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# Serial MR Imaging of Annular Tears in Lumbar Intervertebral Disks

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*BACKGROUND AND PURPOSE:* **Annular tears of lumbar intervertebral disks are found in both symptomatic and asymptomatic persons; therefore, it is difficult to determine whether these findings indicate acute abnormality. Our purpose was to determine whether the MR imaging findings of tears (ie, hyperintensity and contrast enhancement) of the annulus fibrosus persist or resolve over time.**

*METHODS:* **A radiologic database was searched for spinal MR imaging examinations noting annular tears. Eighteen patients were identified who had undergone more than one spinal MR imaging study. The images were reviewed for presence or absence of annular tears, defined as an area of hyperintensity on T2-weighted images or enhancement in the posterior annulus, separate from the nucleus pulposus.**

*RESULTS:* **Annular tears were observed at 29 levels in 18 patients. Two tears developed during the follow-up interval. When contrast-enhanced images were obtained during serial examinations, 10 (100%) of 10 enhancing annular tears persisted on the follow-up contrast-enhanced T1-weighted images (mean interval, 17.2 months; SD, 12.3 months). High signal intensity on T2-weighted MR images was noted in 26 (96%) of 27 tears initially and persisted in 23 (88%) of 26 (mean interval, 21.9 months; SD, 15.0 months).**

*CONCLUSION:* **Hyperintensity on T2-weighted MR images and enhancement of annular tears could not be used to determine the tears' acuity over the range of follow-up provided in this study.**

Tears or fissures of the annulus fibrosus of lumbar intervertebral disks are abnormalities frequently encountered in MR imaging of the lumbar spine. These tears are separations between annular fibers, separations of annular fibers from their vertebral insertions, or breaks through these fibers in any orientation, involving one or more layers of the annular lamellae (1). Although the word *tear* is commonly used to describe the gamut of these lesions, it does not necessarily indicate a traumatic cause (1). Annular tears have been noted in asymptomatic persons (2) and cadavers (3, 4) and are thought by some investigators to represent degenerative changes related to normal aging. Nonetheless, other studies have shown a strong association between imaging evidence of an annular tear and the presence of elicited pain during diskography at the same disk (5, 6). Previous studies have also shown that T1-weighted contrast-enhanced MR imaging is more sensitive than is T2-weighted MR imaging in identifying annular tears or fissures (2, 7) and that unenhanced T2-weighted MR imaging reveals only approximately two thirds of radial tears noted at diskography (3).

The natural history of annular tears in the lumbar spine has not been widely studied. Considering that these lesions are relatively prevalent in both symptomatic and asymptomatic persons (2, 8, 9), it is difficult to determine whether their presence on MR images represents an acute abnormality associated with a recent onset of pain. Our purpose was to determine whether the MR imaging findings of an annular tear persist or resolve over time, and if they resolve, whether their presence could imply acuity of the tear.

## Methods

We searched a computer database of all radiologic results that were obtained at our hospital from July 1997 through June

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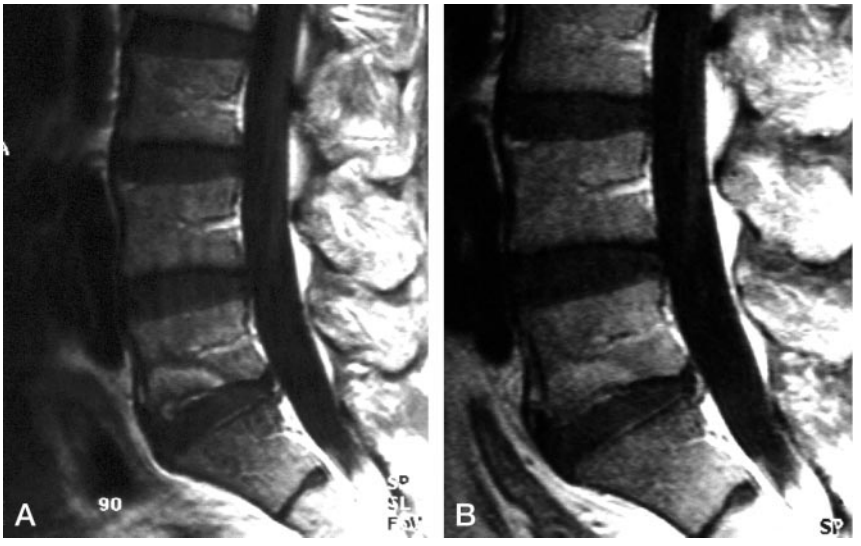


FIG 1. Contrast enhancement of an annular tear at initial and follow-up imaging.

