Recognition of Lumbar Disk Herniation with NMR

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Recognition of Lumbar Disk Herniation with NMR

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Fifteen nuclear magnetic resonance (NMR) studies of 14 patients with herniated lumbar intervertebral disks were performed on the UCSF NMR imager. Computed tomographic (CT) scans done on a GE CT/T 8800 or comparable scanner were available at the time of NMR scan interpretation. Of the 16 posterior disk ruptures seen at CT, 12 were recognized on NMR. Diminished nucleus pulposus signal intensity was present in all ruptured disks. In one patient, NMR scans before and after chymopapain injection showed retraction of the protruding part of the disk and loss of signal intensity after chemonucleolysis. Postoperative fibrosis demonstrated by CT in one patient and at surgery in another showed intermediate to high signal intensity on NMR, easily distinguishing it from nearby thecal sac and disk. While CT remains the method of choice for evaluation of the patient with suspected lumbar disk rupture, the results of this study suggest that NMR may play a role in evaluating this common clinical problem.

Nuclear magnetic resonance (NMR) has been useful in the evaluation of a wide variety of diagnostic problems [1–3]. Our study assessed the role of NMR in the recognition of lumbar disk rupture.

Subjects and Methods

Fourteen outpatients (six women, eight men) with herniated lumbar disks diagnosed by CT were examined with NMR. The age range was 25–62 years (mean, 43.6). Surgery has been performed after the NMR examination in only one patient. Therefore, current CT examinations were used as the diagnostic standard for NMR comparison. The CT findings were in keeping with the clinical impressions. However, only very short-term clinical follow-up was available.

Fifteen studies were performed on the UCSF NMR superconducting-magnet imager at a field strength of 0.35 T. The spatial resolution was 2.1 × 2.1 mm in the configuration used, and each individual imaging plane was 7 mm thick. Transaxial images were obtained in all patients and sagittal images in all but one. Adjacent sections were centered 12 mm apart, resulting in a 5-mm nonimaged gap between sections. The display matrix was composed of 256 horizontal × 128 vertical elements. All images were produced using spin-echo pulse sequence and a two-dimensional Fourier transform image construction technique. The signal-intensity maps were generated for each of the 15 simultaneously acquired adjacent anatomic sections using data from the first (28 msec) and second (56 msec) spin echoes (TE). Pulse repetition intervals (TR) were 500 msec for one study, 1000 msec for one, 1500 msec for seven, and 2000 msec for six. The total imaging time for the 15-section program was 13.5 min.

CT scans were obtained using a GE CT/T 8800 or comparable scanner. NMR and CT scans were performed within 4 months of each other (mean, 2 months). No radiographic contrast material was used. The anatomy of the lumbar spine as seen in 15 normal patients previously reported [4] provided the basis for the diagnosis in our abnormal patients.

The NMR diagnosis of disk rupture rested on a decreased signal intensity of the nucleus pulposus and visualization of the protruding disk either effacing epidural fat or displacing the thecal sac (figs. 1 and 2). The NMR scan was interpreted with knowledge of the CT scans or in conjunction with those images.

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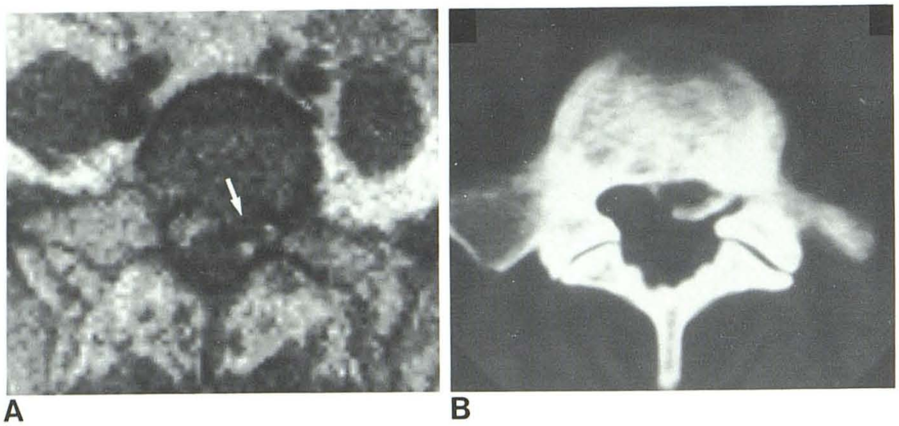

Fig. 1.—Herniated L5–S1 disk. **A**, Transaxial NMR scan; 1500 msec TR, 28 msec TE. Protrusion of disk (*arrow*); distortion of thecal sac; very low signal intensity of rim of calcium. **B**, Comparable CT image.

