Discogenic Lumbar Pain: Correlation between Magnetic Resonance Imaging and Discography

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Abstract

Background: Although numerous previous studies on the subject have been performed, the correlations between various pathologic findings on magnetic resonance imaging and pain reproduction by provoked discography have not been fully explained. A higher sensitivity and positive predictive value (PPV) of the high intensity zone (HIZ) for predicting concordant pain was reported. Moreover, although the apparent validity of this sign has been corroborated by some investigators, it has been questioned by others. The validity of this sign awaits confirmation. The various pathologic parameters seen on magnetic resonance imaging (MRI) in patients with discogenic lumbar pain was assessed and correlated with observations on discography.

Methods: There were 18 patients enrolled, ranging in age from 28 to 64 years with an average age of $48.8 \pm 10.2$ (mean \pm SD) years. Five men (28%) and thirteen women (72%) participated in the study. All patients underwent provocation discography by a standard technique, as mentioned previously. The lumbar discs examined were L3-L4(2), L4-L5(14) and L5-S1(10). The relationship between discogenic lumbar pain and disc morphology was investigated by using MRI and provocation discography.

Results: Of the 26 discs being studied, 16 proved to be concordantly painful at discography relative to clinical back, buttock, hip, groin, and proximal leg pain complaints. Fourteen of the 16 painful and concordant pain discs exhibit grade 2, 3 with annular tears, and four with free leakage of contrast into the epidural space. Using chi-square analysis, we observed a significant correlation ($P < 0.05$) between the annular disruption grade and the provoked pain response. We were not able to demonstrate that the HIZ was associated with any particular grade of disc disruption. Similarly, there was no significant correlation ($P > 0.05$) between a concordant pain response and the presence of an HIZ regardless of the level and grade of disc disruption.

Conclusions: The presence or lack of the HIZ does not exclude the disc as a source of pain and should not replace provocation discography as a means of evaluating low back pain with or without sciatica. (Korean J Anesthesiol 2001; 41: S 26--S 32)

Key Words: Nerve block; provocation discography. Pain: back pain.

INTRODUCTION

In patients suffering from low back pain, any structure of the lumbar spine that receives an innervation can be considered as a potential source of the pain. Obviously,
several components may contribute to the development of the back pain. Besides mechanical compression, other factors including chemical irritation of the nerve root or an autoimmune response to the nucleus pulposus leading to inflammation, may play a role in eliciting the pain response. Moreover, internal disc disruptions are considered to function as important sources of persistent low back pain. In this condition, myelography and computed tomography (CT) do not show an abnormality.

Previous authors have used provocation discography to identify discogenic pain segments in the lumbar spine by comparing pain response patterns and morphologic changes associated with magnetic resonance imaging (MRI) abnormalities. Disadvantages are its invasiveness and potential for iatrogenic discitis. It remains, however, the only available test to evaluate dynamically the disc’s potential to be a source of pain. More important is that it is capable of identifying the painful segment with the patient awake and attention paid to the quality and pattern of the pain response. Previous investigators reported a high incidence of concordant discographically provoked pain associated with a specific marker for internallmanged and symptomatic discs, referred to as the high intensity zone (HIZ), seen best with T1 weighted magnetic resonance pulse sequences. This area also appears to enhance on injection with gadolinium-DPTA, indicating granulation tissue or neovascularization induced by inflammation. This area appears to correlate with the edge neovascularization described by histopathologic sections of prolapsed intervertebral disc.

Although there are other studies regarding disc morphology and pain reproduction, the correlation between disc morphology and pain reproduction by provocation discography and computed tomographic discography (CT discography) have not been explained fully. April and Bogduk reported a HIZ in the posterior outer annulus fibrosus seen on T1 weighted MRI that was a predictive diagnostic sign of discogenic lumbar pain. Moreover, although the apparent validity of this sign has been corroborated by some investigators, it has been questioned by others. The validity of this sign awaits confirmation.

The objective of this study was not only to investigate the validity of the HIZ on MRI in detecting painful lumbar discs, but also to assess annular disruption grade seen on CT discography to correlate them with findings of discography for predicting lumbar discogenic pain with invasive studies.