*A*, Annular tear shows contrast enhancement. Sagittal T1-weighted contrast-enhanced MR image (600/14 [TR/TE]) of the lumbar spine shows focal contrast enhancement at the posterior margin of the L5–S1 disk.

*B*, Image of the same patient shown in *A*. Sagittal T1-weighted contrast-enhanced MR image (600/14) obtained 24 months later reveals persistent enhancement of the annular tear at the posterior margin of the L5–S1 disk.

2000 for spinal MR imaging reports containing the term *annular tear*. Of the reports searched, 212 reports of spinal MR imaging examinations included the term *annular tear*. We evaluated the record of radiologic examinations for each of these patients, and 18 patients were identified who had undergone more than one MR imaging study. The group comprised 11 men and seven women ranging in age from 23 to 68 years (mean age, 46.2 years; SD, 13.9 years). Clinical indications for the examinations included nonspecific low back pain without history of lumbar surgery (six patients), nonspecific back pain with history of lumbar surgery (two patients), radiculopathy (four patients), metastatic disease workup (two patients), evaluation of sacral fracture (one patient), non-radiculopathic leg pain (one patient), nonspecific pain after lumbar puncture (one patient), and follow-up for osteomyelitis (one patient). A retrospective review of these examinations was performed by three radiologists (F.M.M., B.A.W., D.M.Y.), and findings were determined by consensus. An annular tear was defined either as a focal area of hyperintensity at T2-weighted imaging or contrast enhancement in the posterior annulus of a degenerated disk separate from the nucleus pulposus (5–7, 9). The only disks included for review were those that had not previously undergone surgery or those that had not been violated by neoplasm, infection, or any other inflammatory process.

Imaging was performed on several different 1.5-T MR systems. The imaging parameters varied slightly, depending on the manufacturer of the system. All studies included sagittal fast spin-echo T2-weighted MR imaging (2700–4000/98/3 [range of TR/TE/NEX]) and sagittal T1-weighted MR imaging (600/14/3). Both T1- and T2-weighted imaging had the following parameters: section thickness, 4.0 mm; section gap, 0.4 mm; field of view, 175 to 210 × 280 mm; and matrix, 220 × 512. Ten patients received IV administered gadopentetate dimeglumine (0.1 mmol/kg), and contrast-enhanced T1-weighted MR images were obtained with the same parameters as those stated above for unenhanced T1-weighted MR images.

The presence or absence of annular tear(s) was recorded for each examination. The interval between examinations, the configuration of the tear, and the persistence or resolution of findings were noted at each level.

## Results

Annular tears, as defined in Methods, were noted at 29 levels in the 18 patients identified by computer search. Two tears developed during the follow-up interval (ie, they were present only on the follow-up images). The other 27 tears noted were present on the initial MR images. Twenty-five of these tears were radial tears, separate from the nucleus pulposus, and two were transverse tears, adjacent to the end plate. In five patients who had 10 annular tears, contrast material was administered for both the initial and follow-up examinations. In these cases, 10 (100%) of 10 annular tears persisted on the follow-up images, as shown in Figure 1. The range of follow-up duration was 3 to 35 months (mean interval, 17.2 months; SD, 12.3 months). At one disk level in a single patient, hyperintensity of the lesion at initial T2-weighted imaging had resolved at 13-month follow-up, whereas enhancement persisted (Table 1).

**TABLE 1: Annular tears studied with consecutive T2-weighted and contrast-enhanced T1-weighted imaging (n = 10)**

| | Initial Examination | Follow-up Examination |
|---|---|---|
| Abnormal signal (T2-weighted imaging) | 10 | 9 |
| Normal signal (T2-weighted imaging) | 0 | 1 |
| Focal enhancement (contrast-enhanced T1-weighted imaging) | 10 | 10 |
| Absent enhancement (contrast-enhanced T1-weighted imaging) | 0 | 0 |

Three other tears were noted to enhance on the images of patients who had contrast-enhanced images obtained at their first MR imaging study but had no contrast-enhanced images obtained during follow-up. One transverse tear had persistent, abnormal hyperintensity at follow-up T2-weighted imaging 33 months later. One radial tear had resolution of hyperintensity at follow-up T2-weighted imaging 23 months later. One radial tear that had normal signal intensity at initial T2-weighted imaging became hyperintense on a T2-weighted study at 33 months, indicating an annular tear.

