain.

After the procedure, axial CT was performed on all painful discs. Discs exhibiting radial and/or concentric fissures involving the

outer third of the annulus were graded as abnormal.[30](#)

The criteria for a positive discogram were exact pain reproduction and an abnormal image (nucleogram/CT), provided no pain was reproduced at adjacent control level.

Statistical Analysis All data were entered into a dBase IV. Analyses were conducted using the SAS PC Version 6.0 for Windows analysis programs (SAS Institute, Cary, NC). Initial data reduction was accomplished through the production of descriptive statistics. Differences in categorical variables were analyzed using chi square analysis. Continuous variable analysis included the use of t tests, with z tests for proportional analysis, as appropriate. All significant testing was a priori established at $P < 0.05$ for acceptance.

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Results

There were no significant differences between the three pain response groups in regard to gender, age, duration of symptoms, or insurance type.

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Mechanical Evaluation Results

Our study results are illustrated in [Table 1](#). During the initial McKenzie mechanical assessment, the referred pain of 31 subjects (49.2%) could be centralized with a single direction of spinal testing (Centralizers). The pain of 16 patients (25.4%) could not be centralized but did peripheralize (Peripheralizers). The remaining 16 (25.4%) experienced no change in the distal extent of their referred pain (No Change).

Table 1

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Discogram Results

Thirty-six patients (57%) had positive discograms, of which 29 (81%) did not leak dye. The other 27 patients (43%) had negative disc injections.

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Correlation of Mechanical and Discogram Results

[Table 1](#) further illustrates that, of the 31 patients (49.2%) who were

Centralizers, 23 (74%) had a positive discogram ($P < 0.007$). Of those 23, the anular wall of the positive disc was competent in 21 patients, or 91% ($P < 0.001$).

Of the 16 patients (25.4%) who were Peripheralizers, 11 (69%) had a positive discogram ($P < 0.004$). Of those 11, the anular wall of the positive disc was competent in 6 patients (54%) ($P = 0.093$) ([Table 1](#)).

Of those 16 patients (25.4%) whose pain had No Change, only 2 (12.5%) had a positive discogram ($P < 0.001$). The anular walls of these two positive discs were both competent ([Table 1](#)).

Considering the high incidence of positive discograms in Centralizers and Peripheralizers, and the low incidence in the No Changers, the ability to distinguish between a positive and a negative discogram on the basis of these pain responses alone was highly significant ($P < 0.001$) ([Figure 3](#)).

Figure
3

In patients with positive discograms, the difference between the incidence of discs with a competent anulus that occurred in Centralizers was significantly greater than what occurred in Peripheralizers ($P < 0.042$) ([Figure 4](#)).

Figure
4

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Discussion

Both discography and the McKenzie testing methods use a patient's self-report of symptom response in determining testing outcomes. Critics of both types of assessment state that such self-report of symptoms is too subjective to be reliable, largely basing this generalization on the relatively small percentage of the low back pain population in whom psychosocial factors influence the reporting of the character, intensity, and location of their pain.

Pain intensity and one's functional response to symptoms are subjective. However, patterns of pain response to stimulation of the pain generator are, by contrast, quite objective. The provocation of a patient's concordant pain with straight-leg-raise testing and the pattern of neurogenic claudication related to lumbar stenosis are just two common examples of reliable, relevant pain response patterns. Numerous published studies document that self-reporting of pain patterns is quite objective and measurable, with high intertester reliability.[6,10,19,25,26,27,32,33](#) One prospective,

blinded study of self-reporting of pain response to single and repeated end-range lumbar test movements and to Waddell tests concluded: "The presence or absence of pain behaviors during the maneuver is an objective end-point or threshold to determine whether a physical sign is present."[33](#)

Just as discography stimulates the painful anular pathology, our study results would indicate that repeated end-range spinal test movements in multiple directions can identify a lesion-specific direction of asymmetrical disc loading that similarly, but dynamically, stimulates this same symptom-producing pathology. This enables a functional assessment of anular competence, the hydrostatic mechanism, as well as the ability of the internal disc derangement to reduce its displacement.

Although our findings support the validity of McKenzie's dynamic internal disc model, the precise neural mechanism by which pain centralizes remains uncertain. The key role of the anulus as a pain generator, however, seems clear.

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Relevance of Discography

Discography's strength is its ability to provoke the pain-generating lesion evidenced by reproduction of the patient's concordant pain. As a research tool, discography has shown, with high sensitivity, the clinical relevance of the high-intensity zone in the posterior anulus, as seen on MRI, as a source of pain,[2,29](#) as well as the ability of spinal segmental vibration to provoke concordant pain in discs with symptomatic internal anular fissures.[36](#)

Whereas noninvasive spinal imaging procedures (radiography, CT, MRI, myelography) objectively provide detailed visualization of spinal anatomy, they are unable to determine which findings are pain sources. To be useful, a diagnostic intervention must possess both objectivity and relevance to the pain generator.

One of several advantages of the McKenzie assessment is that, unlike invasive discography, it can be easily and safely implemented in the acute setting, allowing for early identification of these relevant pain response groups, enabling nonoperative treatment to be based on objective mechanical findings, with the routine avoidance of expensive imaging and ineffective treatments.