METHODS

All patients previously were treated conservatively with physical therapy and nonsteroidal anti-inflammatory medication without relief of their symptoms for more than 6 months. Twenty-six discs in 18 consecutive patients with low back pain with and without radiculopathy underwent evaluation by MRI and provocation discography, and form the basis of this prospective investigation. There were 5 men and 13 women, ranging in age from 28 to 64 years with an average age of 48.8 ± 10.2 (mean ± SD) years. The lumbar discs examined were L3-L4(2), L4-L5(14) and L5-S1(10). All patients were selected according to the following criteria: chronic low back pain, absence of neurologic deficits, and failure to respond to 6 months of conservative treatments. Each patient was studied with MRI for the presence of the HIZ within the posterior annulus on T1 weighted imaging and pain provocation discography. We used a General Electric MRI unit. T1 and T2 weighted images were consistent in all examinations.

Technique of discography and intradiscal injection

The technique of discography was similar to that described by el-Khoury and Renfrew: a posterolateral extradural approach using a single 15 cm, 22 gauge curved needle was used in each case. Needles were always introduced from the side opposite any lateralizing clinical pain under investigation. One or two level lumbar discograms were performed, with the patient in the prone position, by use of a direct posterolateral extradural approach under fluoroscopic guidance. 10 patients had a one level study: 8 patients had a two level study. The procedures were performed after local infiltration anesthesia had been given with 1% carbocaine. Patients were not premedicated or
given other sedation during the procedure. The puncture was performed with a single needle technique by confirming under fluoroscopic control that the position of the needle tip was in the geometric center of the intervertebral space after which nonionic contrast was injected with fluoroscopic confirmation of intranuclear injection. Omnipaque was then slowly injected into each disc, the injection was continued at each level until one of the following occurred: 1. The patient complained of or manifested an obvious pain response. 2. Extravascular leakage (intravenous, paraspinal, epidural) of contrast was seen. 3. Mechanical resistance to hand injection was felt. The total injected amount varied, in this group of patients, from 0.5 to 1.5 ml. Intravenous prophylactic antibiotics were given. The patients were freely mobilized approximately 2 hours after the intradiscal injection. All were discharged on the first day after the injection.

The pain response was assessed according to the Dallas Discogram Description categories. According to the characteristics of pain reproduction under discography, all discs were separated clinically into two groups: disc with concordant pain, discs with nonconcordant pain. Pain reproduction in the concordant pain group was either exactly the same pain or similar pain to that experienced in daily life. In the nonconcordant pain group, pain was present but not similar to that experienced in daily life or the pain was normal pressure sensation reproduction during discography. Annular tear types and loss of integrity of the outermost annulus on the initial radiographic discography and/or images of CT discography were compared with those observed on MR images. No disc level was studied as a control after eliciting a provoked response at suspect painful level under investigation.

CT was performed after each discogram. The Dallas Discogram Scale for annular disruption was used to classify each CT discogram to identify the depth of posterior annular disruption in relation to the HIZ because of the known presence of nociceptive C-fibers within the outer fibers. The Dallas scheme recognizes four classes. Grade 0 is defined as contrast entirely within a normal nucleus pulposus, Grade 1 if contrast extends radially along a fissure involving the inner annulus fibrosus, Grade 2 if it extends into the outer annulus, and Grade 3 if it extends beyond the outer annulus.

Each level was evaluated for a relationship between the presence of an HIZ and the pattern of disc degeneration. Also the relationship between provoked pain response and annular disruption grade was evaluated. Finally, we evaluated each level for the relationship between an HIZ and a concordant pain response.

**Statistical analysis**

The statistical analysis was performed using analysis of chi-square test. A P value less than 0.05 was considered statistically significant.

**RESULTS**

All disc levels were associated with minimal degree of disc bulging/protrusion, generally posterior and symmetrical and without neural compression against osseous/ligamentous structures or displacement of lumbar nerve root. Of the 26 discs being studied, 16 proved to be concordantly painful at discography relative to clinical back, buttock, hip, groin, and proximal leg pain complaints (Table 1).