Eight patients (12 annular tears) did not have contrast material administered at the initial or follow-up examination. Among these, 11 tears (10 radial, one

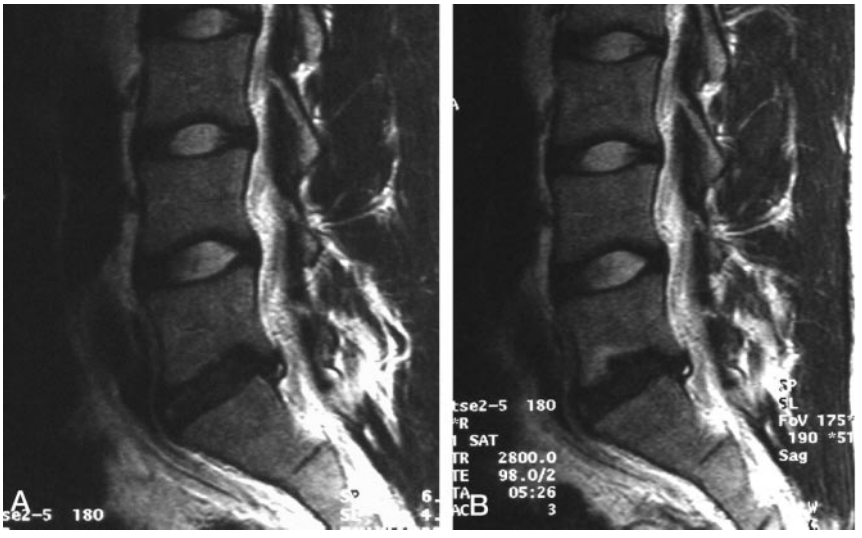


FIG 2. Hyperintensity at initial and follow-up imaging.

*A*, An initial sagittal fast spin-echo (2800/98) T2-weighted MR image shows the lumbar spine has abnormal focal hyperintensity in the posterior margin of the L5–S1 disk, indicating annular tear.

*B*, Image of the same patient shown in *A*. Sagittal fast spin-echo T2-weighted MR image (2800/98) obtained 26 months later reveals persistent abnormal focal hyperintensity at the posterior margins of the L5–S1 disk.

**TABLE 2: Annular tears only studied with consecutive T2-weighted imaging (n = 12)**

| | Initial Examination | Follow-up Examination |
|---|---|---|
| Abnormal signal intensity | 12 | 11 |
| Normal signal intensity | 0 | 1 |

transverse) showed persistent signal intensity abnormality on a follow-up T2-weighted image (Fig 2), and one radial tear resolved 22 months later (Table 2). The range of follow-up duration was 1.5 to 64 months (mean interval, 25.1 months; SD, 18.3 months).

Hyperintensity was noted initially in 26 of 27 annular tears and persisted in 23 (88%). The range of follow-up duration for all T2-weighted studies was 1.5 to 64 months (mean interval, 21.9 months; SD, 15.0 months).

Of the three annular tears that did not persist on the T2-weighted MR images, one was still visible 13 months later at contrast-enhanced T1-weighted MR imaging. In the second case, the patient did not receive contrast material at either examination (22-month follow-up). In the third case, the tear enhanced at initial imaging, but the patient did not receive contrast material at the follow-up examination 23 months later. The patients whose T2-weighted imaging findings of annular tear resolved did not have resolution of their symptoms. One patient had recurrent radiculopathic symptoms, one had persistent non-radicular low back pain, and one had new radicular symptoms at the level of a previous diskectomy.

One patient, with two annular tears, had contrast material administered only for the second of two MR imaging examinations. Both tears had persistent signal intensity abnormality at T2-weighted imaging, and both annular tears enhanced on follow-up images obtained at 29 months.

## Discussion

In a cadaver study, Yu et al (10) identified three types of annular tears. Type I tears, or concentric tears, are characterized by rupture of the transverse fibers connecting adjacent lamellae in the annulus, without disruption of the longitudinal fibers. These tears were not seen on MR images. Type II tears, or radial tears, are fissures extending from the periphery of the annulus to the nucleus, with disruption of the longitudinal fibers, appearing as hyperintense foci on T2-weighted images. Type III tears, or transverse tears, are disruptions of Sharpey's fibers at the annular periphery, adjacent to the end plate, also showing hyperintensity at T2-weighted imaging.

