MRI OF MARROW CHANGES IN THE VERTEBRAL BODIES ADJACENT TO ENDPLATES IN DEGENERATIVE LUMBAR DISC DISEASE.

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ABSTRACT

MR studies of the lumbar spine in 57 patients [285 disc spaces] were analyzed, to assess the appearance and frequency of the bone marrow signal changes in the vertebral bodies adjacent to the normal and degenerative discs. Degenerative changes were found in 144 of 285 discs. Signal abnormalities of bone marrow adjacent to the endplates were identified in 52 of 144 discs (36.1%). In 44 of 52 discs [84.6%], there is an area of relatively increased signal intensity in T1WI & T2WI in the vertebral bodies adjacent to the endplates. In 6 of 52 [11.5%] decreased signal intensity on both T1WI & T2WI was noted in focal and bandlike appearance. In the other 2 discs [3.9%] decreased signal was noted on T1WI and increased signal evidence in T2WI. These marrow changes were not present adjacent to the normal discs. The signal alteration suggests three patterns of bone marrow change; fat phase, sclerotic phase and edematous phase respectively. The ages of the patients with marrow changes in edematous phase (41 and 43 years old) are less than the mean ages of the other two groups (65.52 and 59.4 years respectively).

We conclude that bandlike and focal areas of signal changes in the bone marrow adjacent to degenerative intervertebral discs can occur on MR images of the lumbar spine and should not be confused with signal changes from tumor or infectious process involving the disc space and adjacent vertebral endplates.

INTRODUCTION

MR imaging is a valuable method for detecting bone marrow abnormalities [1]. Normal vertebral marrow consists of hematopoietic marrow that demonstrates intermediate signal intensity of both T1W and T2W images, and fat marrow which shows increased signal intensity on T1WI and decreased signal on T2WI [2]. Bone marrow changes adjacent to the vertebral endplates have been noted on MR imaging in a variety of pathologic conditions [3]. We have observed focal alterations in bone marrow signal intensity adjacent to endplates in patients with degenerative disc disease. The purpose of this study is to assess the appearance and frequency of this finding in MRI of the spine and to determine the pathophysiologic basis of these marrow changes.

MATERIALS AND METHODS

MR studies were performed with a General Electric 1.5 Tesla superconductive system machine for lumbar spine imaging. All patients were studied at least with T1W (TR = 400-600 msec, TE = 10-20 msec) and T2W (TR = 2000-3000 msec, TE = 90-110 msec) in the sagittal plane and T1W in the axial plane.

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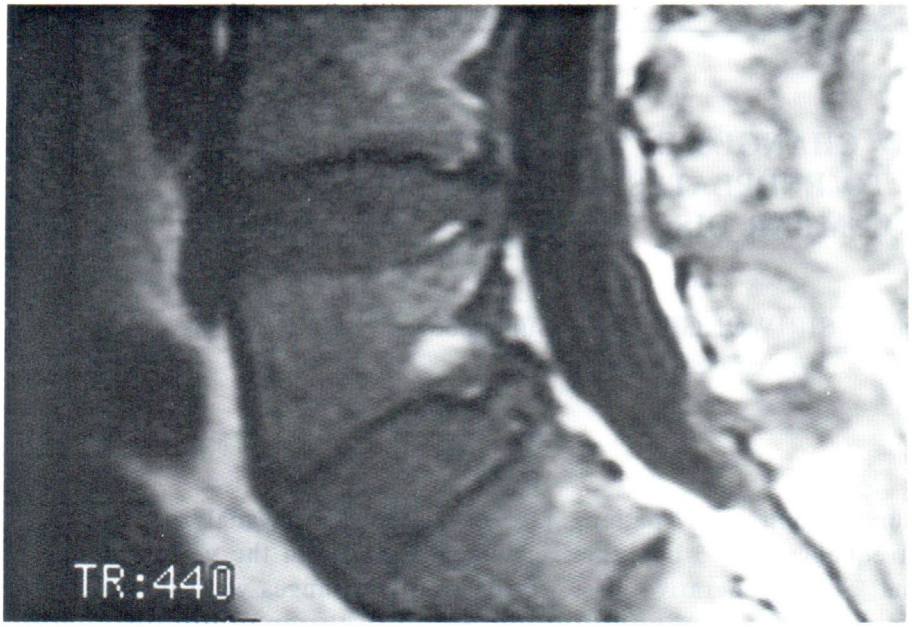

Fig. 1A.
Areas of marrow signal alteration in focal and bandlike appearance of increased signal intensity on both T1W and T2W images suggesting local increases in marrow fat.
Sagittal midline T1WI (TR/TE = 440/11 msec) of the lower lumbar spine. There is focal increased signal of the marrow at infero-posterior aspect of the vertebral body adjacent to the L5-S1 disc.

