

Clinical Studies

Centralization as a predictor of provocation discography results in chronic low back pain, and the influence of disability and distress on diagnostic power

Mark Laslett, PT, DipMT, DipMDT^{a,*}, Birgitta Öberg, PhD^a, Charles N. Aprill, MD^b, Barry McDonald, PhD^c

^aDepartment for Health and Society: Physiotherapy, Linköping University, Linköping 5-581 83, Sweden

^bMagnolia Diagnostics, 2718 Cadiz St., New Orleans, LA 70115, USA

^cMassey University, Institute of Information and Mathematical Sciences, Albany Campus, Private Bag 102-904, North Shore Mail Centre, Auckland, New Zealand

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Abstract

BACKGROUND CONTEXT: The “centralization phenomenon” (CP) is the progressive retreat of referred pain towards the spinal midline in response to repeated movement testing (a McKenzie evaluation). A previous study suggested that it may have utility in the clinical diagnosis of discogenic pain and may assist patient selection for discography and specific treatments for disc pain.

PURPOSE: Estimation of the diagnostic predictive power of centralization and the influence of disability and patient distress on diagnostic performance, using provocation discography as a criterion standard for diagnosis, in chronic low back pain patients.

STUDY DESIGN/SETTING: This study was a prospective, blinded, concurrent, reference standard-related validity design carried out in a private radiology clinic specializing in diagnosis of chronic spinal pain.

PATIENT SAMPLE: Consecutive patients with persistent low back pain were referred to the study clinic by orthopedists and other medical specialists for interventional radiological diagnostic procedures. Patients were typically disabled and displayed high levels of psychosocial distress. The sample included patients with previous lumbar surgery, and most had unsuccessful conservative therapies previously.

OUTCOME MEASURES: Diagnosis: results of provocation discography. Index test: The CP. Psychometric evaluation: Roland–Morris, Zung, Modified Somatic Perception questionnaires, Distress Risk Assessment Method, and 100-mm visual analog scales for pain intensity.

METHODS: Patients received a single physical therapy examination, followed by lumbar provocation discography. Sensitivity, specificity, and likelihood ratios of the CP were estimated in the group as a whole and in subgroups defined by psychometric measures.

RESULTS: A total of 107 patients received the clinical examination and discography at two or more levels and post-discography computed tomography. Thirty-eight could not tolerate a full physical examination and were excluded from the main analysis. Disability and pain intensity ratings were high, and distress was common. Sensitivity, specificity, and positive likelihood ratios for centralization observed during repeated movement testing for pain distribution and intensity changes were 40%, 94%, and 6.9 respectively. In the presence of severe disability, sensitivity, specificity, and positive likelihood ratios were 46%, 80%, 3.2 and for distress, 45%, 89%, 4.1. In the subgroups with moderate, minimal, or no disability, sensitivity and specificity were 37%, 100% and for no or minimal distress 35%, 100%.

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* Corresponding author. 3/346 Richardson Rd., Mt. Roskill, Auckland 4, New Zealand. Tel.: +64 (9) 626-0015.

E-mail address: mark.laslett@xtra.co.nz (M. Laslett)

CONCLUSIONS: Centralization is highly specific to positive discography but specificity is reduced in the presence of severe disability or psychosocial distress. © 2005 Elsevier Inc. All rights reserved.

Keywords:

Chronic low back pain; Diagnosis; Intervertebral disc; Discography; Centralization of pain; Sensitivity; Specificity; Psychosocial distress; Disability

Introduction

Most episodes of low back pain (LBP) are benign, self-limiting, and resolve within a few days or weeks. However, approximately one-third of patients report persisting pain and activity limitation 12–30 months after initial presentation to primary care [1,2]. The intervertebral disc is the most common source of persistent nociception in LBP with at least 39% having internal disc disruption [3]. Approximately 30% of cases have pain mediated by either the sacroiliac joint [4,5] or zygapophysial joints [6]. It is rare for patients to have more than one source of nociception [7].