14 of the 16 painful and concordant pain discs exhibit grade 2, 3 annular tears, 4 with free leakage of contrast into the epidural space. We observed a significant correlation (P < 0.05) between the annular disruption grade

<table>
<thead>
<tr>
<th>Table 1. Correlation between Presence of HIZ and Provoked Pain Response*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain provocation</td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td>Nonconcordant</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Concordant</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

*Total for all discs: P value > 0.05. HIZ = high intensity zone
Table 2. Correlation between Provoked Pain Response and Annular Disruption Grade*

<table>
<thead>
<tr>
<th></th>
<th>Nonconcordant pain</th>
<th>Concordant pain</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 0</td>
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<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Grade 1</td>
<td>4</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Grade 2</td>
<td>4</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>Grade 3</td>
<td>0</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>16</td>
<td>26</td>
</tr>
</tbody>
</table>

*Total for all discs: P value < 0.05

Table 3. Correlation between Presence of HIZ and Discogram Grade*

<table>
<thead>
<tr>
<th></th>
<th>HIZ —</th>
<th>HIZ +</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 0</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Grade 1</td>
<td>4</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Grade 2</td>
<td>5</td>
<td>9</td>
<td>14</td>
</tr>
<tr>
<td>Grade 3</td>
<td>0</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>16</td>
<td>26</td>
</tr>
</tbody>
</table>

*Total for all discs: P value > 0.05. HIZ = high intensity zone

and the provoked pain response (Table 2).

We specifically wanted to look at the relationship between the presence of an HIZ and disc disruption with and without a concordant pain response. We were not able to demonstrate that the HIZ was associated with any particular grade of disc disruption (P > 0.05) (Table 3). Similarly, there was no significant relationship (P > 0.05) between a concordant pain response and the presence of an HIZ regardless of the level and grade of disc disruption (Table 1). Regarding Table 1, we assume from the null hypothesis that there was no relationship between pain provocation and the presence of an HIZ. Using the chi-square analysis, there did appear no correlation between pain provocation and the presence of an HIZ.

An important discographic feature of the concordant HIZ discs is that pain provocation was often immediate with injection. In most of the concordantly painful discs, injection was voluntarily terminated because of immediate and obvious pain response. This contrast sharply to level of nonconcordant pain, where annular distension was typically required to produce a response after an end point to injection was encountered. 6 of the nonconcordant and nonpainful discs exhibited only grade 0 or 1 inner annular tears despite forcible injection and annular distension.

DISCUSSION

Precise localization of the anatomic source of pain leading to an accurate diagnosis is a basic requirement for successful management of low back pain. Attention should be directed to the lumbar disc as a source of pain after other less well recognized causes of low back pain have been excluded. These would include referred pain from the posterior facet joints, sacroiliac joints, muscle syndromes, and radicular pain from spinal stenosis or segmental instability. When the clinical diagnosis suggests that the disc is a source of pain, discography followed by CT scanning is useful in the clinical situations.

Crock was the first to suggest the term internal disc derangement to categorize unremitting spinal pain without extremity pain that lasts more than 4 months, is unresponsive to conservative care, and then requires discography with positive reproduction of pain and abnormal morphology. It is thought that one of the prominent somatic sources of low back pain is the internal disc disruption of the lumbar spine.

Patients with positive concordant pain, that is, pain similar to their usual painful symptom, on disc injection and a relatively pain free control disc injection usually are thought to be symptomatic from the disc that seemed painful on injection. Some authors claim that although there is neither a characteristic clinical pattern nor characteristic disc morphologic pattern to International Classification of Diseases, patients with positive discography should be considered to be primarily symptomatic from that lesion. It is also supposed by some that although theoretically possible, it is very unlikely that a patient with back pain and positive discography would have other (nondiscogenic) primary causes of their low
back symptoms.\textsuperscript{21}

Use of discography to diagnose spinal pain syndromes has increased in popularity and controversy in the past several years. Discography proponents argue that the information provided includes both morphologic and subjective data concerning the pain generator. Although Holt’s initial study\textsuperscript{22} cited a false positive rate of 37\% using discography, later studies have shown this to be much less.\textsuperscript{23,24} Treatment of patients with positive discograms, however, remains controversial.\textsuperscript{25-27}