MR studies of the lumbar spine were reviewed in 57 patients examined in an 8-month period (January to August 1994); 33 women and 24 men; 21-79 years old: mean age 50.74 years old. These include 49 patients with degenerative disc disease and 8 patients with normal disc appearance on MRI. Totally 285 discs were analyzed and 144 degenerative discs were noted. Disc degeneration was considered to be presented when there was decreased signal intensity of the intervertebral disc on T2WI or narrowing of disc space [3,4].

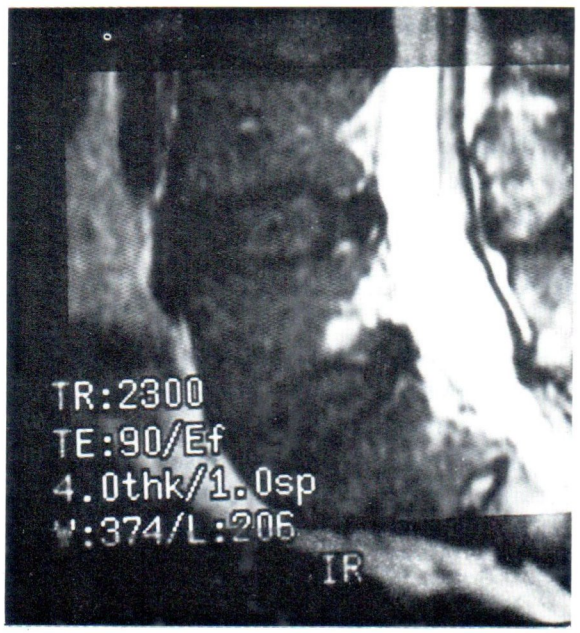

Fig. 1B. Focal increased signal is also seen on sagittal T2WI (TR/TE = 2300/90 msec. Note decreased signal intensity of the intervertebral disc at this level.

RESULTS

Altered signal intensity in the bone marrow adjacent to the endplates was observed in 52 (36.1%) of 144 degenerative discs. This was not seen at any normal disc level. The marrow signal alteration was bandlike, focal or mixed bandlike and focal on one or both sides of the disc. In 44 of the 52 abnormal disc levels (84.6%), there was increased signal intensity on both T1W and T2W images (Fig.1). In 5 patients (6 discs or 11.5%), decreased signal intensity was demonstrated on both T1W and T2W images (Fig.2). In 2 patients (2 discs or 3.8%), decreased marrow signal intensity on T1WI and relatively increased signal intensity on T2WI was observed (Fig.3).

The patients who have degenerative disc disease with altered marrow signal intensity appeared to be somewhat older than the patients who have degenerative disc disease with normal marrow signal (mean age, 59.55 and 45.2 years, respectively).

The two patients with decreased marrow signal on T1WI and relatively increased signal on T2WI were quite younger (41 and 43 years old) than the other two groups. The mean age of the group with increased marrow signal on both T1W and T2W images and that of the group with decreased signal on both T1W and T2W images were 65.53 and 59.4 years respectively.

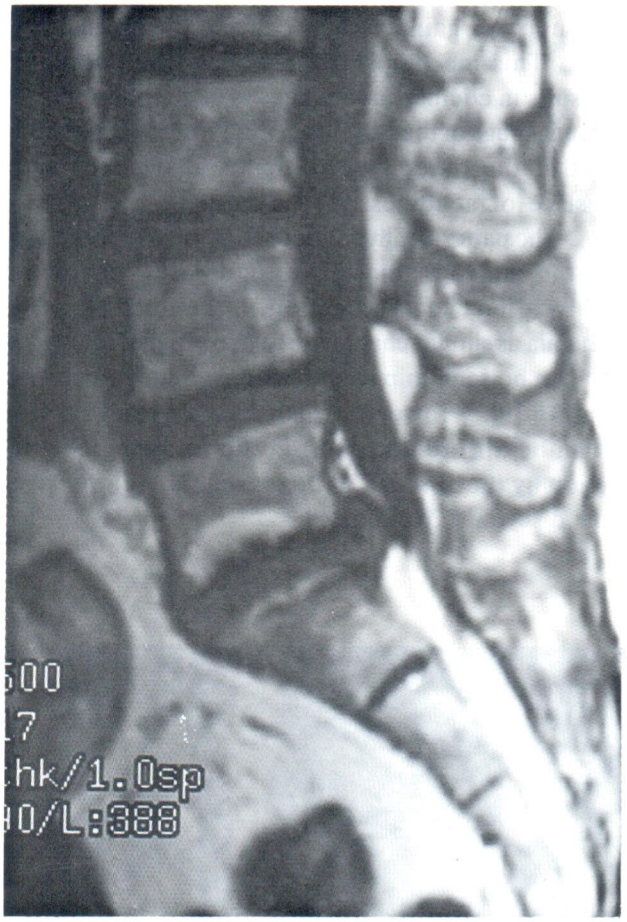

Fig. 1C. Sagittal T1WI (TR/TE=500/17 msec) of the other study. Again there is bandlike increased signal adjacent to the endplate of L5-S1 disc.