Making the diagnosis of primary discogenic pain is not straightforward. Plain radiographs and computed tomography cannot differentiate painful from nonpainful pathology [8,9]. Magnetic resonance imaging can identify many morphological identities, but most of these are present in asymptomatic individuals [10–13]. Outer annulus disruptions and high-intensity zones imaged by magnetic resonance imaging correlate with provocation of familiar pain during discography [12,14–16], but not all discs that produce pain during discography have abnormal signal intensity, disc contour, or significant signs of degeneration on magnetic resonance imaging [17]. Hydraulic distension of lumbar discs during discography does not normally provoke pain in asymptomatic patients [18], but does provoke familiar LBP in at least one level and is painless at an adjacent level in at least 39% of patients [3].

Provocation discography is the only credible method of directly testing the disc, and is the only reference standard available for validity studies of clinical tests for discogenic pain [19]. Yet there is controversy surrounding its validity. Proponents of discography argue that it is a highly specific test for primary discogenic pain [18,20], and inter-examiner reliability of discographic findings is acceptable [15]. Others have doubts about its diagnostic and clinical value [21,22]. Regardless, it remains the de facto standard for confirming the disc as a pain generator in LBP patients [17,19]. However, not all patients should receive this test because it is invasive and expensive. It has been stated that the key challenge for discographers is to determine how to identify those patients likely to benefit from this diagnostic test [20].

The physical examination is generally regarded of little value in diagnosis of the tissue source of pain [23], or classifying back pain patients into subgroups that respond differently to different treatments [9,24]. The only clinical assessment methods potentially capable of identifying LBP of discogenic origin are vibration [25] and centralization

or peripheralization of referred pain during a McKenzie assessment of repeated movements [26]. The centralization phenomenon (CP) is the progressive retreat of referred pain towards the midline of the back in response to standardized movement testing during evaluation of the effect of repeated movements on pain location and intensity. Peripheralization is the progressive movement of the pain further from the midline of the back towards the periphery or significant worsening of the most peripheral symptoms [27]. Inter-examiner reliability of the examination for these phenomena is acceptable when carried out by trained examiners [28,29], but unreliable when carried out by examiners with minimal or no training [30].

What does the CP actually represent with regard to the experience of LBP? McKenzie hypothesized that movement of the internal contents of the intervertebral disc is the mechanism underlying the progressive movement of pain towards or away from the spinal midline [27,31]. The relationship between these phenomena and discogenic pain has been investigated. In a study of 63 chronic LBP patients, Donelson et al. [26] reported that centralization of pain occurred in 31 (49%) patients during the McKenzie evaluation, of whom 23 (74%) had positive provocation discography. Of 16 patients whose symptoms peripheralized, 11 had positive discography. From these data, it can be calculated that centralization has sensitivity, specificity, and positive likelihood ratios of 0.92, 0.64, and 2.5, respectively, and peripheralization of 0.69, 0.64, and 1.9, respectively. Collectively these two signs have sensitivity, specificity, and positive likelihood ratios of 0.92, 0.52, and 1.96, respectively [32]. Although Donelson et al. describe the phenomena in detail, it is unclear whether the physical therapy examiners in his study actually used the definition for determining CP or peripheralization in a formal prospective fashion and consistently among the different examiners.

This report presents the results of a study investigating the predictive value of centralization in relation to provocation discography as the reference standard. The criteria for centralization and peripheralization were consistently applied throughout the study in a prospective fashion. There is abundant evidence that psychosocial and patient distress factors profoundly influence therapeutic outcomes [33], and discogenic back pain patients are more disabled and distressed than other back pain patients [34]. Patient disability and distress appear to be associated with increased reports of pain during discography [35] and discography false-positive rates [21,36]. In this study we also evaluated the influence of distress and disability dimensions on the diagnostic power of the CP in relation to provocation discography.

Methods

Design

A blinded prospective concurrent validity design was used to evaluate the diagnostic value of centralization in relation to the reference standard of provocation discography. Measures of disability, psychosocial distress, and illness behavior were evaluated as factors influencing diagnostic power.

Patients

Ethical approval for the study was granted by the local Institutional Review Board. Patients with persistent LBP with or without lower extremity symptoms referred to a private radiology practice specializing in the diagnosis of spinal pain were invited to participate in the study. Between May 2001 and October 2002, a physical therapist attended the clinic in blocks that ranged from 4 to 8 weeks and examined patients before discography. Normal scheduling of patients was not affected, so patients were consecutive during these periods. Patients were excluded from the study if they had a normal magnetic resonance imaging, severe degeneration associated with spondylolisthesis and other relative contraindications for discography, or the terms of referral ruled out discography. Patients too frail to tolerate a full physical examination or who denied informed consent were excluded. Most patients were referred by a variety of medical and paramedical practitioners. A few were self-referred.

