Differentiation Between Postoperative Scar and Recurrent Disk Herniation: Prospective Comparison of MR, CT, and Contrast-Enhanced CT

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Twenty-five symptomatic postlumbar surgery patients had findings on lumbar spinal noncontrast CT that were equivocal for distinguishing recurrent disk herniation from postoperative epidural fibrosis (scar). Contrast-enhanced CT and lumbar MR imaging were performed to differentiate these two conditions.

Of the 14 levels, surgically explored, the diagnosis of scar or recurrent disk herniation was correct with contrast-enhanced CT at 10 levels and with MR imaging at 11 levels. At the levels operated on less than 2 years prior to MR imaging, scar more frequently demonstrated intermediate than low signal intensity. Scar older than 2 years most often showed low signal intensity.

These preliminary findings suggest that MR may be useful in differentiating postoperative fibrosis from recurrent disk herniation in a significant proportion of patients whose unenhanced CT scans are equivocal.

The diagnostic evaluation of patients presenting with failed back surgery syndrome is a challenge to both radiologists and surgeons. Although the cause of this syndrome is complex and often multifactorial, recurrent disk herniation and postoperative epidural fibrosis (scar) at the previously explored level(s) are frequent sources of symptoms [1]. While recurrent disk herniations are surgically manageable, many surgeons are reluctant to repeat surgery with reliable evidence of only postoperative fibrosis. Even though excessive intraspinal perineural scar formation with or without associated arachnoiditis can be responsible for failed back surgery syndrome, it is unlikely that a new operation will help this group of patients, since additional scarring will often result [2, 3].

Myelography and CT have not proved very reliable in differentiating between recurrent disk herniation and postoperative fibrosis [4–7]. However, it has been shown that lumbar spinal CT after administration of IV contrast medium can improve the CT differentiation between recurrent disk herniation and scar [8, 9]. Moreover, MR imaging has been demonstrated to compare favorably with myelography and CT in the evaluation of low back pain [10–16]. In fact, MR imaging, with its superior soft-tissue characterization and multiplanar imaging capability, may provide a more reliable means of distinguishing between the two tissues in question [17].

The aim of this prospective study was to assess the relative value of contrast-enhanced CT and MR imaging in distinguishing between recurrent disk herniation and scar. For this purpose, we compared the results of each imaging method with the clinical findings from 12 patients, who underwent repeat surgery.

Subjects and Methods

The recent unenhanced lumbar CT scans of 78 consecutive postoperative back patients were reviewed by two radiologists experienced in interpretating spinal CT exams. Thirty-three levels in 25 of these patients were selected for study. The following selection criteria were used: (1) previous lumbar surgery with recurrence of symptoms; (2) an assurance from the surgeon that reexploration at the level in question was a serious consideration; (3) an

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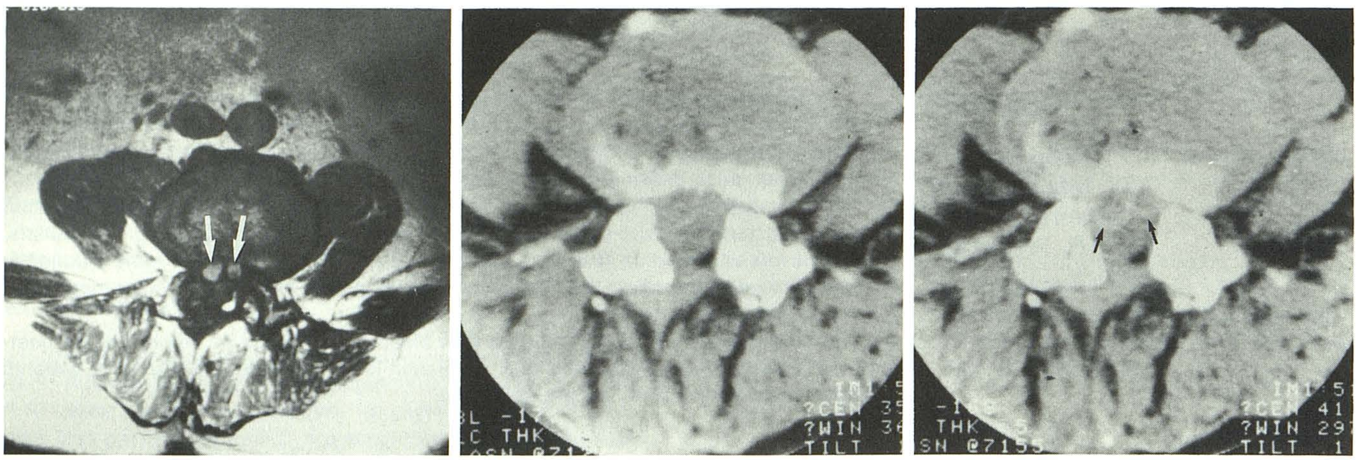
initial CT at the previously explored level(s) judged indeterminate in differentiating between recurrent disk herniation and scar; (4) absence of bony spinal canal stenosis; and (5) absence of medical contraindications to IV contrast agents.