Results

Posterior protrusion of 12 intervertebral disks was shown on NMR; each disk also demonstrated diminished signal intensity of the nucleus pulposus. An additional four disks (one at L4–L5 and three at L5–S1) with subnormal intensity signals from the nucleus pulposus were unremarkable on CT. Four of the 16 disk ruptures seen on CT were not apparent on NMR (three at L4–L5 and one at L5–S1).

The recognition of posterior disk rupture was easier in the NMR sagittal images than in the direct transaxial images. The one patient scanned twice showed reduced signal intensity from the nucleus pulposus of the protruding disk on the first study and absence of this signal on the second study, after chemonucleolysis. In addition, the disk mass indenting the anterior thecal sac had partly retracted in the 2-month interim (fig. 3).

Two patients had regions of intermediate to high signal intensity adjacent to the thecal sac. One with a wide laminectomy at the L4 level showed CT findings of postoperative fibrosis (fig. 4). Another patient, who had undergone several laminectomies (the most recent of which was 1 year before the study), demonstrated an intermediate to high signal intensity region adjacent to the thecal sac on NMR (fig. 5). At surgery 1 month later, this region was found to represent fibrous tissue or scar.

Discussion

Our study reveals that lumbar disk rupture can be recognized on NMR. The parasagittal images were more informative than the transaxial images because the skip regions and partial-volume effect of the large voxel compromise diagnostic accuracy to a greater extent in the transaxial plane. A registered sagittal scout view, not currently available, would be of great assistance in identifying anatomy in the transaxial images. It is often easier to identify the nucleus pulposus on a sagittal image because other nuclei seen in the same image substantiate the location as being at or near the midline. Consequently, absence of signal from the nucleus pulposus is appreciated more readily. In contrast, uncertainty of disk location on axial images is often a problem unless the structure is normal.

The loss of the normal high-intensity signal of the nucleus pulposus seems to be related to the desiccation that occurs with degeneration or the extrusion of nuclear material at the time of herniation [5]. Chemonucleolysis seems to lead rapidly to a similar appearance. The reduction in the signal intensity of the nucleus pulposus noted in all ruptured disks examined suggests an intrinsic abnormality. This finding in nonruptured disks is presumably an indication of deterioration of the disk. However, it is not clear how commonly such a disk will, with time, rupture. NMR is unique in providing data regarding the condition of the nucleus pulposus; although the meaning of this information is open to speculation, such data cannot be ascertained by CT.

The intermediate-intensity signal of postoperative fibrosis in two patients is of particular interest. On the basis of the very low signal intensity of ligamentum flavum and the posterior longitudinal ligament, both fibrous structures, one might have anticipated a similar low-intensity signal for scar tissue. Perhaps the loosely organized fabric of postoperative scar when compared with the dense organization of the ligaments may account for the finding.

On CT the density of postoperative fibrosis can be similar to that of disk, rendering discrimination from recurrent disk herniation at a previously operated but subsequently painful disk level a difficult task. Both intravenous and intrathecal contrast media have been used in a attempt to make this differentiation [6, 7]. Furthermore, in the presence of extensive postoperative fibrosis, the entire cross section of the spinal canal can be rendered uniform in density on CT, thus obscuring the borders separating fibrosis, disk, thecal sac, and ligamentum flavum. Our two cases suggest that NMR may allow distinction among fibrosis, disk, and thecal sac and may be of particular use in the evaluation of the post-spinal-surgery patient. This finding awaits confirmation in a larger series.