Measurements

At the initial interview, clinic staff recorded basic demographic and medical data that included the following: *Pain*: 100-mm visual analog scales for current, best, and worst pain. The 23-point Roland–Morris Disability Questionnaire [37] was completed to evaluate disability, and psychosocial distress was estimated using the Zung Depression Index [38], Modified Somatic Perception Questionnaire (MSPQ) [39], and the Distress Risk Assessment Method (DRAM) [40].

The physical examination

After the initial interview, a history was taken, and a structured physical examination was carried out by a physical therapist with 30 years of clinical experience as a manipulative therapist who is a former senior instructor for the McKenzie Institute International. Some patients were examined by another therapist with 17 years of clinical experience who is credentialed in the McKenzie method of examination and treatment. The examination required 30–60 minutes and was conducted before the discography examination, and in almost all cases on the same day. Inconclusive findings or incomplete examinations were documented. The physical examination included a visual assessment of flexion, extension and lateral flexion range of motion, documentation of

anatomical location of dominant pain, and a standard examination of nerve root function. Provocation sacroiliac joint tests [41,42] and the items of history and physical examination previously used to identify symptomatic facet joint pathology were also included [43]. Where possible, Waddell's tests for signs of inappropriate pain behavior were carried out [44].

The physical examination included a McKenzie styled assessment [27], which uses but is not limited to: assessment of the lumbar lordosis, presence of a visible lateral shift, and standardized repeated end range movements. The most commonly used movements are depicted in [Figure 1A–H](#). A complete examination was attempted in all cases. When limited by patient tolerance or time constraints, this was recorded.

During this study, centralization of pain was recorded if the pain in the furthest region (buttock, thigh, calf, or foot) from the midline of the lumbar spine was abolished or significantly reduced. Peripheralization was recorded when pain was caused to move further from the midline of the spine towards the foot, or if the most peripheral symptoms were substantially worsened, but could not be reduced or centralized again. If a clear symptomatic response to repeated movements revealed centralization or peripheralization, this portion of the examination was terminated. A current pain visual analog scale was repeated after the clinical examination and following discography.

Discography examination

Discography was carried out using standard technique [45], by a practitioner with 20 years of experience performing discography or by a resident under his guidance. Patient responses to the introduction of fluids into the center of the disc were recorded, with pain provoked being documented as either concordant or atypical. The pressures at which fluids initially entered the disc (opening pressure), at pain provocation and at maximum (final pressure) were recorded. When at least one disc provoked a concordant pain response and an adjacent disc provoked no pain, a diagnosis of discogenic pain was recorded. Discography at a single level fails to satisfy the accepted reference standard [19], and these cases were excluded from the main analysis. Failure of the patient to report pain provocation or the report of atypical/discordant pain during injections resulted in the conclusion that discogenic pain was excluded, at least at those levels. Local anesthetic was injected into discs that were painful. After discography, axial computed tomographic sections were obtained through selected discs within 30 minutes to evaluate contrast distribution and fissuring patterns.

Blinding

The physical therapist conducting the clinical examination was unaware of the results of previous imaging studies, any previous diagnostic injections, and the Roland–Morris Questionnaire, Zung Depression Index Questionnaire, and



Fig. 1. Repeated test movements used to identify the centralization and peripheralization phenomena. (A) Flexion in standing. (B) Extension in standing. (C) Right side gliding. (D) Right side gliding with overpressure. (E) Flexion in lying. (F) Extension in lying. (G) Extension in lying in left side gliding. (H) Right rotation in flexion (continued next page).

MSPQ. The discographer was blinded to results of the physiotherapy examination and diagnostic conclusions, but not to the results of questionnaires.

Data analysis

Basic statistical values for demographic and other variables and regression or multivariate analyses were calculated using statistics software (Minitab version 14.12, Minitab Inc., State College, PA, 2004). A few patients refused or failed to complete the Roland–Morris, Zung, and MSPQ questionnaires. Raw scores from incomplete questionnaires may underestimate the magnitude of the behavior measured. Adjusted scores were calculated as the product of the raw

score and the total number of questions divided by the number of questions answered.