The 25 patients fulfilling these criteria (33 levels) were studied by contrast-enhanced CT and MR imaging. Contiguous, 3-mm-thick axial CT scans were generated on a GE 9800 CT scanner. CT was performed only at the previously explored levels both before and after IV administration of contrast medium. Contrast-enhanced CT was obtained after a bolus injection of 100 ml of Conray-60 and during drip infusion of 150 ml of Conray-30.

The MR examinations were performed on three different imagers: two 0.35-T Diasonics MT/S superconductive scanners (20 patients) and one 1.5-T GE superconductive scanner (five patients).

On the mid-field system, sagittal images were obtained by using a spin-echo technique with a TR of 1000 or 1500 and TEs of 30 and 60 for 1-cm contiguous slices, and TEs of 40 and 80 for 5-mm contiguous slices. Axial images with a slice thickness of 5 mm were obtained with a TR of either 1500 or 2000 and TEs of 40 and 80. The image matrix consisted of 256 × 256 elements; the field of view was 24 cm for axial and coronal scanning.

On the high-field system, axial and sagittal images were obtained with a 25-cm prototype surface coil and a spin-echo technique with TRs ranging from 1000 to 2000 and TEs of 25 and 50, 25 and 70, or 40 and 80. Axial and sagittal images were 5-mm thick with an interslice gap of 1 mm. The image matrix consisted of 256 × 256 elements, the field of view was 20 cm for axial scanning and 24 cm for sagittal scanning.

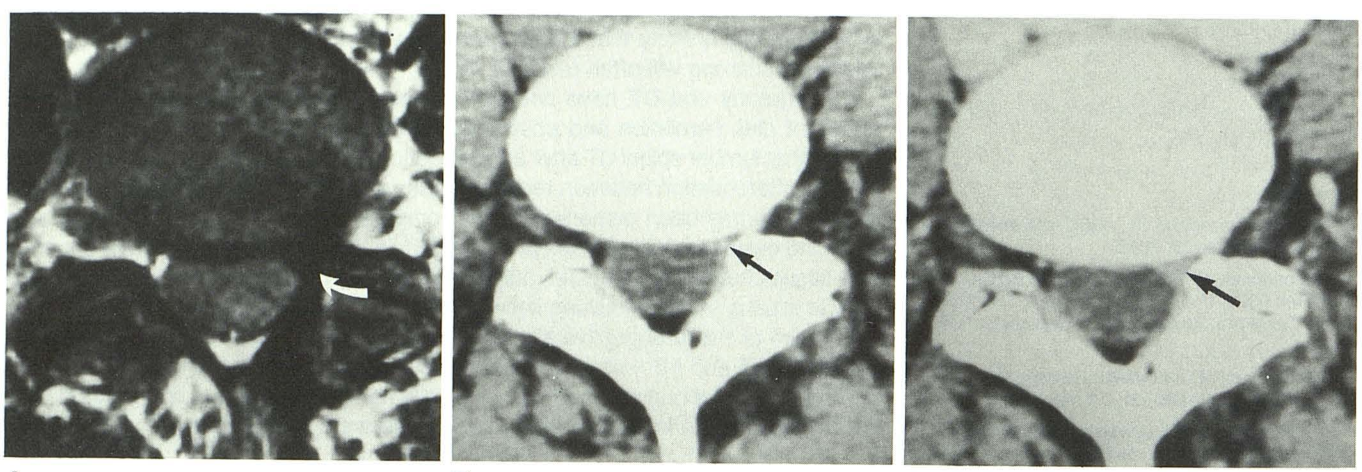


A B C

Fig. 1.—*A*, Axial MR image (1000/25) at 1.5 T shows bilobed disk herniation anterior to thecal sac (*arrows*).