The type II, radial tears initially described by Yu et al (10) were tears that extended from the nucleus into the annulus, with hyperintensity in continuity with that of the nucleus. The high-signal-intensity zones described later by Aprill and Bogduk (5) were focal areas of hyperintensity at T2-weighted imaging in the annulus that, by their definition, were separate from the nucleus. Several authors have considered that these foci of hyperintensity, although separate from the nucleus, represent a form of radial annular tear (5–7, 9). Saifuddin et al (11) showed that the presence of an annular high-signal-intensity zone on T2-weighted MR images correlated with the presence of painful annular tears on diskograms.

Previous studies have also indicated that contrast-enhanced T1-weighted MR images are more sensitive than are T2-weighted MR images for revealing these annular tears. Stadnik et al (2) noted that in 28 tears found in 20 asymptomatic volunteers, 27 were apparent on contrast-enhanced T1-weighted MR images, whereas only 21 of 28 were seen on T2-weighted MR images. Ross et al (7), in an evaluation of 12 patients, noted 18 separate areas of annular enhancement (ie, annular tears); only five of the tears had hyperintensity at T2-weighted imaging. Our review also noted a similar trend. In our patients who received contrast material, one tear was seen on only contrast-en-

hanced T1-weighted MR images, whereas the T2-weighted MR images appeared normal. All of the tears that were noted on T2-weighted MR images were visible on contrast-enhanced MR images. The aforementioned authors have postulated several explanations for the apparent increased sensitivity of contrast-enhanced MR imaging in the detection of annular tears. The ingrowth of vascularized granulation tissue into the tear, and its subsequent enhancement, may afford somewhat improved contrast and signal-to-noise ratios on T1-weighted MR images between the tear and the adjacent intact annular fibers than are apparent on the T2-weighted MR images (7). This phenomenon of ingrowth of vascularized granulation tissue was noted in a single annulus from the study presented by Ross et al (7), which had the MR imaging findings of a radial tear. However, one may surmise that a similar phenomenon could occur in the transverse, type III tears that enhanced in both our study and the Ross study.

Previous studies have conflicted regarding the significance of the presence of annular tears noted during spinal MR imaging. Annular tears are seen with some frequency on MR images of asymptomatic persons. Stadnik et al (2) noted annular tears present in lumbar intervertebral disks in 20 of 36 asymptomatic volunteers (28 tears). However, in studies of symptomatic persons, MR findings of annular tears are also frequently shown. In symptomatic patients, the location of these tears has been shown to correlate with the level of painful disk noted at diskography. Aprill and Bogduk (5) noted an 86% positive predictive value of hyperintense annular tears on T2-weighted images for pain elicited at diskography, and Schellhas et al (6) noted that 87% of hyperintense annular tears on T2-weighted images were painful during subsequent diskography. These studies have raised the question regarding whether the finding of an annular tear can be used to infer that the lesion is acute and therefore the source of a patient's pain. This is an important question, because many complaints of low back pain and subsequent spinal MR examinations are precipitated by trauma, especially from work-related accidents or motor vehicle collisions (12). Jensen et al (8) noted that low back pain is the second most common reason that patients seek medical care in the United States and that the estimated annual cost of related medical care is more than $8 billion. Robertson (12) noted that the rate of low back–related disability has grown at a rate 14 times that of the population during the last 30 years.

To our knowledge, no study has addressed how the MR imaging findings of annular tears change over time. The demonstration of such a change, if any, would have major implications, because the imaging characteristics could be used to help identify the time of injury. The accurate dating of an injury would be useful to more definitively define liability for injury in motor vehicle accidents and work-related injuries. Any improved accuracy in dating the acuity of an annular tear could certainly influence the disability rating or amount of compensation a person receives for a specific injury.

Our study was retrospective, and as a result of our search criteria, we have included only patients who had the finding of one or more annular tear(s) included in their official report. Screening the dictation database as a first step to identify patients with annular tears, rather than reviewing all lumbar spine MR imaging studies performed, introduces a clear limitation in that we excluded patients who had annular tears that were present but missed at the time of evaluation and were therefore not initially reported. However, no logical reason exists to assume that a tear that was present but not reported should differ in its imaging characteristics from those of tears reported and described in our review. Our design did not allow for a uniform imaging protocol for each patient. We therefore report a mixture of patients who did or did not undergo contrast-enhanced MR imaging at initial and follow-up examinations. Despite this limitation, our results showed persistence of findings of annular tears over time, regardless of whether contrast material was used. Saifuddin et al (11) remarked that the ability to identify annular tears on MR images can be related to section thickness and that sequences using 4- to 5-mm-thick sections with intersection gaps could miss a small tear. These limitations clearly should be considered if one is designing a protocol specifically to identify annular tears. Our retrospective review included patients who had other clinical indications for lumbar MR imaging, as elaborated in Methods, with the annular tears identified primarily as incidental (although possibly symptomatic) findings.

