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Comparison of discographic findings in asymptomatic subject discs and the negative discs of chronic LBP patients: Can discography distinguish asymptomatic discs among morphologically abnormal discs?

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Abstract

BACKGROUND CONTEXT: Lumbar discography has been widely used for evaluating discogenic low back pain (LBP). Comparison of pain responses from suspected symptomatic discs with pain responses from asymptomatic negative discs is routine. However, the ability of discography to distinguish asymptomatic morphologically abnormal discs from those that are symptomatic has been understudied. In addition, the discographic characteristics of negative discs in patients with chronic discogenic LBP have not been reported. Criteria for negative morphologically abnormal discs may be valuable for excluding discs from further treatment and examination.

PURPOSE: To determine if discography can distinguish asymptomatic discs among morphologically abnormal discs in patients with suspected chronic discogenic LBP and establish the standard characteristics of negative discs.

STUDY DESIGN/SETTING: Prospective, experimental with control group.

PATIENT SAMPLE: Fifty-five discs from a control group of 16 healthy volunteers without current back pain (11 men, 5 women, 32–61 years of age, mean age: 47 years) and 282 discs from a patient group of 90 LBP patients (59 men, 31 women, 20–70 years of age, mean age: 44.7 years) were recruited.

METHODS: Discography was performed using a pressure-controlled manometric technique with an injection rate of 0.05 mL/s and a 3.5 mL restricted total volume. Concordance was rated as none/unfamiliar, or familiar. Pain was rated via a 0–10 numerical rating scale (NRS). The pressure and volume at which pain was evoked and NRS pain responses at 15, 30, and 50 psi were recorded. Annular disruption grade was rated during the procedure by computed tomography discography and fluoroscopic imaging. Negative discogram required no pain described by the participant as "familiar," with no pain responses $\geq$6/10 NRS at pressures $\leq$50 psi above opening pressure and $\leq$3.5 mL total injected volume. Patient discs were partitioned into two subgroups based on discographic findings: Neg-D (negative discs) and Pos-D (positive discs). Only discs with Grade 3 annular tears (Dallas Discogram Scale) were included in the study.

RESULTS: Among 55 asymptomatic control group discs, 32 (58.2%) exhibited Grade 3 annular tear. All discs in the asymptomatic control group satisfied negative response criteria. Among 282 patient group discs, 199 (70.6%) exhibited Grade 3 annular tear. Of 199 discs with Grade 3 annular tears, 104 (52.3%) satisfied negative response criteria and were categorized as the Neg-D group. The other 95 discs were categorized as a Pos-D group. Patients showed significantly lower pain tolerance relative to control subjects ($p<.05$). The control and Neg-D groups showed similar

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pressures and volumes at which pain was initially evoked. Mean control group pain scores were 0.47 NRS at 15 psi and 1.58 NRS at 50 psi. Mean Neg-D group pain scores were 0.11 NRS at 15 psi and 1.1 NRS at 50 psi. Discographic findings for the Pos-D group were significantly different from those of the control and Neg-D groups ($p<.001$).

CONCLUSIONS: Pain tolerance was significantly lower in patients relative to asymptomatic subjects. Negative patient discs and asymptomatic subject discs showed similar characteristics. Pressure-controlled manometric discography using strict criteria may distinguish asymptomatic discs among morphologically abnormal discs with Grade 3 annular tears in patients with suspected chronic discogenic LBP.

Keywords: Asymptomatic disc; Pressure-controlled discography; Discogenic low back pain

Introduction

Since the 1950s, lumbar discography has been extensively used for evaluating low back pain (LBP). Discography remains particularly useful in problematic cases unresolved by magnetic resonance imaging (MRI) or myelography, and for patients for whom surgery is contemplated [1]. In 1992, Osti and Fraser [2] compared MRI with discography in disc disease and found that, using the current standard techniques, MRI failed to demonstrate some structural changes in the annulus that were visualized by discography. A similar result was obtained in a comparison of high-resolution computed tomography with discography [3]. Several studies have demonstrated that MRI cannot reliably predict which discs are painful, at least not to the level of confidence required to be relied on solely for surgical decision making [4,5]. Despite the long history and widespread use of discography, the reliability of this approach has been questioned [6–8]. Critics point towards false positive rates and mismatches between morphologic features and clinical complaints.