Sensitivity, specificity, and likelihood ratios with 95% confidence intervals were calculated for individual variables using Confidence Interval Analysis software (copyrighted Bryant T.N., 2000) [46]. Multiple logistic regression analyses were used to identify variables influential in the prediction of provocation discography, such as psychosocial factors.

Results

A physical examination and discography were carried out on 118 patients. Eleven were excluded from initial analysis



Fig. 1. Continued.

for technical reasons; eight because discography was carried out only at a single level and no negative control was possible; one with negative discography at two levels and an uninjected level with resolving discitis at one level that was not injected (diagnosis based on radiographic imaging); two because of conflicts in reporting of discography results. A

total of 107 patients were included in the initial analysis. Basic demographic and questionnaire results for all, excluded and included patients are presented in [Table 1](#). In a proportion of cases, intolerable pain, unwillingness to cooperate, fear avoidance, and incapacity because of disability or poor physical condition prevented accumulation of data

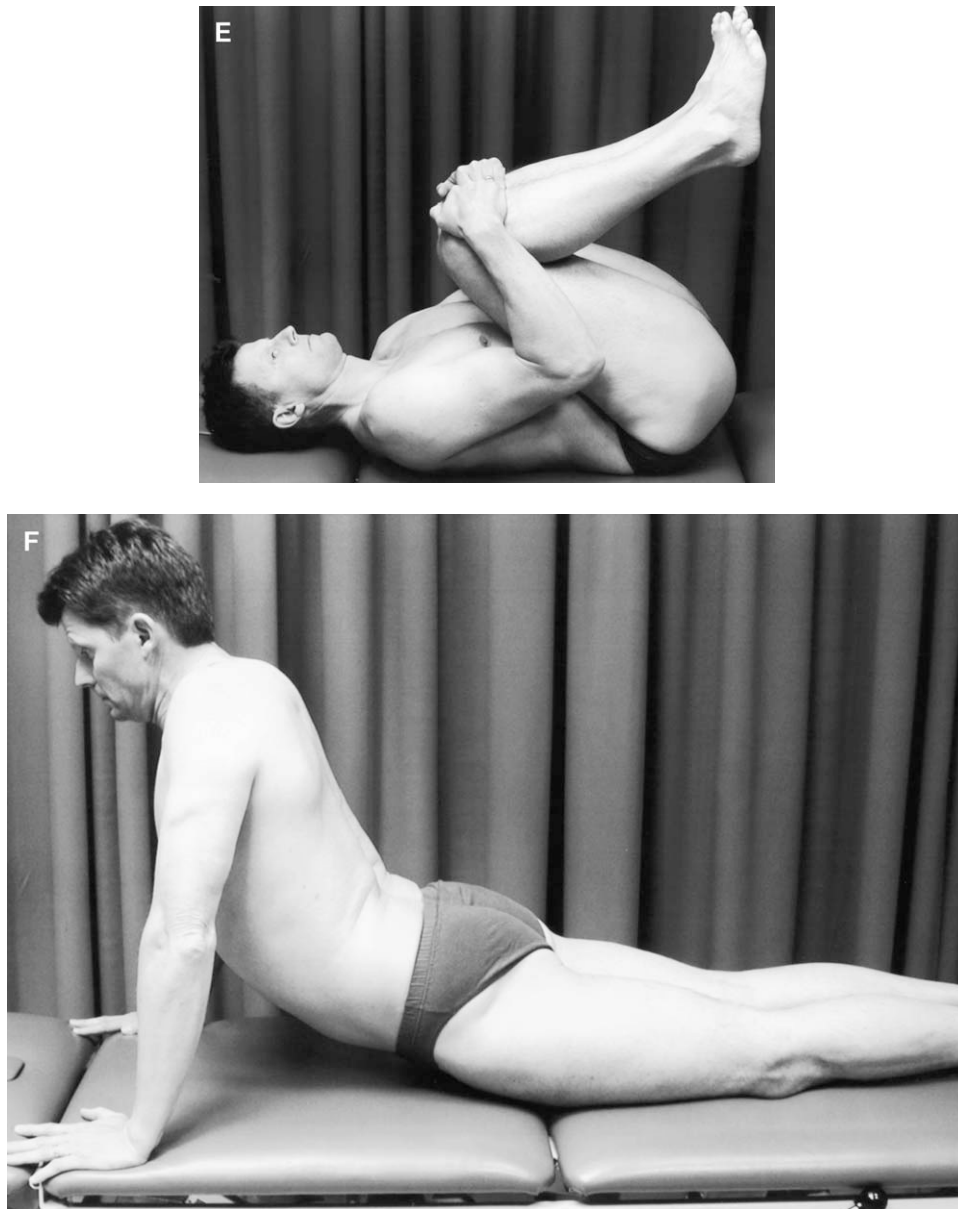


Fig. 1. Continued (continued next page).

relating to the McKenzie assessment. A full evaluation was achieved in 69 cases (64%), a partial examination in 21 cases, and no examination in 17. Those not undergoing a complete examination had higher pain scores ($p \leq .001$), greater disability ($p < .001$), higher depression scores ($p = .009$), and a greater proportion had previous lumbar spinal surgery (42% vs. 23%, $p = .05$). Table 2 presents data on the number of levels injected and the number of discs that were provocation positive for each group.

Of those included in the main analysis, differences between patients with negative versus positive discography with regard to disability, depression, somatization, and pain intensity were insignificant ($p > .1$). However, pain intensity

at its worst showed a trend to being more severe in the positive discography group ($p = .06$).

Table 3 presents diagnostic performance statistics for all patients and various subgroups. The examining physical therapist offered an opinion regarding the CP for 83 patients even though the repeated movements examination was incomplete in some cases (Table 3, Line A). Line B of the table presents results for those cases where a full repeated movements examination was completed ($n = 69$). Lines C and D present results for subgroups dichotomized for distress as determined by the Distress Risk Assessment Method [40]. Lines E and F present results for subgroups dichotomized for severe disability as determined by the Roland-Morris Questionnaire [47].