Identification of distortion of the thecal sac and recognition of neural elements, easily done by CT, currently is more difficult with NMR in part because of lower spatial resolution and volume averaging. Greater familiarity with normal lumbar spinal structures, improvement in spatial resolution, and the capability for thin, contiguous, high-resolution slices will make NMR more effective. In our study, the CT results were known at the time of NMR interpretation; without this information,

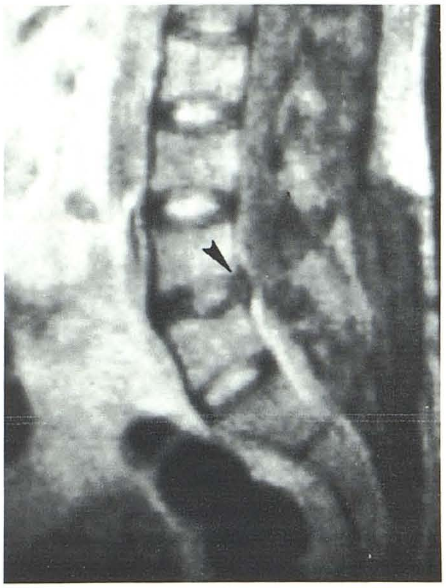

Fig. 2.—Herniated L4–L5 disk. Near-midline parasagittal image; 1500 msec TR, 56 msec TE. Decrease in intensity of nucleus pulposus at L4–L5 and displacement of epidural fat that normally separates disk from thecal sac (*arrowhead*).

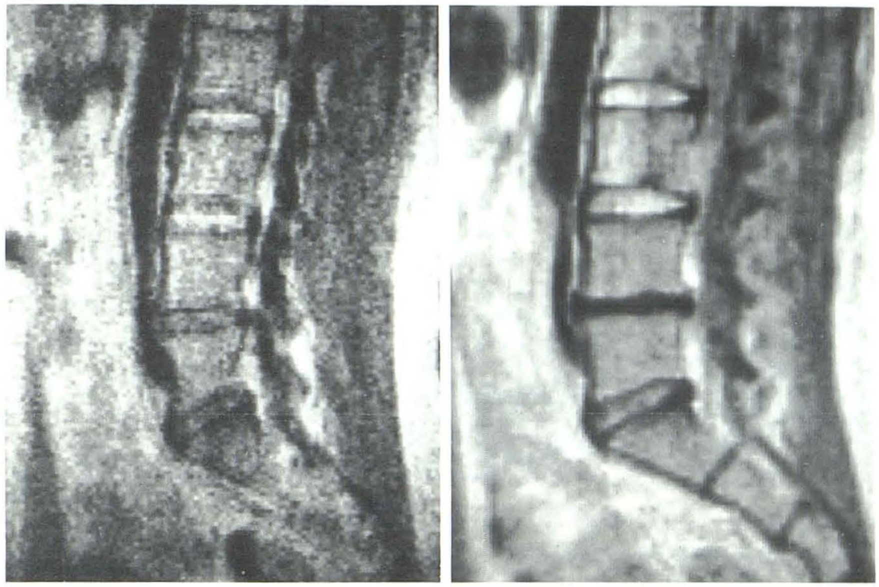

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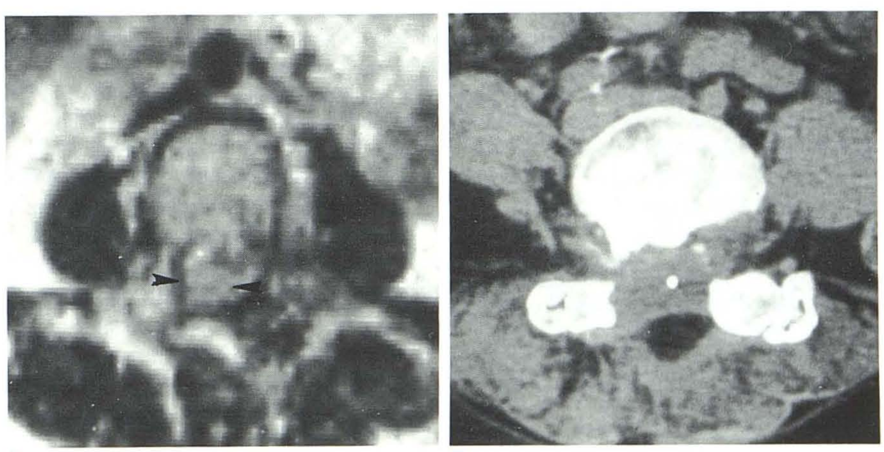
Fig. 3.—Abnormal L4–L5 and L5–S1 disks. Sagittal NMR scans. **A**, 1500 msec TR, 28 msec TE. Low signal intensity of L5–S1 and L4–L5 nucleus pulposus and posterior rupture of L4–L5 disk. **B**, 3 months after L4–L5 chemonucleolysis; 2000 msec TR, 28 msec TE. Further loss of nucleus pulposus signal and retardation of disk mass away from thecal sac. Improvement in image quality due to modifications in equipment.

