Magnetic Resonance Imaging Of Intervertebral Discs In Elderly Patients With Vertebral Compression Fractures Due To Minor Trauma

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Citation

Abstract
Lumbar discs adjacent to fractured vertebral bodies were evaluated, using magnetic resonance imaging (MRI), to elucidate how often these discs were injured and how the injured discs were depicted by MRI. We retrospectively reviewed MR images of 74 discs from 37 elderly patients (> 65 years old) with a single level vertebral fracture (fracture group). Patients with multiple-level fractures, burst fractures and/or major trauma, such as that resulting from a traffic accident, were excluded from this study. We also reviewed MR images of 190 discs from 27 elderly patients diagnosed with lumbar stenosis, who had no previous history of vertebral body fractures (stenosis group). In the fracture group, 23% (17/74) of T1-weighted images exhibited a high-intensity area in the disc, whereas only 3% (5/190) exhibited a high-intensity area in the stenosis group. In some cases, in the T2-weighted images we also found a high-intensity zone in discs that showed low or iso-intensity. This phenomenon was more frequently observed in the fracture group (47%: 35/74) than in the stenosis group (10%: 19/190).

The present study indicates that, in elderly patients, intervertebral discs adjacent to vertebral fractures resulting from minor trauma are often injured. Because hemorrhage is the most likely cause of a high-intensity T1-weighted image, the results indicate that hemorrhage can be induced in a disc adjacent to a vertebral body fractured by even minor trauma.

INTRODUCTION
Vertebral body fractures due to minor trauma, which commonly occur in the elderly, are a frequently encountered clinical problem. In some cases, even a sneeze or cough can cause a vertebral fracture. Some of these fractures become asymptomatic after adequate conservative treatment, while some need surgical interventions, such as vertebroplasty and kyphoplasty. However, cases have been reported in which severe back pain persisted. Nonunion of the vertebral fractures, late collapse of the vertebral body and delayed neurological complications occur in some cases and cause poor clinical results. Early diagnosis is thought to be essential for the treatment of vertebral fractures. MRI has recently been recognized as a useful tool for the early diagnosis of thoracolumbar fractures due to minor injury. Therefore, in our institution, we utilized MRI in patients with acute back pain following minor injury to ensure the earliest possible diagnosis. It is generally recognized that the intervertebral disc is one of the most common sources of back pain in a patient. It has been reported that intervertebral discs were damaged in patients with unstable spinal fractures; however, damage to discs in patients with stable spinal fractures due to minor trauma have not been reported. Using MRI, Oner et al. observed changes in adjacent disc morphology after thoracolumbar vertebral fracture and suggested that the discs may have been simultaneously injured with the fracture. However, there has been no study that demonstrated signal changes in the MR images of intervertebral discs following minor injury. We therefore investigated the disc intensity in T1- and T2-weighted MR images of patients with thoracolumbar vertebral fracture due to minor trauma. In addition to examining patients with a thoracolumbar fracture, a subgroup without a past history of spinal trauma was utilized as a control group.

MATERIALS AND METHODS
THORACOLUMBAR FRACTURES (FRACTURE GROUP)

We retrospectively reviewed MR images of 74 discs from the 37 elderly subjects (inclusion criteria, > 65-years-old) with a single level vertebral fracture (T10 to L5) resulting from minor trauma referred to our institution in 2003. In this sample were seven men and 30 women (mean age ± standard deviation (SD): 80 ± 6.3 years; range, 67-96 years). Patients with multiple-level vertebral fractures, burst vertebral fractures and/or major trauma, such as that resulting from a traffic accident, were excluded from this study. Only patients who underwent MRI within 14 days after onset were evaluated. Past medical history with special attention to malignant disease, clinical examination and plain radiographs of the corresponding levels (thoracic or lumbar spine) were thoroughly evaluated in all patients, after which patients with malignant vertebral collapse were excluded. We evaluated the intervertebral discs adjacent to the fractured vertebral body. To minimize the influence of previous trauma, patients who had an old vertebral fracture adjacent to the intervertebral discs were excluded.