***B*, Axial CT scan shows soft-tissue density replacing epidural fat on right and anterior aspects of thecal sac—findings are equivocal for scar vs recurrent disk herniation.**

***C*, Axial CT scan obtained after IV contrast administration shows enhancement of border between anterior tissue abnormality and thecal sac in a pattern that is typical of disk herniation (*arrows*).**



A B C

Fig. 2.—*A*, Axial MR image (1500/40) at 0.35 T shows low signal intensity region in left anterolateral epidural space (*arrow*). No clear distinction between scar or recurrent disk herniation is possible.

***B*, Axial CT scan shows soft-tissue density (*arrow*) in left lateral aspect of epidural space in this patient 7 years after lumbar surgery.**

***C*, Axial CT scan obtained after IV contrast administration shows opacification of soft-tissue density in question (*arrow*), indicating that it is postoperative fibrosis rather than recurrent disk herniation fragment.**

The imaging studies were evaluated blindly by three radiologists. Twelve patients (14 levels) subsequently underwent surgery on the basis of the clinical findings and imaging studies. The findings from imaging studies and surgical reexploration were compared at each level. The signal intensity of scar was correlated with the time interval between the last operation and MR imaging in the initial 25 patients studied by both contrast-enhanced CT and MR imaging.

Results

Comparison of Imaging Studies and Operative Findings in 12 Patients

In the 12 patients (14 levels) who underwent subsequent surgery, recurrent disk herniations were found intraoperatively at eight levels and scar at five levels. One patient (one level) had neither recurrent disk herniation nor scar; exploration was negative. At the explored levels, there were 10 correct diagnoses on contrast-enhanced CT and 11 on MR imaging. There were four incorrect diagnoses on contrast-enhanced CT and three on MR imaging.

Of the eight surgically proved cases of recurrent disk herniation, seven were correctly identified by contrast-enhanced CT and all eight by MR (Fig. 1). In one case of proved recurrent disk herniation, diagnosis by contrast-enhanced CT was that of scar.

Of the five surgically proved scar cases, three were correctly identified by contrast-enhanced CT and two by MR imaging; in one case of proved scar, the diagnosis by contrast-enhanced CT was recurrent disk herniation, while in another the result was indeterminate. Conversely, in one case of proved scar, the diagnosis by MR imaging was recurrent disk herniation, while in two others the results were indeterminate (Fig. 2). At one level, where exploration was negative, contrast-enhanced CT was indeterminate, while MR at the same level provided the correct diagnosis of normal.

Scar was typically identified as a mass, band, or strandlike structure of intermediate to low MR signal intensity that often replaced or was surrounded by epidural fat (Fig. 3A). In a few of the levels studied, ovoid fat collections were demonstrated within scar tissue. Recurrent disk herniation, on the other hand, was frequently smooth and globular in shape.

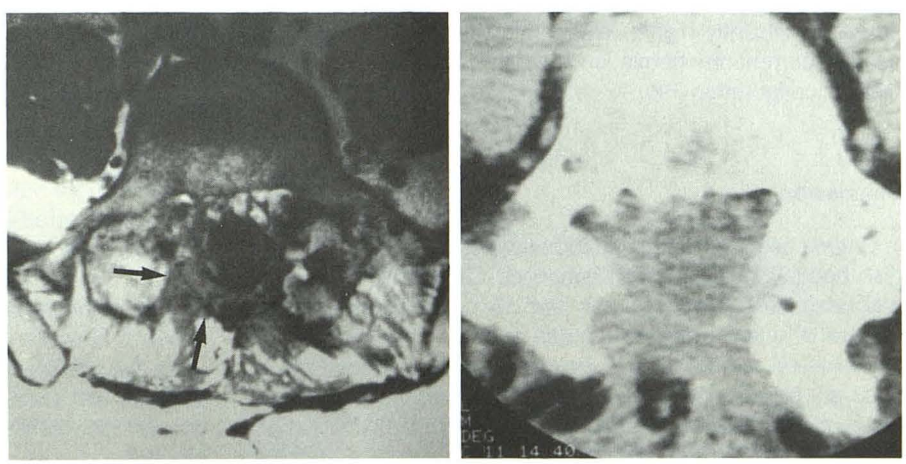
In 10 of the 12 patients who had repeat surgery the scar assumed a band or strandlike form. In the other two patients, the configuration of the scar was masslike (Fig. 3), with a bulky mass at the laminectomy site compressing the thecal sac as a form of soft-tissue-related spinal canal stenosis (Fig. 4). This finding was clearly depicted preoperatively by MR. Contrast-enhanced CT in one of these two cases also showed the abnormality, but the level of confidence in making this diagnosis was not as high as with MR imaging.

