MRI AND DISCOGRAPHY OF ANNULAR TEARS AND INTERVERTEBRAL DISC DEGENERATION
A PROSPECTIVE CLINICAL COMPARISON

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We attempted to correlate the findings of MRI and discography in patients with low back pain, examining 108 lumbar intervertebral discs in 33 consecutive patients. MRI results were assessed from the intensity and shape of the signal obtained from the central part of the disc. Discography was classified according to the pattern of contrast material, the pressure accepted and the pain reproduced.

All discs which were abnormal on MRI had altered patterns on discography, but 18 of the 60 discs with normal MRI had abnormal discograms. Of 39 asymptomatic discs, 33 had normal MRI signals and 24 had normal discograms. None of the 15 discs showing severe degeneration on MRI sustained high levels of intradiscal pressure, but only six of the 60 discs giving normal MRI had low pressure.

With current techniques, discography is more accurate than MRI for the detection of annular pathology: a normal MRI does not exclude significant changes in the peripheral structure of the intervertebral disc which can produce low back pain.

Tears within the annulus fibrosus are one of the main features of intervertebral disc degeneration (Schmorl and Junghanns 1971; Vernon-Roberts 1987). Discography has been used extensively to identify such tears (Holt 1968; North American Spine Society 1988; Esses, Botsford and Kostuiik 1989; Nachemson 1989) and to assess their clinical significance in patients with low back pain (Crock 1983; Colhoun et al 1988). Magnetic resonance imaging (MRI) can show degeneration of the intervertebral disc by the analysis of signal intensity obtained from the nucleus pulposus and the inner annulus (Modic and Weinstein 1984; Pech and Haughton 1985; Gibson et al 1986; Schneiderman et al 1987), and it has been suggested that special techniques may reveal tears within the annulus fibrosus (Yu et al 1988).

We have made a prospective analysis of the correlation between MR appearance and the results of discography in a consecutive series of patients with low back pain.

PATIENTS AND METHODS
We reviewed patients investigated for low back pain from May 1987 to December 1988, excluding those with spinal osteomyelitis, discitis or other infectious diseases, trauma or tumour. There were 33 patients, in whom we studied a total of 114 lumbar intervertebral discs. The mean age of the patients was 35 years (24 to 64).

For MRI we used a Siemens Magnetom 1.0 Tesla machine (Siemens AG, Erlangen, Germany). T2-weighted spin echo sagittal images of 5 mm thickness were obtained using a TR (repetition time) of 2.5 sec and a TE (echo time) of 90 msec. The images of the intervertebral discs were classified according to the signal intensity from the central zone. This was recorded as normal, reduced, or absent when no difference could be seen between the central and peripheral zones in central sagittal slabs (Fig. 1). We tried to classify the shape of the central signal as normal, enlarged anteriorly, enlarged posteriorly, or both. This distinction proved to be extremely difficult in most cases, and we therefore limited the MRI classification to intensity only.

We performed discography after MRI, using a posterolateral approach and a two-needle technique with stilettles. The radiographic contrast material was mixed with cefazolin as a prophylactic measure to prevent discitis (Osti, Fraser and Vernon-Roberts 1990a).

Discographic patterns were classified as follows:
Type 1. Normal: the nucleus was well outlined in a roundish, regular, simple or bilobulated pattern and no annular tears were seen.
Type 2. The nucleus was well outlined but an anterior or posterior tear extended to the inner or outer annulus, with no leaking into the epidural space.
Type 3. The nucleus was well outlined, but one or more tears extended to the outer annulus anteriorly or...
posteriorly, with leakage of contrast into the epidural space or along the anterior longitudinal ligament.

*Type 4.* The nucleus itself was not outlined; the contrast extended throughout the disc space, with or without leakage into the epidural space (Fig. 2).

Pain reproduction was recorded as absent, atypical (when injection caused discomfort or pain which was clearly different from the usual symptoms) or typical (when injection reproduced the patient's usual back symptoms). The pressure used for the injection of contrast was recorded as high, medium or low.

The assessments of the MRI signal and discography patterns were made by one of the authors (OLO) while pain reproduction and pressure were graded by one of the three radiologists performing the discography.

**RESULTS**

The results are summarised in Tables I and II.

All discs identified as abnormal by MRI showed abnormal discography patterns, but six of the 60 discs with normal MRI showed marked degenerative changes at discography (Figs 3 and 4). None of the 15 discs showing definite degeneration on MRI had high levels of

Discogram patterns. Figure 2a – L4-L5 is normal, type 1; L5-S1 shows a posterior annular tear, type 2. Figure 2b – At L3-L4, there is physiological pooling in the centre of the disc but the contrast is also outlining the inner and middle fibres of the anterior annulus. There is a cleft running towards the upper end-plate of the lower vertebra. This is a type-2 pattern. Figure 2c – At L4-L5 there is extravasation of contrast posteriorly along the perispinal ligaments and into the epidural space. This is a type-3 pattern. Figure 2d – At L5-S1 there is no pooling of contrast, and multiple tears anteriorly and posteriorly. This is a type-4 pattern.
intradiscal pressure, while only six of the 60 with normal MRI had low pressures.