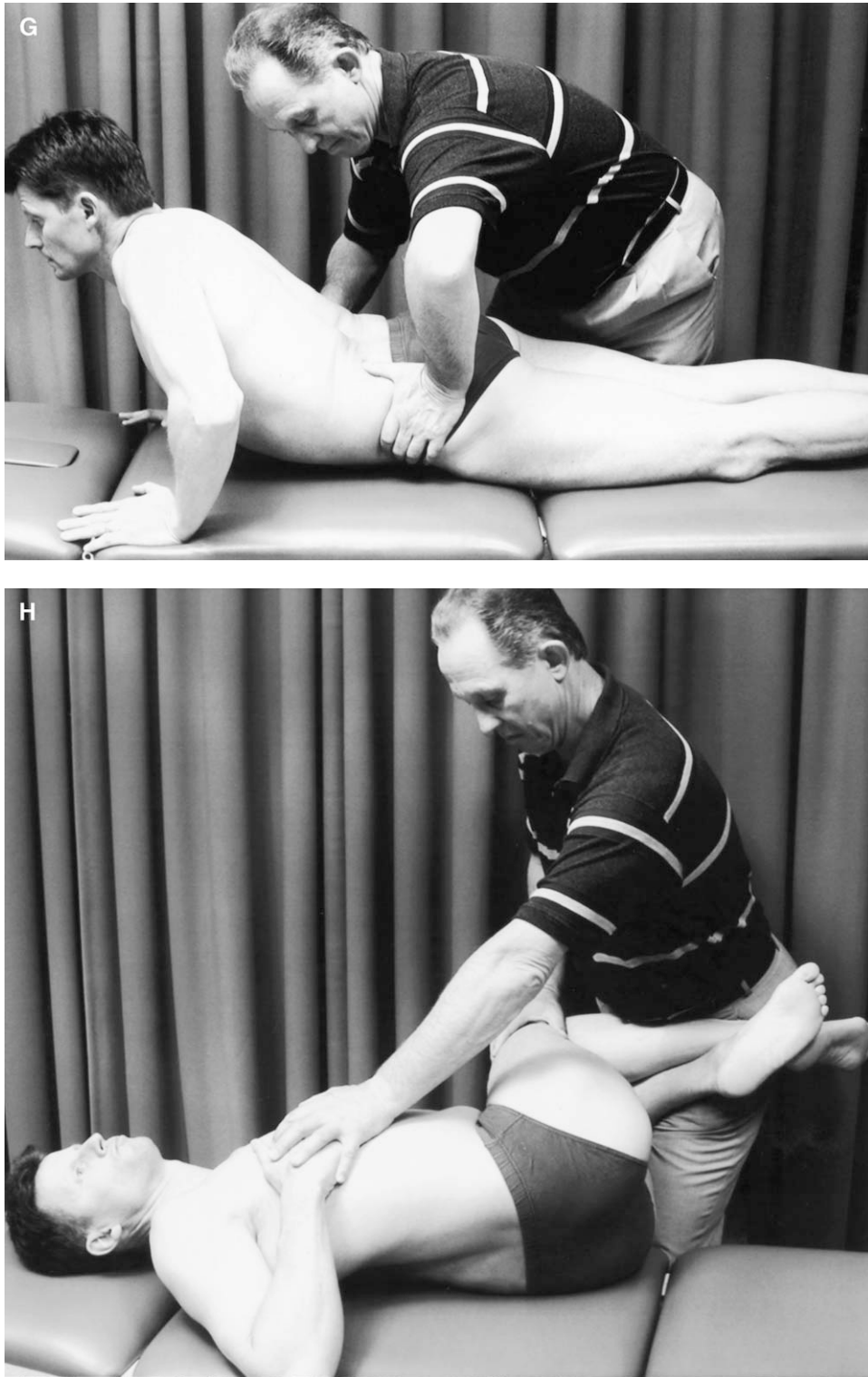


Fig. 1. Continued.

The effect of potential confounding factors on the diagnostic power of centralization was estimated. The factors examined were: Roland–Morris, Zung, and MSPQ questionnaires, DRAM categories, pain intensity, symptom dura-

tion, and time off work. Multiple logistic regression analysis revealed that higher Roland–Morris questionnaire, MSPQ, and “worst” pain intensity scores and a lower Zung questionnaire score were associated with positive discography. In a

Table 1
Demographics and psychometric profile for patients receiving lumbar discography (n=107)

	All discography patients (n=107)			Incomplete or no exam* (n=38)			Completed exam (n=69)			p value (complete/ incomplete exam)
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	
Age (years)	42.9	43	10.9	43.5	43	9.0	42.5	42	11.8	0.5
Duration (weeks)	170.1	104	188.6	179.0	104	188.5	165.2	104	189.8	0.6
Time off work (weeks)	118.8	83	131.2	169.0	93	190.8	85.3	80.5	46.8	0.2
VAS (current)	59.1	63	24.4	68.5	71.5	23.7	53.9	58	23.3	0.001 [†]