MR Signal Characteristics of Postoperative Scar

In the 33 initially examined levels (25 patients, 12 of whom were reexplored), the MR signal intensity of scar on the first echo of the long TR sequences was lower than that of thecal sac in 16 levels (Fig. 2A), approximately equal to that of thecal sac in 13 levels, and higher than that of thecal sac in four levels (Fig. 4A).

In all instances, the thecal sac demonstrated a significant increase in signal intensity from first to second echo because of the CSF, making a distinction between scar and thecal sac quite easy; on the second-echo images, scar was isointense with the thecal sac in only four levels, whereas scar demonstrated a lower signal intensity than thecal sac in 27 levels. In two levels, scar remained higher in signal intensity than the thecal sac on second-echo images. Scar signal intensity was lower than adjacent intraspinal or paraspinal fat at all levels.

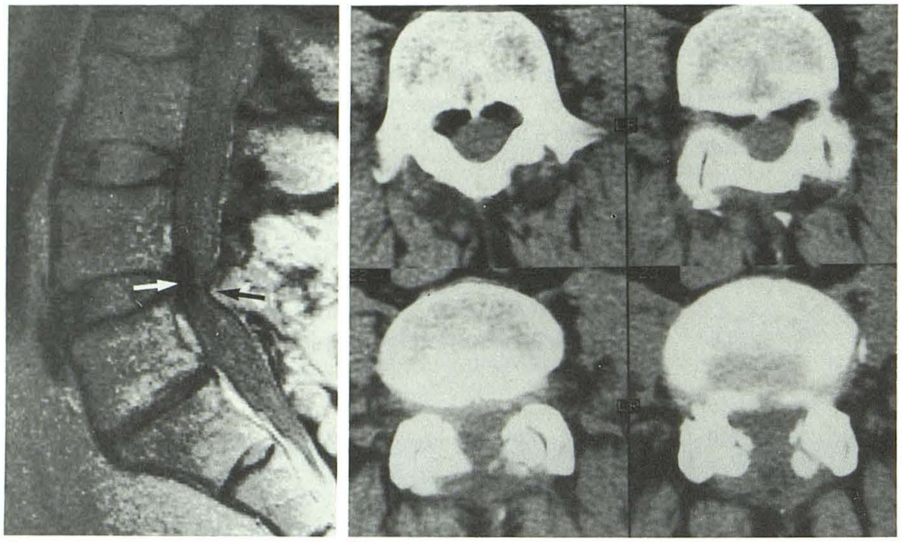
Of 33 levels examined, 21 had been operated on more than 2 years prior to MR and CT; 12 levels had undergone surgery within 2 years of MR and CT examination. Of the 21 levels, 15 were noted to contain scar of low MR signal intensity (Fig. 2A); five levels had intermediate intensity; and one level had high intensity. Of the 12 levels that had been operated on within 2 years of MR and CT, MR signal intensity of scar was high in two, intermediate in eight (Fig. 3A), and low in two.



A B

Fig. 3.—*A*, Axial MR image (1000/25) at 1.5 T shows superior soft-tissue delineation afforded by MR. High signal intensity of fat can be separated from intermediate signal intensity of scar (*arrows*), which in turn is distinct from lower signal intensity of thecal sac and nerve roots.

***B*, Axial CT scan at a level close to that of MR image shows soft-tissue density surrounding thecal sac. Note that contrast between neural and scar tissue is less than that demonstrated on MR.**



A B

Fig. 4.—*A*, Sagittal MR image (1500/40) at 0.35 T shows compression of thecal sac at L4–L5 level by low signal intensity herniated disk anteriorly (*white arrow*) and by intermediate signal intensity postoperative fibrosis posteriorly (*black arrow*).

B, Four axial CT scans at L4–L5 level. Lower two scans demonstrate a laminectomy defect and replacement of normal epidural fat by soft-tissue density of indeterminate origin.