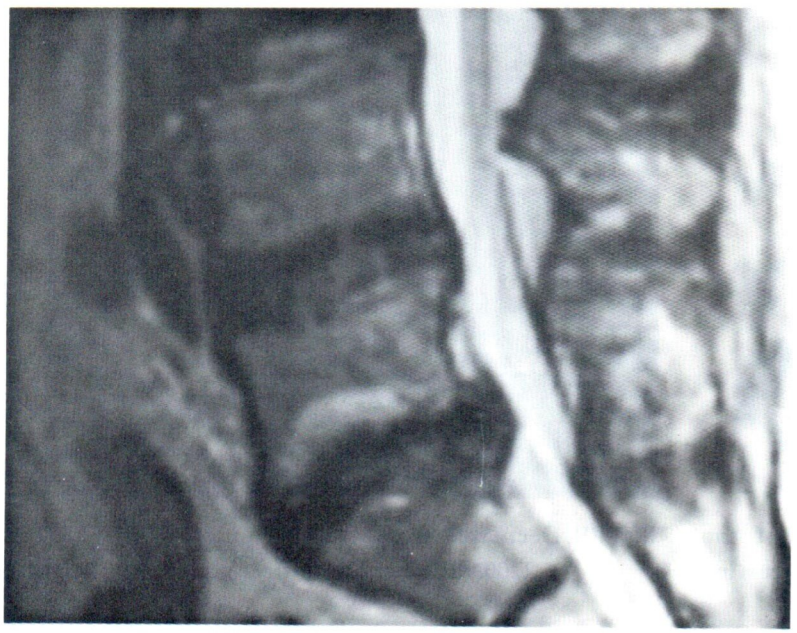

Fig.1D. Sagittal T2WI (TR/TE=3000/108 msec) shows degenerative disc at L4-5 and area of bandlike increased signal intensity.

DISCUSSION

The normal lumbar vertebral body has intermediate to high signal intensity on both T1W and T2W images due to the signal contribution of fat and hematopoietic marrow [2]. The normal intervertebral disc has relatively homogenous low signal intensity on T1WI. On T2WI, the normal nucleus pulposus has a high signal intensity and a central cleft [3,4].

Alterations in marrow signal intensity adjacent to the intervertebral discs was found in 36.1% of cases with degenerative discs. Three basic patterns of marrow change were observed: (1) hypointense T1 and hyperintense T2 = edematous phase, (2) hyperintense T1 and hyperintense T2 = fat phase, and (3) hypointense T1 and hypointense T2 = sclerotic phase [5].

The study about endplate marrow signal alteration in patients with degenerative discs was previously reported by de Roose et al. [6] and revealed similar results. The following study by Modic et al. for assessment of vertebral body marrow change related to degenerative disc disease suggested that there is a spectrum of vertebral marrow signal intensity change that occurs with increasing frequency with age [7]. And from this study, two types of vertebral signal intensity change were identified; type 1 showed decreased signal intensity on T1WI and increased signal intensity on T2WI, type 2 showed increased signal intensity on T1WI and isointense or slightly increased signal intensity on T2WI.

Whether the endplate should be considered as part of the vertebral body or intervertebral disc is a matter of great debate and speculation [8].In infants and young children, blood supply to the cartilagenous endplate and intervertebral disc is from a vascular network which soon atrophies and may disappear by the age of 8-12 years. The metabolism of the intervertebral disc becomes dependent on diffusion of fluid either from the marrow of the vertebral bodies across the subchondral bone or cartilagenous endplate or through the annulus fibrosus from the surrounding blood vessels. During aging, morphologic changes in the vertebral bone and endplate occur. These can interfere with normal disc nutrition and result in one or more

degenerative processes [8]. Focal histologic changes in the cartilagenous endplates appear to precede histologic changes in the nucleus pulposus and annulus fibrosus. With advancing age, a vascular network along the endplates atrophies and local marrow ischemia can cause a conversion of normal hematopoietic marrow to fatty marrow [6,8]. Furthermore, bony trabeculae adjacent to the endplate became thickened, resulting in sclerosis as part of degenerative process [6].