Fig. 4.—Postoperative fibrosis in patient with wide posterior spinal surgical decompression. **A**, Transaxial NMR scan; 2000 msec TR, 56 msec TE. Intermediate to high-intensity signal region in central canal at L4 (*arrowheads*) which correlates with CT scan (**B**) appearance of postoperative fibrosis.



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the diagnostic accuracy of NMR might not have been quite as high.

The appearance of normal and abnormal intervertebral disk material with various scan parameters was not specifically addressed in this preliminary study. All examinations were performed using the spin-echo technique, and only one patient was examined at more than one TR value. Nucleus-anular differentiation was readily apparent on spin-echo images at all TR values used and (presumed) abnormal nucleus pulposus was always less intense than normal nucleus pulposus at each TR value. Nucleus-anulus differentiation appeared to increase as the TR and TE values increased. Since the signal-to-noise ratio increases with increasing TR values (over the range of TR values used in this study), longer TR values seem to offer the optimal combination of high signal-to-noise ratio and maximal nucleus pulposus–anulus fibrosus contrast in normals. As the anulus fibrosus was more readily distinguished from neighboring cortical bone with 28 msec TE, disk rupture was more apparent at this setting. However, differentiation of anulus from nucleus was easier at 56 msec TE, making the recognition of an abnormal nucleus pulposus more obvious. Other scanning parameters, some of which may offer more diagnostic information than the protocol used in this study [5], await investigation. For the moment, CT

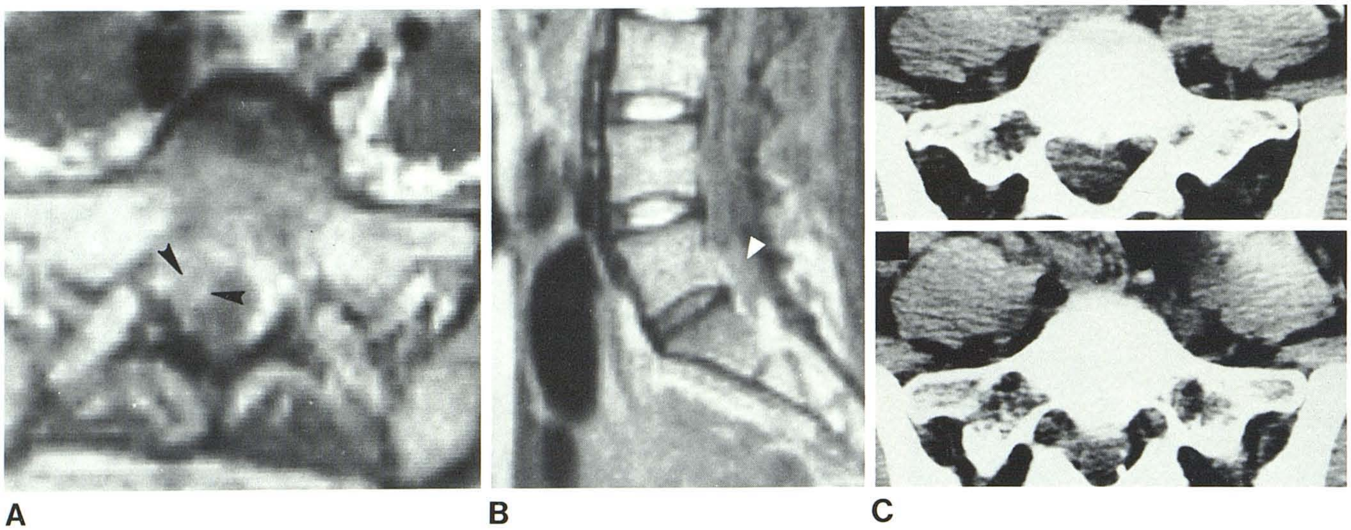

Fig. 5.—Postoperative fibrosis in patient with previous laminectomies. Transaxial (**A**) and right parasagittal (**B**) NMR scans; 2000 msec TR, 28 msec TE. Right-sided intermediate to high-signal-intensity tissue in epidural space of central canal (*arrowheads*). **C**, Corresponding CT scan is nondiagnostic as to origin of soft-tissue mass. Fibrous tissue was found at surgery.

remains the imaging method of choice for evaluating suspected lumbar disk rupture.

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