The mechanism of discography involves stimulation of nerve endings via fissures extending to the innervated outer third of the annulus, which elicits a concordant pain response and may identify a tear as a nociceptive source [9]. Most discs with Grade 3 [10] annular tears afford positive discography. Morphologic findings other than annular tear may not be associated with pain provocation. Vanharanta et al. [11] found that 75% of Grade 3 annular torn discs were associated with exact or similar pain reproduction.

Criteria for determining asymptomatic, morphologically abnormal discs may be useful for excluding discs from further treatment or evaluation. Although comparison of pain responses from suspected symptomatic discs and asymptomatic negative discs is an important part of procedures for determining positive discs, the characteristics of negative discs in patients with chronic discogenic LBP remain understudied.

We have investigated the ability of pressure-controlled manometric discography to distinguish asymptomatic discs among morphologically abnormal discs using strict criteria for positive response. Only lumbar discs with Grade 3 annular tears according to the Dallas Discogram Description [10] were included in the study. Discographic findings in asymptomatic control subjects were analyzed and compared with findings in patients with suspected chronic discogenic LBP.

Methods

Subject recruitment

The study was approved by the Institutional Review Board of Quorum Review, Inc. No remuneration was provided. Subjects were informed of the nature of the study and the risks of discography before consenting to participate. To be eligible, subjects had to have no allergies to contrast media, iodine, or cephalosporin antibiotics; and were able to undergo MRI scanning. An MRI scan of the lumbar spine taken within the last 6 months was required for participation. An asymptomatic control group consisting of 16 healthy volunteers without present LBP problems (11 men, 5 women, age: 32–61 years, mean age: 47 years) was recruited. Volunteers were required to have no more than two episodes of LBP in the previous year. The control group included nine physicians with no knowledge of the purpose of this study. Ninety chronic LBP patients, who had unremitting pain despite all appropriate methods of conservative therapy, were also recruited (59 men, 31 women, age: 20–70 years, mean age: 44.7 years).

Discogram

Discography was performed in a surgical suite under aseptic conditions by one of three discographers, who respectively had 5, 25, and 30 years experience with the procedure. Intravenous antibiotics (2 g cephalosporin) were administered 20 minutes before the procedure, and subjects were premedicated with 0.025 mg/kg midazolam. A few participants were given a minimal dosage (1–2 mL) of propofol during needle insertion. Subjects were monitored throughout the procedure with pulse oximetry and a blood pressure cuff. Supplemental oxygen was administered by nasal cannula.

Before injection, a fluoroscopic examination of the spine was performed to confirm segmentation and identify test segments. At least three levels between L1-2 and L5-S1 were tested in each subject. Using a posterolateral approach, a 20-gauge, 3.5-inch introducer needle was advanced to the surface of the target disc. A 25-gauge, 6-inch needle was then passed through the introducer needle into the disc center. Needle position was confirmed by anteroposterior and lateral fluoroscopic imaging. Nonionic contrast medium mixed with 6 mg/mL cephalosporin was injected into each disc at

0.05 mL/s using a controlled injection syringe with digital pressure readout (Intelli system; Merit Medical Systems, South Jordan, Utah). At the time of injection, each subject was awake, alert, and able to respond to instructions and questions. Subjects were asked to report the nature and location of pain evoked during the procedure, and rate pain intensity on a 0–10 numerical rating scale (NRS).

Dynamic pressures (A pressure recorded as contrast is injected intradiscally) were monitored during the procedure. Opening pressures were recorded when contrast medium was first seen entering a disc. As each subsequent 0.5 mL of contrast medium was injected, the pressure, location of contrast medium, and pain responses were recorded. Injection was continued until one of the following end points was reached: 1) the subject reported pain ≥6 NRS; 2) an intradiscal pressure of greater than 50 psi above opening in a disc with a Grade 3 annular tear or 80–100 psi in a normal appearing nucleogram; or 3) a total of 3.5 mL contrast medium had been injected. In some cases the pressure rose rapidly during the final seconds of injection, causing the final pressure to briefly exceed 100 psi.

When each injection was terminated, anteroposterior and lateral spot films were obtained to record the distribution of contrast medium. After discography, computerized tomography was performed on all examined levels.