MR Appearance of Postoperative Intervertebral Disks

In the majority of postoperative levels, the sagittal MR images demonstrated a loss of disk height as well as various degrees of anterior and/or posterior bulging of the disk; in most instances the bulge was broad-based.

Of the 33 disk levels initially examined by both contrast-enhanced CT and MR, the overall MR signal intensity of the operated disk as demonstrated on the sagittal images was considerably lower than that of both the thecal sac and the adjacent disk in 19 levels. In 12 of the 33 levels, the signal intensity of the intervertebral disk was intermediate. In two of the 33 levels, the intervertebral disk demonstrated normal signal intensity.

In many levels, no clear differentiation could be made between the posterior aspect of the intervertebral disk and adjacent scar if criteria based solely on signal intensity differences were employed. In 18 of the 33 levels, scar tissue was only slightly higher in signal intensity than the disk on the first echo, whereas in 14 of 33 levels the two structures were of approximately equal signal intensity. At only one level did a postoperative disk (proved recurrent disk herniation) demonstrate significantly higher signal intensity than the adjacent scar. Recurrent disk herniation, however, was frequently globular in configuration (Fig. 1).

Discussion

Criteria used for differentiating between scar and recurrent disk herniation on contrast-enhanced CT scans have been well described. Recurrent disk herniation is diagnosed when a mass of unenhanced soft tissue is seen in the anterior or anterolateral epidural space. Scar is diagnosed when there is relatively uniform enhancement of the extradural soft tissue in question. Secondary effects of recurrent disk herniation (i.e., mass effects on neural structures) and scar (i.e., retraction of neural structures toward scar) can be of help in distinguishing the structure in question. Scar in the anterior and anterolateral epidural space, however, may be similar in both configuration and density to a recurrent disk herniation. Although both IV and intrathecal contrast agents have been described as helpful in increasing the specificity of CT, the distinction between scar and recurrent disk herniation remains difficult. A prospective study demonstrating that contrast-enhanced CT reduced the number of incorrect diagnoses of 23 conventional CT examinations from 13 to six indicates that IV contrast enhancement is helpful but still inconclusive in approximately 25% of cases [9].

MR imaging is routinely used in the evaluation of patients with low back pain. The appearance of scar after surgery in regions of the body other than the spine as well as after myocardial infarction suggests that such tissue has a low signal intensity on MR. Furthermore, the fibrous tissue of tendons and ligaments demonstrates low signal intensity. The signal intensity of scar, however, is affected by various factors such as scar morphology and fat content, age of scar and vascularity, inflammatory changes, and technical factors.

Low-intensity strands of scar could be visually separated from adjacent fat. However, mass- or bandlike scars more often demonstrated intermediate MR signal intensity. Among the levels that were operated on less than 2 years before MR, scar more frequently demonstrated intermediate than low signal intensity (Fig. 3A), whereas older scar most often showed low signal intensity (Fig. 2A). In those instances in which regions of low signal intensity taking the form of strands or bands were noted to be coursing through fat, little difficulty was encountered in recognizing such structures as fibrotic in nature on MR. CT, however, frequently demonstrated a mixed pattern of a masslike structure, which was irregular and patchy in these patients. In these cases, the location of the tissue in question and its effect on adjacent neural structures were the only bases for the CT diagnosis. In four unoperated patients with such findings, the decision to reexplore (based on contrast-enhanced CT) was abandoned when the MR diagnosis of scar rather than disk became known.

Since there was no histologic examination of the scar tissue removed at the time of surgery, correlation between signal

intensity and degree of vascularity and extent of granulation tissue was not possible. We can only speculate that granulation tissue and vascularity might have been responsible for the higher signal intensity of immature scar. The low MR signal intensity as demonstrated in some postoperative patients may reflect the more tightly knit cohesive structure of fibrous tissue than is present in scar, which has a higher MR signal intensity.

The location and configuration of the strands of low MR signal intensity suggested scar rather than vascular structures at these locations. Intraoperative findings also failed to demonstrate vascular structures at these locations.

The MR signal intensity of the postoperative disk was most frequently lower than that of thecal sac or adjacent disks. Removal of nuclear material, which has high proton density, at the time of previous surgery, and progressive desiccation of the usually already preoperatively degenerated disk probably account for the low disk signal at the postoperative levels.