Our data showed that the MR imaging findings of annular tear do not, for the most part, change over time, at least not during intervals described ($\leq$64 months). The data suggested that findings of hyperintensity or contrast enhancement or both in the annulus (ie, an annular tear) at a single MR imaging examination cannot be used as documentation of acuity. MR imaging findings of an annular tear can be, and in almost all cases are, stable for long periods. Rather, our data indicated that annular tears in the lumbar spine can be suggested to have occurred during a specific interval only if MR images obtained at the start of that interval show absence of annular tear. Even this suggestion could be challenged, considering that a patient's initial MR imaging examination may not be 100% sensitive in the demonstration of any annular tears truly present, as noted by Yu et al (3) in their 1988 cadaver study. Because our study made no attempt to reestablish the sensitivity of MR imaging in detecting annular tears, we must concede the possibility, however slight, that negative results of an initial study and then positive results of a follow-up study may be explained by a false-negative initial study rather than a true change in the disk. However, we tend to rely on MR imaging findings, and the changes in MR imaging findings over time, as documenting true changes in the structures being imaged in the vast majority of cases.

## Conclusion

Hyperintensity and enhancement noted on spinal MR images of an annular tear did not indicate the acuity of the tear during the range of follow-up provided in this study.

## References


1. Fardon DF, Millette PC (Chairpersons). *Nomenclature and Classification of Lumbar Disc Pathology: Recommendations of the Combined Task Forces of the North American Spine Society, American Society of Spine Radiology, and American Society of Neuroradiology.* Retrieved from the World Wide Web: http://www.asnr.org/spine_nomenclature/
2. Stadnik TW, Lee RR, Coen HL, Neirynck EC, Buisseret TS, Osteaux MC. **Annular tears and disk herniation: prevalence and contrast enhancement on MR images in the absence of low back pain or sciatica.** *Radiology* 1998;206:49–55
3. Yu S, Haughton VM, Sether LA, Wagner M. **Comparison of MR and discography in detecting radial tears of the anulus: a postmortem study.** *AJNR Am J Neuroradiol* 1989;10:1077–1081
4. Yu S, Haughton VM, Sether LA, Wagner M. **Anulus fibrosus in bulging intervertebral disks.** *Radiology* 1998;169:761–763
5. Aprill C, Bogduk N. **High intensity zone: a diagnostic sign of painful lumbar disc on magnetic resonance imaging.** *Br J Radiol* 1992;65:361–369
6. Schellhas KP, Pollei SR, Gundry CR, Heithoff KB. **Lumber disc high-intensity zone: correlation of magnetic resonance imaging and discography.** *Spine* 1996;21:79–86
7. Ross JS, Modic MT, Masaryk TJ. **Tears of the anulus fibrosus: assessment with Gd-DTPA-enhanced MR imaging.** *AJNR Am J Neuroradiol* 1989;10:1251–1254
8. Jensen MC, Brant-Zawadzki MN, Obuchowski N, Modic MT, Malkasian D, Ross JS. **Magnetic resonance imaging of the lumbar spine in people without back pain.** *N Engl J Med* 1994;331:69–73
9. Weishaupt D, Zanetti M, Hodler J, Boos N. **MR imaging of the lumbar spine: prevalence of intervertebral disk extrusion and sequestration, nerve root compression, end plate abnormalities, and osteoarthritis of the facet joints in asymptomatic volunteers.** *Radiology* 1998;209:661–666
10. Yu S, Sether LA, Ho PS, Wagner M, Haughton VM. **Tears of the anulus fibrosus: correlation between MR and pathologic findings in cadavers.** *AJNR Am J Neuroradiol* 1988;9:367–370
11. Saifuddin A, Braithwaite I, White J, Taylor BA, Renton P. **The value of lumbar spine magnetic resonance imaging in the demonstration of anular tears.** *Spine* 1998;23:453–457
12. Robertson JT. **The rape of the spine.** *Surg Neurol* 1993;39:5–12