The role and capabilities of MRI scanning are currently evolving and being defined. The histopathology of the HIZ as seen on MRI is uncertain. The HIZ was noted to be an area of brightness or high signal intensity (bright white) located in the posterior annulus fibrosus, distinctly separate from the nucleus pulposus and brighter than the nucleus on T2 weighted images. Brock et al.\textsuperscript{28} found edge neovascularization to be present in 43\% of free fragments and 30–40\% of nonsequestered fragments. They thought it was the contact of nuclear material with epidural tissue that induced the formation of granulation tissue and vascular sprouting. Granulation tissue within the disc also is seen to enhance with gadolinium-DTPA.\textsuperscript{29,30} To date, there are no studies that specifically look for enhancement of the HIZ with gadolinium.

Aprill and Bogduk\textsuperscript{11} reported an higher sensitivity and positive predictive value (PPV) of the HIZ for predicting concordant pain (82\% and 90\%, respectively) than was recorded in the study.\textsuperscript{31} A main reason for this discrepancy is the wide variation in pain response between patients during discography. Because pain responses from the patients and classification of the pain by the observers are subjective, some degree of personal differences between patients or observers cannot be avoided. The discrepancy also may be a result of differences in patient populations. Further research is needed to clarify the differences between the results in the two studies.\textsuperscript{11,31}

Moreover, although the apparent validity of this sign has been corroborated by some investigators,\textsuperscript{29} it has been questioned by others.\textsuperscript{16,17} The validity of this sign awaits confirmation.

In degenerative lumbar spine disease, recent studies have supported the clinical usefulness of discography, especially when used with CT scanning. Discograms and CT discogram may at times allow detection of clinically correlative and significant pathology (usually annular disruptions) not suggested by MRI scanning. This fact should be considered in patients with normal MRI scanning and continuing unexplained symptomatology.\textsuperscript{40}

The CT/discographic findings from 225 discs in 91 low-back pain patients were compared to the pain provocation during the injection of contrast into the disc.\textsuperscript{35} The radiographic appearance of disc deterioration demonstrating disc degeneration and annular disruption of each disc was classified. Pain reaction to the discogram at each level was recorded as follows: no pain, dissimilar pain, similar pain, or exact reproduction of the patient’s clinical pain. This more precise analysis demonstrated a significant relationship between pain and deterioration of discs. The CT/discogram presents an axial view of the disc that allows a subgrouping of disc deterioration that can discriminate between peripheral deterioration (degeneration) and internal deterioration (disruption). The disruption supposedly occurs earlier and is more likely to be the source of exact pain reproduction.\textsuperscript{40}

At each level studied, we were not able to demonstrate that the HIZ was associated with concordant pain response regardless of the level and grade of disc disruption. Our results are similar to the original study,\textsuperscript{16} suggesting that in an individual with symptomatic back or radicular pain, the presence of a HIZ defect does not necessarily suggest the presence of an internally deranged and clinically painful lumbar intervertebral disc until proven otherwise. Remarkably, we did not appreciate this relationship in a reliable fashion. We found Grade 3 annular defects to exist in all of our painful and concordant HIZ discs. Although we performed the post discographic CT scans routinely, it is difficult for us to know the end point of nonionic contrast injection and we might have missed the exact ratio of grade 2, 3 because we terminated many of the most painful disc injections after only 0.5 to 1.0 ml of contrast had been injected. Still the presence of significant annular disruption is obvious universal in our concordantly painful group.
At present, it is still not possible to characterize the relationship between morphologic features on MRI and the clinical symptoms as meaningful. Although discography cannot be replaced by MRI in the diagnosis of discogenic lumbar pain, the better understanding of each finding on MRI appears likely to be helpful in selecting patients for discography and to lessen the risks for the patients who have persistent low back pain without neurologic deterioration.

The finding of the current study show that severity of discogram grade has a strong relationship with concordant pain reproduction. The presence or lack of the HIZ does not exclude the disc as a source of pain and should not replace provocation discography as a means of evaluating low back pain. Although the lumbar intervertebral discs with HIZ are likely to produce pain, we need more studies for the validity of these signs for predicting discogenic lumbar pain.

REFERENCES