LUMBAR STENOSIS (STENOSIS GROUP)

We also retrospectively reviewed MR images of 27 elderly patients (nine men, 18 women; mean age ± SD, 74 ± 5.3 years; range, 65-85 years) examined in our institution in 2003 who were found to have lumbar stenosis, but no vertebral fractures. Those patients with a past medical history of spinal trauma or other spinal disorders (i.e., malignant tumor, infection, old compression fracture) were excluded from this study. We evaluated 190 intervertebral discs between T10-11 to L5-S1 that were included in the MR images.

MAGNETIC RESONANCE IMAGING (MRI)

The subjects with vertebral fractures underwent MRI an average of 6.6 days (range, 2-14 days) after injury. T1-weighted (TR 525-570: TE 12) and T2-weighted (TR 4000: TE 112) images were obtained with a SIEMENS MAGNETOM Impact (1.0 T) (Siemens AG., Munich, Germany). Images were always obtained in the sagittal plane. The control group with lumbar stenosis underwent MRI using the same protocol.

DATA ANALYSES

The signal intensity of the discs in T1- and T2-weighted images was independently evaluated and compared with adjacent normal discs by two observers. If their opinions differed, the final description was determined by a third observer. The \( \chi^2 \) test was used to assess the significance of the difference of the occurrence of changes in signal intensity between the groups. Statistical significance was assumed if \( p \) was less than 0.05.

RESULTS

A total of 74 discs from fracture group patients and 190 discs from stenosis group patients were studied. The distribution of fracture levels is shown in Figure 1.

T1-WEIGHTED IMAGES

In the stenosis group, almost all the discs (97%; 185/190) exhibited low- or iso-intensity in T1-weighted images (Figure 2A). In the fracture group, 23% (17/74) of the discs exhibited a high-intensity area in at least part of the disc (Figure 3A). We found that the percentage of high-intensity discs was significantly higher (\( p<0.05 \)) in the fracture group than in the stenosis group (Table 1). Of the 17 high-intensity discs found in the fracture group, six discs exhibited low-intensity in T2-weighted images (Figure 3B).

<table>
<thead>
<tr>
<th>Signal intensity*</th>
<th>Fracture group</th>
<th>Stenosis group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iso- or low-intensity</td>
<td>57 (77)</td>
<td>185 (97)</td>
</tr>
<tr>
<td>High-intensity (in at least part of the disc)</td>
<td>17 (23)</td>
<td>5 (3)</td>
</tr>
<tr>
<td>Total</td>
<td>74 (100)</td>
<td>190 (100)</td>
</tr>
</tbody>
</table>

Percentages are in parentheses.

*Compared with the signal intensity of adjacent normal discs.
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Figure 3
Figure 2: A 75-year-old woman with lumbar stenosis. All discs exhibit low-intensity in both T1- and T2-weighted magnetic resonance images. In the stenosis group, 133 of the 190 discs show low- or iso-intensity in both T1- and T2-weighted images.

Figure 4
Figure 3: A 67-year-old woman with vertebral fracture at T11. Magnetic resonance (MR) images were obtained seven days after injury.

A. T1-weighted sagittal MR image. Both cranial and caudal discs (T10-T11 and T11-T12 discs) express high-intensity, compared to other discs. B. T2-weighted sagittal MR image. Both cranial and caudal discs express low intensity compared to other discs.

Although the remaining 11 discs exhibited high-intensity areas in T2-weighted images in at least part of the disc, the areas did not correspond to the high-intensity area in T1-weighted images. Interestingly, in the fracture group, we encountered one case with a disc that exhibited iso-intensity six days after the injury but had changed to high-intensity after three months (Figure 4).

Figure 5
Figure 4: A 74-year-old woman with vertebral fracture at L1.

A. T1-weighted sagittal magnetic resonance (MR) image obtained six days after injury. Both cranial and caudal discs (T12-L1 and L1-L2 discs) express iso-intensity, compared to other discs. B. T1-weighted sagittal MR image obtained three months after the injury. The caudal disc expresses high-intensity compared to other discs.