Of the 39 discs which caused typical pain on discography, 27 had abnormal signals on MRI. All the symptomatic discs had degenerative contrast patterns at discography. Conversely, 33 of the 39 asymptomatic discs had normal MRI signals, and only 24 had normal discographic patterns. Only six of the 46 discs diagnosed as degenerate on MRI were asymptomatic at discography.

**DISCUSSION**

Cloward (1952) first discussed the diagnostic value of discography for highlighting tears and disorganisation of the annulus fibrosus in cases of ruptured lumbar intervertebral disc. Brodsky and Binder (1979) suggested that pain produced by intradiscal injection was due to the transmission of pressure through a torn or weakened annulus to stretch its outer fibres. Park et al (1979)

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Table I. Comparison of results of MRI and discography in 114 lumbar discs

<table>
<thead>
<tr>
<th>MRI signal intensity</th>
<th>Discography type*</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Normal</td>
<td>27</td>
<td>15</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Decreased</td>
<td>Normal</td>
<td>9</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Absent</td>
<td>Normal</td>
<td>6</td>
<td>9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*see text

Fig. 3a - The discogram shows marked extravasation of contrast anteriorly and posteriorly at L4-L5 reaching the epidural space and outlining the most peripheral anterior and posterior layers of the annulus fibrosus (type 3). At L5-S1 there is a type-4 pattern. Figure 3b - On MRI of the same case, the L4-L5 level shows some distortion of the central signal, and the L5-S1 disc shows absence of signal, except for a small area in the posterior annulus. This is consistent with the type-4 pattern seen at discography.

Fig. 4a - Discograms are normal at L3-L4 and L4-L5 levels. At L5-S1 there is extravasation of contrast into the posterior annulus possibly related to a posterolateral tear. Figure 4b - The MRI scan shows no obvious abnormality in signal intensity or shape at any of the three levels.
reported on 14 young adult patients with discographic evidence of posterior annular fissures extending from an otherwise normally outlined nucleus, and postulated that radiating fissures could be early evidence of disc injury. They also considered that pain provocation could be the result of transference of increased nucleus tension to the outer annulus, which would not occur if there was a complete radial rupture.

Adams, Dolan and Hutton (1986) correlated discographic patterns with stages of degeneration in cadaver material. They also considered that radiating clefs with no leakage of contrast material into the epidural space would be commonly found in patients with back pain and would often be associated with typical symptoms during the injection.

In our series 36 of the 39 discs with typical pain at injection showed tears extending to the outer annulus. None of the 27 discograms showing a normal pattern produced typical pain: 24 of them caused no discomfort.

We were unable to correlate intradiscal pressure with pain. Most normal discs accepted a high intradiscal pressure with no pain, but three of the nine discograms with a low pressure reproduced the patients' typical pain.

MRI is now an alternative method of obtaining information on the state of the intervertebral disc. Gibson et al. (1986) compared the findings of MRI and discography in five discs, and concluded that MRI was more accurate in the diagnosis of degeneration. Schneiderman et al. (1987) correlated MRI and discography of 101 discs in 36 patients. MRI was accurate in predicting normal or abnormal disc morphology at 100 levels, but MRI signal intensity alone could not determine the exact pattern seen at discography. They also found that in patients with early symptoms due to acute herniation or tears of the annulus, MRI may not show changes in signal intensity. Zucherman et al. (1988) reporting on 18 patients also considered that MRI did not accurately reflect the internal disc morphology, and may not detect significant pathology.

Our results suggest that, using current standard techniques, MRI fails to demonstrate some of the structural changes in the annulus which would be seen on discography. A normal MRI signal intensity from the central zone is not proof of normal disc morphology.

In an animal model of disc degeneration we found that MRI using standard T2 spin echo sequences failed to detect changes in signal intensity until 12 months after the initial lesion (Osti, Fraser and Vernon-Roberts 1990b). This confirmed previous experimental studies which showed that after an acute failure of the annulus the content of nuclear proteoglycan of the disc shows a temporary increase (Lipson and Muir 1981), which is associated with high values of hydration and therefore with a normal MRI signal.

We found no false-positive results on MRI, and it may therefore be a useful screening procedure for disabling disc disease. Discography should be considered, as suggested by Zucherman et al. (1988), for patients with normal MRI and continuing severe symptoms.

Yu et al. (1988) comparing anatomical specimens and MRI of human intervertebral discs, concluded that T2-weighted image sequences showed different types of tear within the annulus fibrosus. This study was based on cadaver material, but it is likely that continuing technological improvements and the use of enhancing contrast agents may soon improve the quality of the MRI signal from the annulus. This may allow the visualisation of annular tears in the absence of major degenerative changes in the nucleus pulposus.

We conclude that discography is, at present, the more accurate investigation for annular tears which are likely to produce low back pain.

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