Evaluation of pain

Subjects were scored via 0–10 point NRS. The pressure and injected volume at which pain was first evoked and the NRS values at 15, 30, and 50 psi above opening pressure were recorded.

Pain tolerance analysis

Because pain tolerance may vary among patients as a result of factors such as chronic pain, emotional stress, psychological factors, and social stressors (eg, worker's compensation) [12], each patient was evaluated individually during needle insertion for local anesthesia. Self-reported NRS pain intensities were scored during local anesthetic injection in soft tissue (0–highest pain tolerance, 10–least pain tolerance). Because patients underwent multiple disc examinations, pain intensities at each level were recorded and then averaged to give a final NRS value. Patients who had average pain intensity <5 NRS during local anesthesia in soft tissue were categorized as a high tolerance group. Patients who had average pain intensity ≥5 NRS during local anesthesia in soft tissue were categorized as a low tolerance group.

Image analysis

Annular disruption was graded as 0–3 for the presence and extent of radial fissures according to the Dallas discogram scale [10]. Grading utilized both fluoroscope and computed tomography discogram results. The MRI of each disc tested was graded for signal intensity using a 1 to 5 scale for disc degeneration [13]. Abnormal MRI was determined as more than Grade 3.

Negative discogram criteria

Patients were asked to describe any discomfort during the procedure as "familiar" or "unfamiliar." Negative discogram required no pain described by the participant as "familiar," with no pain responses ≥6/10 NRS at pressures ≤50 psi above opening pressure and ≤3.5 mL total injected volume. Patient discs with Grade 3 annular tears were partitioned into two subgroups on the basis of discographic findings: Neg-D (negative discs), and Pos-D (positive discs).

Data analysis

Control and patient group data were compared using only Grade 3 annular torn discs. Statistical analyses were performed with SPSS/PC+ software (SPSS, Inc., Chicago, IL). Comparisons of provoked pain intensity and pressure and volume when initial pain was evoked between three groups (control group, Neg-D, and Pos-D group) were performed using an analysis of variance test. Pain intensity and the frequency of negative disc between high and low pain tolerance groups were compared using a chi-square test. All differences were regarded as significant only if $p<.05$.

Results

Sample characteristics

Discograms were performed on a total of 337 discs (55 control group discs and 282 patient group discs, L1-2 through L5-S1) from 16 asymptomatic subjects and 90 chronic LBP patients (Table 1).

Among 55 asymptomatic control group discs, 32 (58.2%) exhibited Grade 3 annular tears. All 55 asymptomatic control group discs satisfied negative response criteria. Among 282 patient discs, 83 (29.4%) exhibited Grade 0–2 annular tears: 19 (6.7%) for Grade 0, 29 (10.3%) for Grade 1, and 35 (12.4%) for Grade 2. Of 83 Grade 0–2 annular tear patient discs, 78 discs (94%) satisfied negative response criteria. Grade 3 annular tears were observed in 199/282 (70.6%) of discs in the patient group. Of 199 discs with Grade 3 annular

Table 1
Number of patient and control group discs at each level

		Patient group		
Disc level	Asymptomatic control group	Negative response	Positive response	Total
L1-2	4	14	3	21
L2-3	6	36	5	47
L3-4	16	57	12	85
L4-5	16	46	32	94
L5-S1	13	29	48	90

tears in the patient group, 104 discs (52.3%) satisfied negative response criteria. These discs were categorized as the Neg-D patient group (vide supra). Thirty-two discs for the asymptomatic control group, 104 for the Neg-D group, and 95 for the Pos-D group were analyzed (Table 2).

All 32 asymptomatic control group discs showed abnormal MRIs. Abnormal MRIs were obtained for 92% of Neg-D group discs and 99% of Pos-D group discs.

Pain tolerance

Average pain intensities during needle insertion for local anesthesia were significantly lower in the asymptomatic control group (4.6±2.9 NRS) than the patient group (8.0±3.3 NRS, $p<.001$). These results demonstrate a significantly higher pain tolerance in the control group relative to the patient group. The frequency of negative discs was significantly greater in patients with high pain tolerance (58.2%) relative to patients with low pain tolerance (46.5%; $X^2=5.076$, $p<.018$, Table 3).