The two patients who have altered marrow signal in edematous phase both presented with acute symptom of back pain and the studies showed disc herniation. Herniated discs always show associated disc degeneration while degeneration may be seen without herniation. All herniated discs eventually degenerate and there is immediate dehydration followed by a temporary gain in water content during a short period. This mechanism also affects the endplate and results in edematous changes in acute phase [3,5]. The younger age of the patients in this group as compared to that of the other two groups is also noted and suggestive of acuteness.

The pattern of hypointense T1 and hyperintense T2 of the marrow adjacent to endplates may conceivably reflect local infection, inflammation and/or ischemia as similar changes in marrow signal intensity which can be seen in patients with ischemic necrosis of the hip [9]. However, this pattern of degeneration can be differentiated from the findings seen in infection by the absence of increased signal intensity of the disc on T2W1 [5,10]

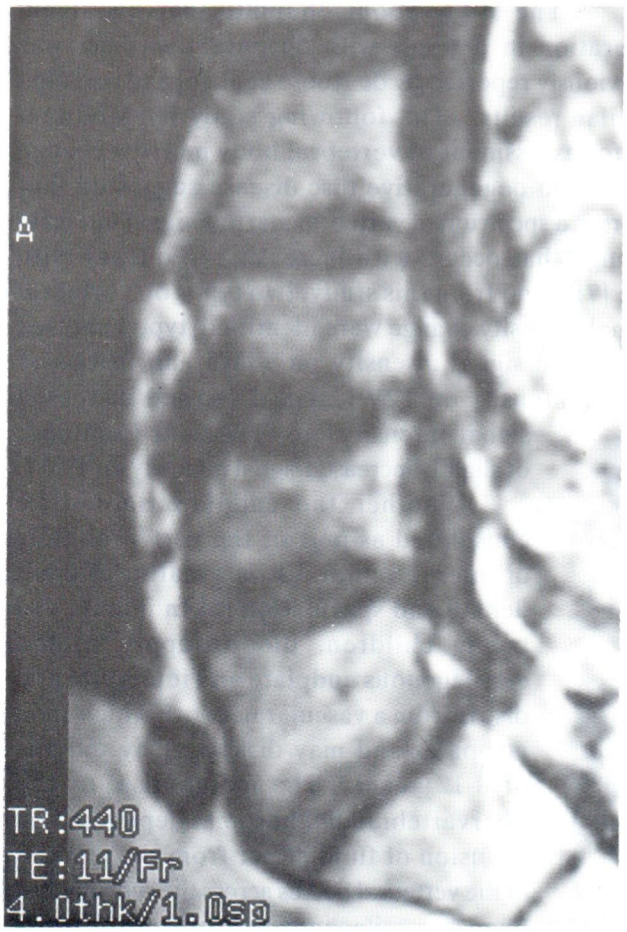

Fig. 2A. Bandlike decreased signal intensity of the marrow in both T1WI and T2WI suggesting sclerotic change.
Sagittal T1WI (TR/TE=440/11 msec) shows decreased signal intensity of the adjacent marrow on both sides of the L3-4 disc.

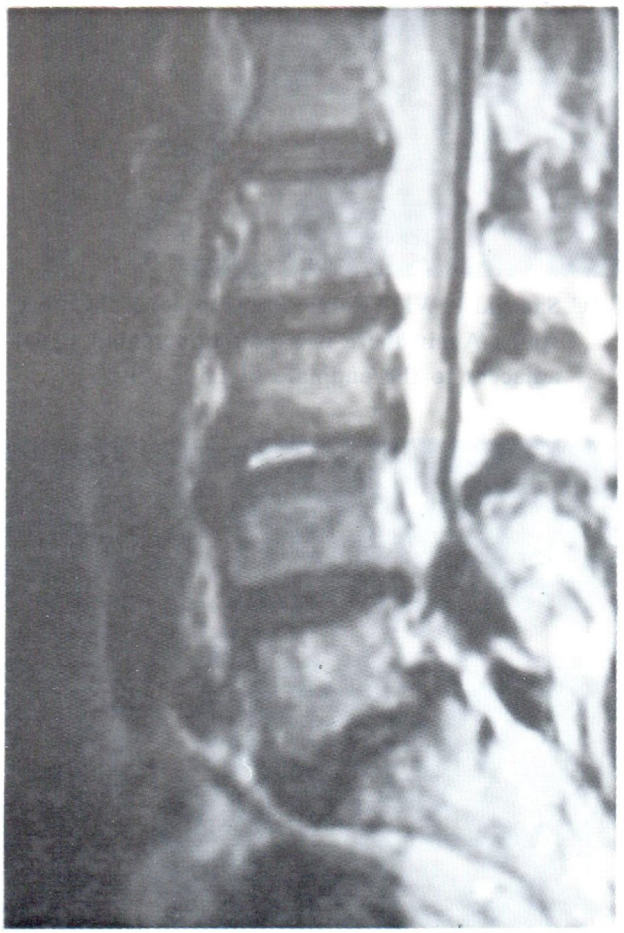

Fig. 2B. Decreased signal is also seen on T2WI (TR/TE = 2200/90 msec). Note decreased disc height.