VAS (best)	32.9	35	21.3	43.2	44	21.8	27.4	27	19.0	<0.001 [†]
VAS (worst)	87.7	90	12.9	91.5	96.5	13.3	85.6	88	12.3	0.002 [†]
Roland–Morris Questionnaire	19.0	20	3.9	21.2	21.5	2.4	17.8	18.8	4.1	<0.001 [†]
Zung Depression Index Questionnaire	32.5	32	1.6	36.5	37	12.4	30.3	29	10.6	0.009 [†]
MSPQ Questionnaire	10.7	11	6.7	12.3	12.9	6.8	9.8	9	6.5	0.06
% Male	52.3			48.4			55.1			0.5
% Smoker	43.0			51.6			37.7			0.1
% Off work	58.9			68.4			53.5			0.1
% Previous spinal surgery	29.9			42.1			23.2			0.05 [†]
Traumatic onset	77.6			81.6			75.4			0.4
Disabled (Roland–Morris 19 or more)	63.6			92.1			47.8			<0.001 [†]
Distressed (DRAM)	56.1			76.3			44.9			0.001 [†]

DRAM=Distress Risk Assessment Method; MSPQ=Modified Somatic Perception Questionnaire; VAS=Visual analog scale.

* exam=McKenzie styled repeated movements examination for centralization/peripheralization.

[†] significance p≤.05 comparing groups receiving complete versus incomplete examination.

model that included these variables and centralization, the odds (95% confidence intervals) of positive discography were 14.9 (1.57, 141.1), p=.001.