Several reports have indicated that herniated disk material in the previously unoperated patient may demonstrate quite variable signal intensities on MR [10, 11]. One of the patients studied demonstrated a recurrent disk herniation with high MR signal intensity. Intraoperatively, the reherniated tissue in this patient was found to consist primarily of nuclear material. In general, however, it appears that the postoperative disk has less variable signal intensity characteristics than the nonoperated disk.

MR and contrast-enhanced CT correlated with surgical results in 79% and 71% of the levels, respectively. MR correctly identified all eight surgically proved recurrent disk herniations whereas contrast-enhanced CT did almost as well detecting seven of eight recurrent disk herniations. When scar was the main surgical diagnosis, both methods performed poorly (only two correct MR diagnoses as compared with three by contrast-enhanced CT). Although the images acquired on the mid-field system were diagnostic in most of the patients, it appeared that the high-field system provided a clearer delineation of spinal structures and the tissues in question at the reexplored levels.

In conclusion, we believe that when nonenhanced CT of the postoperative lumbar spine is indeterminate, it is highly likely that contrast-enhanced CT or MR imaging will provide a more confident and definitive diagnosis.

REFERENCES

1. Burton CV, Kirkaldy-Willis WH, Yong-Hing K, Heithoff KB. Causes of failure of surgery on the lumbar spine. *Clin Orthop* **1981**;157:191–199
2. Langenskiold A, Kiviluoto O. Prevention of epidural scar formation after operations on the lumbar spine by means of free fat transplants. *Clin Orthop* **1976**;115:92–95
3. Yong-Hing K, Reilly J, de Korompay V, Kirkaldy-Willis WH. Prevention of nerve root adhesions after laminectomy. *Spine* **1980**;5:59–64
4. Teplick JG, Haskin ME. Computed tomography of the postoperative lumbar spine. *AJR* **1983**;141:865–884.
5. Mall JC, Kaiser JA. Computed tomography of the postoperative spine. In: Genant HK, Chafetz NI, Helms CA, eds. *CT of the lumbar spine*. Radiology Research and Education Foundation, **1982**
6. Mall JC, Kaiser JA, Heithoff KB. Postoperative spine. In: Newton TH, Potts DG, eds. *Computed tomography of the spine and spinal cord: modern neuroradiology*. San Anselmo, CA: Clavdel Press, **1983**:187–204
7. Jacobs RR, McClain O, Neff J. Control of post-laminectomy scar formation: an experimental and clinical study. *Spine* **1980**;5:223–229
8. Braun IF, Hoffman JC Jr, David PC, Landman JA, Tindel GT. Contrast enhancement in CT differentiation between recurrent disk herniation and postoperative scar: prospective study. *AJNR* **1985**;6:607–612, *AJR* **1985**;145:785–790
9. Schubiger O, Valvanis A. CT differentiation between recurrent disc herniation and postoperative scar formation: the value of contrast enhancement. *Neuroradiology* **1982**;22:251–254
10. Chafetz NI, Genant HK, Moon KL, Helms CA, Morris JM. Recognition of lumbar disk herniation with NMR. *AJR* **1983**;141:1153–1156
11. Han JS, Kaufman B, El Yousef SJ, et al. NMR imaging of the spine. *AJR* **1983**;141:1137–1145
12. Berquish TH. Magnetic resonance imaging: preliminary experience in orthopaedic radiology. *Magn Reson Imaging* **1984**;2:41–52
13. Edelman PR, Shoukimas GM, Stark DD, et al. High-resolution surface-coil imaging of lumbar disk disease. *AJR* **1985**;144:1123–1129
14. Modic MT, Feiglin DH, Piraino DW, et al. Vertebral osteomyelitis: assessment using MR. *Radiology* **1985**;157:157–166
15. Modic MT, Pavlicek W, Weinstein MA, et al. Magnetic resonance imaging of intervertebral disk disease: clinical and pulse sequence considerations. *Radiology* **1984**;152:103–111
16. Smith FW, Runge V, Permezel M, Smith CC. Nuclear magnetic resonance (NMR) imaging in the diagnosis of spinal osteomyelitis. *Magn Reson Imaging* **1984**;2:53–56
17. Sotiropoulos S, Chafetz NI, Genant HK, Winkler M. Assessment of the postoperative lumbar spine: distinction between postoperative fibrosis and recurrent disk herniation. IV contrast enhanced CT vs MRI (abstr). Presented at the Association of University Radiologists, Hartford, CT, May **1986**