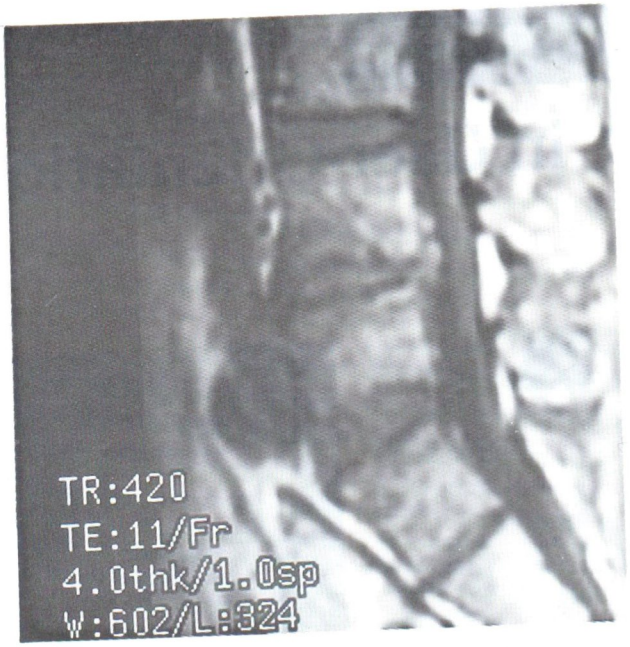

Fig. 3A. Decreased signal intensity in T1WI and increased signal intensity in the marrow adjacent to the endplate suggesting increase in water fraction in the marrow.
Sagital T1WI (TR/TE = 420/11 msec) shows decrease - signal marrow adjacent to L4-L5 disc.

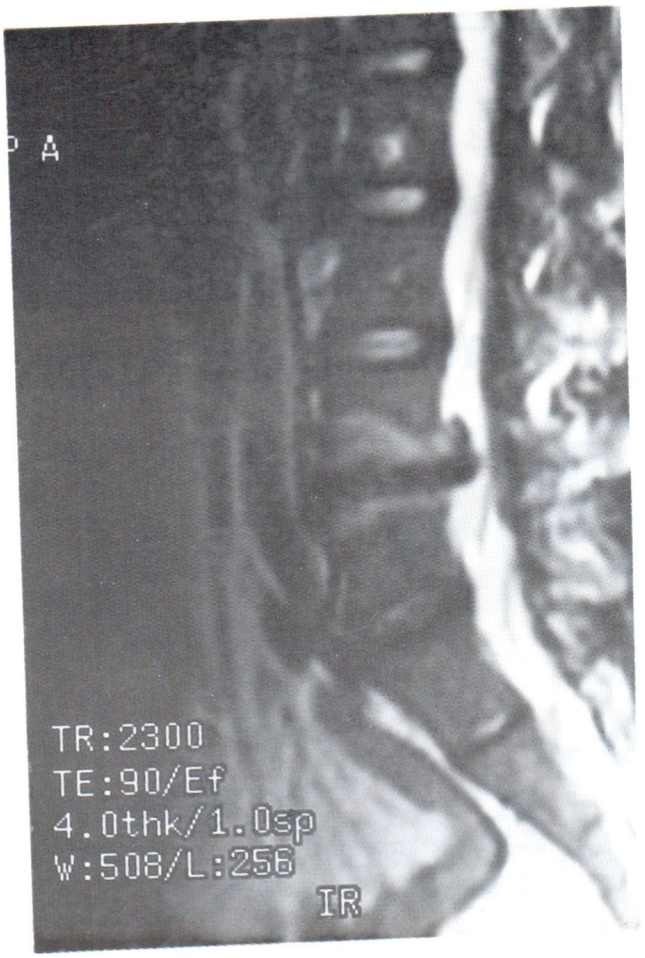

Fig. 3B. The low signal of the marrow on T1WI turns to be high on T1WI (TR/TE = 2300/90 msec). Note disc herniation.

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