Comparison of asymptomatic control group and patient group discs

Provoked pain intensity

The mean NRS scores at 50 psi above opening pressure were 1.58±1.89 for the control, 1.10±1.83 for the Neg-D, and 8.68±1.27 for the Pos-D group (Fig. 1). There were no significant NRS score differences between the control and Neg-D groups at 15, 30, and 50 psi above opening pressure. In contrast, the Pos-D group NRS scores were significantly higher than those of the control and Neg-D groups ($p<.001$).

Pressure of initial pain response

The mean pressures initially evoking any pain were 46.25±24.20 psi for the control, 60.48±17.12 psi for the Neg-D, and 20.18±11.45 psi for the Pos-D groups (Fig. 2). Although there were no significant differences in the pressures that evoked pain in the control and Neg-D groups, the mean pressure that evoked pain in the Pos-D group was significantly lower than that of the other groups ($p<.001$).

Table 2
Number of patient and control group discs at each annular disruption grade

Annular disruption grade*	Asymptomatic control group	Patient group		Total
		Negative discs	Positive discs	
0	8	19	0	27
1	5	27	2	34
2	10	32	3	45
3	32	104†	95‡	231
Total	55	182	100	337

* Dallas Discogram Description [9].
† These discs were categorized as a Neg-D group.
‡ These discs were categorized as a Pos-D group.

Table 3
Pain tolerance in patient grade 3 annular torn discs

Pain tolerance	Neg-D subgroup	Pos-D subgroup	Total
Low tolerance	47	54	101
High tolerance	57	41	98
Total	104	95	199

High tolerance: average pain intensity during local anesthesia in soft tissue <5; Low tolerance: average pain intensity during local anesthesia in soft tissue ≥5.

Volume of initial pain response

The mean injected contrast media volume at which pain was initially evoked was 2.43±1.46 mL in the control, 2.69±1.41 mL in the Neg-D, and 0.73±0.56 mL in the Pos-D groups (Fig. 3). Whereas there were no significant differences in volumes when control and Neg-D groups were compared, the volumes for the Pos-D group were significantly lower than those of the other groups ($p<.001$).

Distribution of pain scores

The pain responses of the Pos-D and Neg-D groups differed significantly. While 70.2% (73/104) of Neg-D group discs did not evoke any pain (0 NRS) at <50 psi stimulation, the Pos-D group showed substantially greater pain responses, with 78.9% (75/95) of discs reporting ≥8/10 NRS under the same stimulation (Fig. 4).

Discussion

A convincing positive discogram provocation response occurs when stimulation of a suspected disc reproduces significant familiar pain, whereas stimulation of 1–2 adjacent

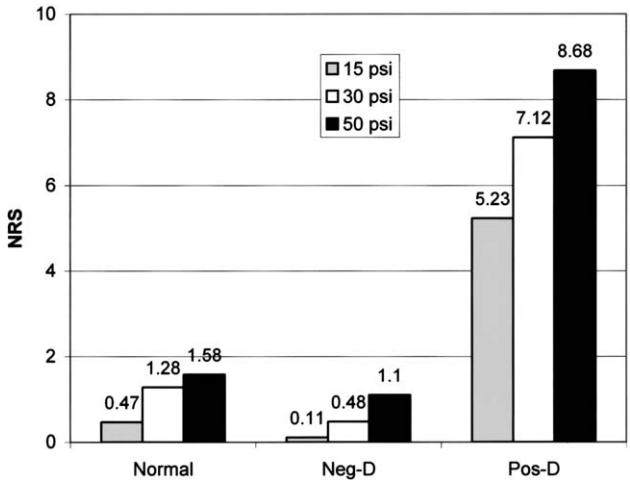

Fig. 1. Mean self-reported numerical rating scale (NRS) scores for discs in each group at three pressure levels: Pain intensity in Grade 3 annular torn discs at each pressure. Pressures indicate the pressure above opening pressure. The Neg-D group scores did not differ significantly from asymptomatic control subject scores. The Pos-D group differed significantly from the control and Neg-D groups ($p<.001$). NRS: numerical rating scale (0–10); Neg-D: discs meeting negative response criteria among Grade 3 annular tear discs in patient; Pos-D: discs not meeting negative response criteria among Grade 3 annular tear discs in patient.