Discussion

Diagnostic confidence is a function of prevalence and the positive likelihood ratio [23]. In the present study, prevalence of positive discography was 75% and the likelihood ratio for centralization was 6.9. Pre-test odds of 75:25 change to post-test odds of 95:5, ie, a 20% increase, and diagnostic confidence was 95%. If the expected prevalence of internal disc disruption is used (39%), improvement from pre- to post-test odds is greater and diagnostic confidence increases from 39% to 82%. Although this is encouraging, the wide confidence intervals for the likelihood ratios indicate that caution is appropriate.

Current data indicate that centralization has high specificity, especially in those patients categorized as not being severely disabled. The acronym “SpPin” is a mnemonic for the statistical rule that high specificity (95% or above) allows the clinician to “rule in” the disorder when the test is positive [48]. Thus, when centralization is reported during an initial McKenzie evaluation (in the absence of severe disability or psychosocial distress), positive provocation discography is highly likely and a diagnosis of discogenic pain is reasonable. The current data present a paradox. The modest sensitivity of centralization does not allow this clinical sign to be used as a screening tool to select patients for discography, but its high specificity does enable the clinician to make the diagnosis of discogenic pain without recourse to the invasive discography examination.

McKenzie’s original definition of centralization [31], and some studies of the phenomenon [49,50] take into account

Table 2
Number of disc levels injected and provocation positive

	All cases (n*=107)		Incomplete or no examination (n=38)		Completed examination (n=69)	
	n	%	n	%	n	%
Disc levels injected						
2	42	39.3	11	29.0	31	44.9
3	51	47.7	21	55.3	30	43.5
4	11	10.3	5	13.2	6	8.7
5	3	2.8	1	2.6	2	2.9
Number of discs provocation positive						
0	31	29.0	14	36.8	17	24.6
1	56	52.3	16	42.1	40	58.0
2	14	13.1	5	13.2	9	13.0
3	6	5.6	3	7.9	3	4.4

* n=number of cases.

Table 3

Diagnostic performance statistics for the centralization phenomenon (CP) versus provocation discography as the reference standard

Patient Group	No.*	TP	TN	FP	FN	Sensitivity (95% CI)	Specificity (95% CI)	+LR (95% CI)	-LR (95% CI)
A. All discography patients examined with repeated movements	83 [†]	23	20	2	38	0.37 (0.27, 0.50)	0.90 (0.72, 0.97)	4.1 (1.1, 16.2)	0.69 (0.54, 0.87)
B. Full repeated movement examination	69	21	16	1	31	0.40 (0.28, 0.54)	0.94 (0.73, 0.99)	6.9 (1.0, 47.3)	0.63 (0.49, 0.82)
C. Nondistressed patients (DRAM “normal” or “at risk”)	38	11	8	0	19	0.37 (0.22, 0.54)	1.00 (0.67, 1.00)	Incalc	Incalc
D. Distressed patients (DRAM “Depressed” or “Somatic”)	31	10	8	1	12	0.45 (0.27, 0.65)	0.89 (0.57, 0.98)	4.1 (0.6, 27.5)	0.61 (0.39, 0.96)
E. Not severely disabled patients (Roland < 19)	36	9	10	0	17	0.35 (0.19, 0.54)	1.00 (0.72, 1.0)	Incalc	Incalc
F. Severely disabled patients (Roland ≥ 19)	33	12	6	1	14	0.46 (0.29, 0.65)	0.80 (0.49, 0.94)	3.2 (0.5, 20.8)	0.63 (0.39, 1.0)

CI=confidence intervals; FN=false negatives; FP=false positives; Incalc=incalculable because of zero in cell; +LR=positive likelihood ratio; -LR=negative likelihood ratio; TN=true negatives; TP=true positives.

* Number in group.

[†] Repeated movements examination in 24 of 107 patients either not done or incomplete, leaving 83 patients with complete data for analysis.

the clinical reality of a time factor. Although centralization may occur rapidly and can be complete during the initial examination, it may take several days for the process to become clearly evident. In this study, only an initial “one-off” examination was possible, requiring a definition of the phenomenon reflecting this limitation. By necessity, our definitions exclude the time factor, with several consequences. First, those patients classified as centralizers may not have remained in that classification if they had been examined over several days. In a recent study, complete centralization occurred in only 3.2% of an acute/subacute LBP population in the initial evaluation, but rose to 63.8% over several days [50]. In the current study, prevalence of centralization was 32% at the initial evaluation in a chronic pain sample. The noncentralizing, positive discography patients were either potential centralizers who could not be identified at the initial evaluation, or represent a separate subgroup of discography-positive patients.