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Frequency of Centralization

Considering the lack of objective clinical findings on which to base a diagnosis, prognosis, or treatment selection for patients with low back pain,[3,32](#) it is significant and highly useful that centralization of referred pain and the related rapid abolition of central pain (occurring with movements in a patient's "directional preference") are so commonly identifiable during repeated end-range test movements in this and other studies [6,7,8,9,12,18](#) and with evidence of intertester reliability.[15,25,26,33](#)

The 50% rate of centralizers found in our chronic population compares closely with Long's [18](#) report of 47% in a long-term work-hardening program and 58% in a two-part, prospective, randomized study evaluating the various directions of spinal testing that centralized an individual's pain [8,9](#); Delitto et al [6](#) and Erhard et al [12](#) reported 61% and 55%, respectively. Referred pain centralized in 84% of patients symptomatic for longer than 12 weeks in a private, general orthopedic practice, where the duration of symptoms may have been considerably less than either Long's or our study populations.[7](#) In addition, there were no time or technique constraints to the McKenzie assessment process in this latter study,[7](#) compared with our current and the Long studies.[18](#)

Centralization occurred in the Donelson study even more frequently in the acute and subacute patients [7](#): in 89% of those symptomatic for less than 4 weeks and in 86.6% of those symptomatic between 4 and 12 weeks. If centralizing pain is discogenic with a competent anulus, as our current study demonstrates ($P < 0.001$), this strongly suggests that the disc and its innervated anulus may be the source of pain in a high percentage of patients with low back pain, supporting Kuslich's conclusion that "the outer anulus is the tissue of origin in most cases of low back pain."[17](#)

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Outcome Predictor

The Long and Donelson studies further show there to be strong predictive value in identifying whether referred pain can be centralized.[7,18](#) In both studies, centralizers had superior

recoveries compared with noncentralizers. The Donelson study reported excellent and good outcomes in 98% of centralizers symptomatic for less than 4 weeks, 77% of those symptomatic 4-12 weeks, and 81% symptomatic for longer than 12 weeks. Such favorable outcomes clearly need further research for verification.

In this same study, patients whose imaging demonstrated an extruded disc had all been noncentralizers when mechanically assessed, and then underwent successful surgical disc excisions.⁷ This suggests that centralizing pain might arise from a contained intervertebral disc source while noncentralizing pain may also be discogenic, but with a breached anular wall and an incompetent hydrostatic mechanism.

Centralization may well be related to the "reversibility" of the pain-generating lesion in many patients, as well as the specificity of those directional exercises/positions identified during the assessment that reduced the displacement and decompressed the pain-generating anulus, thereby centralizing and abolishing patients' pain.

These findings suggest that the centralizers in this study, despite their chronicity, may still have a favorable prognosis for recovery with nonoperative treatment using the directional exercises and postural strategy identified during their McKenzie assessment. Retrospectively, the pain of our centralizing patients may have responded very well at the time of symptom onset (average duration of symptoms at time of study: 15 months) if they had just been similarly assessed and treated at that time. The potential cost savings in eliminating the need for their many subsequent ineffective treatments and expensive diagnostic tests would be significant and needs further study.

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McKenzie Learning Curve and Reliability

The therapists in this study possessed a high level of training in the McKenzie assessment process. An understanding of this expertise is important in light of the Riddle and Rothstein study, which reported that a group of physical therapists designated as being "trained in McKenzie," although in reality having completed only the first of the four basic courses, were found to be no more reliable in their assessment findings than an "untrained" group.²⁸

Kilby et al [15](#) compared the assessment findings of just two physiotherapists who had each completed only the first basic course in McKenzie and found there to be strong intertester agreement in arriving at a mechanical diagnosis and determining the presence or absence of centralization.

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Study Limitations

Since discography, as an invasive study, cannot be justified in patients with acute or subacute pain, our study had to be limited to patients with chronic back pain. However, the high correlation between centralization and contained disc pathology seen here might also be anticipated within the populations with acute and subacute pain. The greater value of the McKenzie assessment is in its application in the acute and subacute populations.

Because of the large number of referring physicians distributed throughout a wide geographic area, this study includes no patient follow-up to document subsequent treatment selection or outcomes.

It has not been documented how successfully clinicians with lesser expertise in the McKenzie system of evaluation would be in centralizing the pain of patients with chronic low back pain. Our extensive clinical experience would indicate, however, that more experienced McKenzie clinicians can more frequently identify mechanical means of centralizing pain than those with less experience.

Clinical experience with the McKenzie assessment process indicates that the directional mechanism that will centralize and/or abolish pain is at times complex and requires two or three sessions to identify and confirm, especially in the chronic population. Because therapists in this study were limited to a single 30- to 45-minute session with each patient, it is possible that the percentage of centralizers in our study population may have been even higher if either longer or multiple assessment sessions had been available.

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Summary

This study of nonherniated discs in a chronic, out-of-work, workers-compensation/litigation patient population strongly

supports that a noninvasive, low-tech, relatively inexpensive clinical assessment using repeated end-range lumbar test movements can provide considerably more relevant information than noninvasive imaging studies. Namely, it can reliably distinguish between discogenic and nondiscogenic pain and provides considerable help in distinguishing between a competent and incompetent anulus.

Specifically, centralization occurred frequently (50%) in this chronic population. Most "centralizers" had discogenic pain with a functionally competent anulus, whereas "peripheralizers" also tended to have discogenic pain but with a much higher incidence of outer anular disruption. In addition, patients whose referred/radiating pain could not be affected were shown to have negative discograms.

To our knowledge, there has never been such a strong correlation demonstrated between disc morphology and clinical assessment findings in any population with low back pain.

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Key words: anulus; centralization; directional preference; discography; McKenzie; peripheralization

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Section Description

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Figure 1

Figure 2

Table 1

Figure 3

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