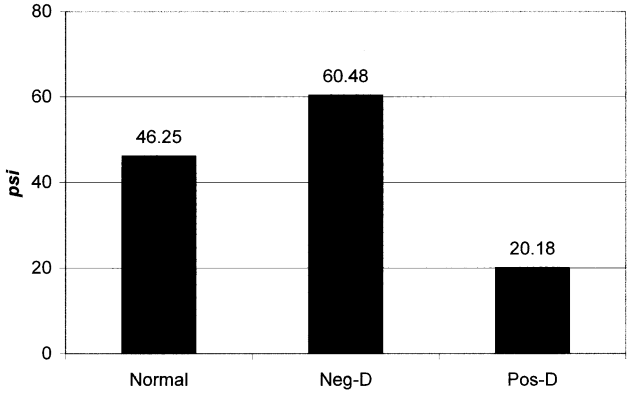

Fig. 2. Mean pressures initially evoking pain in each group: pressure in Grade 3 annular torn discs. Pressures indicate the pressure above opening pressure. The control and Neg-D groups showed no significant difference, whereas the Pos-D and Neg-D groups differed significantly ($p<.001$). Neg-D: discs meeting negative response criteria among Grade 3 annular tear discs in patient; Pos-D: discs not meeting negative response criteria among Grade 3 annular tear discs in patient.

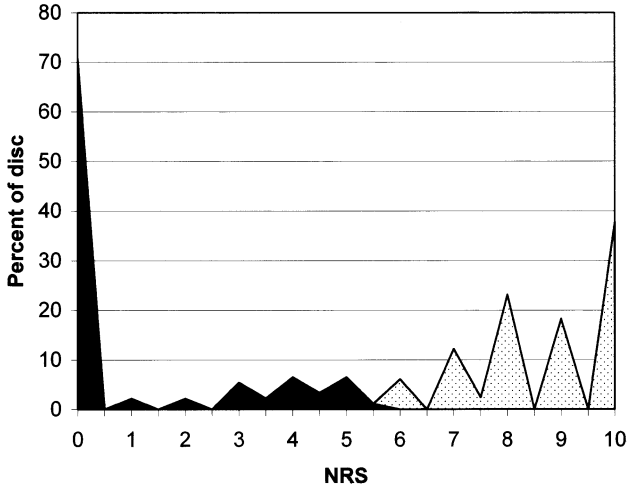

Fig. 4. Distribution of NRS pain scores in the Pos-D (dotted areas) and Neg-D (black areas) groups at <50 psi above opening pressure. Each group showed significantly different distribution of pain scores. NRS: numerical rating scale (0–10). Neg-D and Pos-D defined as in Figures 1 and 2.

discs is painless or evokes unfamiliar pain. Vanharanta et al. [11] found that pain reproduced by discography correlates with the extent of annular disruption. Grade 0 and Grade 1 disruptions were rarely painful. Grade 2 disruptions were less regularly associated with pain reproduction, whereas discs with Grade 3 disruption usually caused pain reproduction. Our data also showed infrequent provocation of pain in Grade 0–2 tissues. Because discs with Grade 3 annular tears are most likely associated with pain reproduction, only Grade 3 discs were selected for analysis in our study.

All discographic findings, including the intensity of pain response to increasing intradiscal pressure and volume, were markedly similar in the asymptomatic control group and the Neg-D group (patients with negative discs with Grade 3 annular tears). The results were markedly similar despite a significantly lower pain tolerance recorded in the Neg-D and Pos-D patient groups.

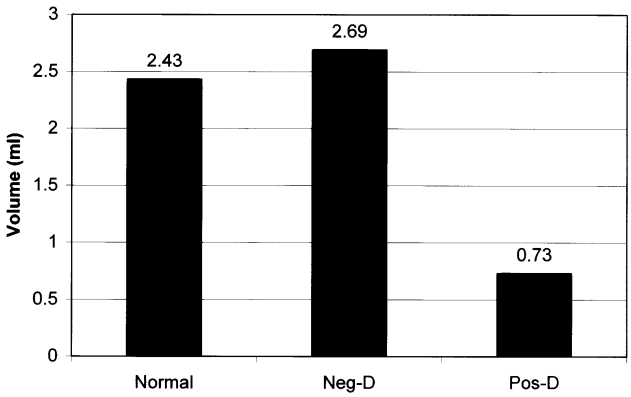

Fig. 3. Mean injected contrast media volumes initially evoking pain in each group: volume in Grade 3 annular torn discs. There was no significant difference between the Neg-D and asymptomatic control groups, whereas the Pos-D group showed significantly lower volumes relative to the other groups ($p<.001$). Neg-D and Pos-D defined as in Figures 1 and 2.