Although the influence of psychosocial distress and disability has been evaluated with regard to the clinical value of diagnostic discography [21,35,36], to our knowledge, this study is the first to examine the influence of these dimensions on the predictive power of spinal clinical tests in relation to a discography as a reference standard for discogenic pain. Centralization seems to be relatively stable in the presence of distress as identified by the DRAM instrument, retaining good specificity (89%). However severe disability as measured by the Roland-Morris instrument is a confounding factor with specificity falling to 80%. In these cases centralization is suggestive of discogenic pain, but not diagnostic. In our opinion, a few days’ trial of a McKenzie treatment protocol is warranted before discography, to determine if centralization is possible.

Patients included in the main analysis were less disabled, less distressed, and less likely to have had previous spinal surgery than those who were excluded because of an incomplete physical examination. The proportion of distressed patients (by DRAM categorization) in the group completing

a full physical examination was comparable to that observed in pain clinics elsewhere (44.9% vs. 52.6% [38]), and significantly lower than in the group unable to complete the examination (44.9% vs. 76.3%, $p=.001$). The inability to tolerate a McKenzie styled assessment is strongly associated with high levels of distress ($p<.01$). Generalizability of the current results to acute and subacute populations is inappropriate.

Compared with the study of Donelson et al., the prevalence of CP was lower in the current data (31.9% vs. 49.2%) as was peripheralization (14.5% vs. 25.4%). Our patients had longer duration of symptoms (41.3, SD 46.7 months vs. 15.3, SD 12.2 months), and we included patients with a history of prior lumbar surgery, many with instrumentation. Our results contrast strongly with regard to sensitivity and specificity of centralization. The differences in patient characteristics may have contributed to the high specificity/low sensitivity in the current data versus the high sensitivity/low specificity in Donelson et al.’s study. In our opinion, the most likely explanation is the influence of our simpler definition for CP, which was: “the pain in the furthestmost region (buttock, thigh, calf or foot) from the midline of the lumbar spine was abolished or significantly reduced”, whereas Donelson defined CP as “the most distal extent of the referred or radicular pain, even if the pain has spread only as far as the lateral back, rapidly recedes toward and/or to the lumbar midline”. In Donelson’s study, one therapist examined 40/63 (63%) cases and four other therapists examined the remaining 23. In the current study, the principal author examined 61/69 patients (88%) and another therapist examined the other eight patients. A complex definition is prone to variations in interpretation, compared with a simpler definition that is easier to apply consistently, especially when a single clinician examines the great majority of cases. Donelson’s study showed that peripheralization was associated with symptomatic discs having an incompetent annulus [26]. In the current data, peripheralization was recorded in only 10 cases, five with positive and five with negative

discography. There are insufficient data to reach a conclusion regarding this clinical phenomenon or to evaluate its diagnostic value.

Summary of study limitations

1. Sample size. A larger sample may well produce results different from the current data, and the width of the 95% confidence intervals for sensitivity and specificity reflects this problem. However, in any consecutive series, only a proportion of patients will be investigated using discography, and to accumulate a much larger sample size would require the continuous presence of a suitably trained physical therapist over a much longer time interval than was possible in this study.
2. The current study protocol did not permit a McKenzie evaluation over several days. There is value in such a protocol in future studies. The CP could be more thoroughly investigated, and psychosocial factors could be examined in greater detail also.
3. Levels of distress and disability were very high in the current study, with only 5.6% of patients being DRAM “normal” and 10.3% having no or minimal disability. A better balance between subgroups based on disability or distress instruments would be useful. However, it must be acknowledged that patients without disability or distress are much less likely to warrant discography.

Conclusions

In relation to positive discography, centralization observed during a McKenzie evaluation of repeated movements has specificity of 89%, and among patients without severe disability or distress it is 100%. However, in the presence of severe disability, specificity is reduced to 80%. The report of centralization in nondistressed and not severely disabled chronic LBP patients suggests that discography may be delayed if a McKenzie treatment program is available, because the expected result of discography is already known (ie, positive pain provocation), and there is a good prognosis with conservative care.

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