Although the Neg-D and asymptomatic control groups showed similar characteristics, findings for the Pos-D group differed markedly from those of the control and Neg-D groups. These results suggest that pressure-controlled manometric discography using strict criteria may distinguish negative, asymptomatic discs among morphologically abnormal discs with Grade 3 annular tears.

To increase the reliability of discography, precise technology and strict diagnostic criteria are required. Pressure-controlled manometric discography using precise criteria can increase diagnostic specificity when discogenic LBP is suspected [14]. This approach involves use of a slow, controlled intradiscal injection speed (0.05 mL/s), dynamic pressures recorded during contrast injection, and strict criteria (reproducible NRS pain ≥6/10, <50 psi intradiscal pressure, ≤3.5 mL total volume) [14,15].

To determine if a disc is a pain generator, intradiscal pressure is key. The intensity of intradiscal stimulation correlates linearly with injection speed [16]. Rapidly increasing intradiscal pressure may stimulate mechanical nociceptors in the outer third of the annulus. Inadvertent stimulation of nonpathogenic discs may be one cause of false positives in discography. Conventional manual discography without pressure manometry neglects this significant technical factor. Static pressures are typically used due to convenience. However, the actual pressure that stimulates nociceptors is higher than the static pressure. The dynamic pressure may represent the actual pressure within the nucleus pulposus when slow injection speeds (e.g, 0.05 mL/sec are used [unpublished data]).

Because of potential false positive responses, it is difficult to say that conventional discography without precise control of stimulating pressure is a reliable test for identifying pain generators. In the authors' experience, uncontrolled high pressures may produce significant pain responses even in

asymptomatic discs. Precisely evaluating pain concordance with patient accustomed pain is also challenging. The criteria used in this study permitted us to reliably distinguish asymptomatic discs among morphologically abnormal discs containing Grade 3 annular tears. These data may be useful for excluding asymptomatic discs from surgical consideration.

The frequency of negative discs (58.2%) in patients with high pain tolerance was greater than that of patients with low pain tolerance (46.5%). This may result from the pain threshold of chronic LBP patients differing from that of the normal population. Differences in pain threshold among LBP patients may impact patient attitude and expression.

This study contains two possible limitations. One unavoidable shortcoming is related to study design. Because there is no gold standard for diagnosing disc pain, categorization of discs as Neg-D and Pos-D used discographic findings. As a result, discs may have been grouped erroneously based on inaccurate discographic findings. However, 70.2% (73/104) of Neg-D group discs did not evoke any pain with $<$50 psi stimulation, whereas the Pos-D group discs showed severe pain responses with a mean score of 8.68/10 NRS under the same stimulation. Significant, unambiguous differences in findings among the two groups suggest that these data are not the result of random errors. A second shortcoming of the study involves asymptomatic control subjects. To compare negative patient discs with asymptomatic control discs, an unambiguous source of control discs was required. As a result, nine physicians were recruited to the asymptomatic control group. Physicians can describe pain intensity and distribution accurately, and are more homogeneous regarding knowledge, training, attitudes, and behavior relative to the general population [17]. Thus, comparatively accurate discographic findings may be obtained.

Conclusion

Discographic findings in chronic discogenic LBP patient discs have been analyzed and compared with findings in the discs of asymptomatic control subjects. Only discs with Grade 3 annular tears were included. Discography was performed using a pressure-controlled technique with strict criteria for a negative response. The discogram response was negative if the patient did not report $\geq$6/10 concordant pain at pressures $\leq$50 psi above opening pressure and $\leq$3.5 mL total injected volume. Findings for negative patient discs and positive patient discs differed significantly, whereas findings for negative patient discs and asymptomatic control subject discs were markedly similar. Although the pain tolerance was lower in patient discs overall relative to the discs of asymptomatic control subjects, the discographic findings between asymptomatic controls and the negative patient discs were markedly similar. Advanced discography techniques and strict criteria may distinguish negative asymptomatic discs among morphologically abnormal discs in patients with suspected chronic discogenic LBP.

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