T2-WEIGHTED IMAGES

In the present study, in both groups, less than 20% of the discs exhibited high-intensity in T2-weighted images. Although we have not examined patients younger than 65-years-old, this finding indicates that a relatively high proportion of the discs exhibited low- or iso-intensity in elderly patients (Figure 2B).

However, in some cases, we found high-intensity zones within the low- or iso-intensity discs. This high-intensity zone in the low- or iso-intensity discs was more frequently observed in the fracture group (47%: 35/74), than in the stenosis group (10%: 19/190) (Table 2).
Fortunately, we had performed MRI examinations prior to the spinal fracture in four subjects, and found that, in two of the four cases, the high intensity zone was not observed before the fracture, but appeared after the fracture. We also performed MRI examinations three to six months after the fractures in five cases and found that the high-intensity zone had disappeared during that follow-up period in three of the five cases (Figure 5).

**Figure 7**
Figure 5: An 84-year-old woman with fracture at L1.

A. T2-weighted sagittal magnetic resonance (MR) image obtained before injury. Both cranial and caudal discs express iso-intensity, compared to other discs. B. T2-weighted sagittal MR image obtained four days after injury. The cranial disc (T12-L1 disc) expresses a high-intensity zone in the iso-intensity disc. C. T2-weighted sagittal MR image obtained six months after injury. The high-intensity zone in the cranial disc has disappeared.

As mentioned above, we found 17 discs in the fracture group that exhibited high-intensity in T1-weighted images. Of those 17 discs, two exhibited overall high-intensity in T2-weighted images. However, the range of the high-intensity area in the T2-weighted images was not identical to that in the T1-weighted images. The remaining 15 discs exhibited low- or iso-intensity in T2-weighted images, but nine of these contained high-intensity zones.

**DISCUSSION**
A cadaver study showed that MRI is capable of evaluating actual damage to the discs adjacent to a fractured vertebral body. However, that study was limited because bleeding and edema can not be simulated in a cadaver study. In the present study, using MRI, we demonstrated intensity changes in the discs of living patients with thoracolumbar fracture due to minor trauma. Intervertebral discs usually exhibit low- or iso-intensity in T1-weighted images. However, we found that some discs adjacent to the fractured vertebral body exhibited high-intensity in T1-weighted images. This finding is more frequently observed in the fracture group than in the stenosis group. Generally, sub-acute hemorrhage shows a high-intensity on T1-weighted images. Although the signal intensity of hemorrhage varies with time, hemorrhage could be a cause of this finding. It was recently reported that some calcified discs occasionally exhibit high-intensity in T1-weighted images because fatty marrow may exist during the ossification process. However, in our study, high-intensity in T1-weighted images was more frequently observed in the fracture group than in the stenosis group. This suggests that the high-intensity area in T1-weighted images reflects hemorrhage in the discs, at least in some of the fracture group. Because the discs could not be examined histologically, we are unable to show any pathological changes in the injured discs. With this limitation in mind, we suggest that this finding might reflect hemorrhage in the discs of patients with a thoracolumbar fracture.

Although there have been no reports showing hemorrhage in the intervertebral disc, we recently encountered a 61-year-old male patient whose herniated lumbar disc revealed high-intensity in T1-weighted images (Figure 6A). Laminectomy and discectomy were performed and the disc was surgically obtained. During the surgery, we found that the disc was brown (Figure 6C) and, histologically, iron plaque was microscopically observed in the disc (Figure 6D, E). This indicates that bleeding may accompany disc herniation. The patient had no evidence of previous spinal trauma; however, disc herniation represents its own kind of disc injury. This finding raises the possibility that hemorrhage occurs from injury to discs.
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Figure 8
Figure 6: A 61-year-old man with a herniated disc at the L4-L5 level.

A. T1-weighted sagittal magnetic resonance (MR) image before surgery. The L4-L5 disc exhibits high-intensity compared to other discs. B. T2-weighted sagittal MR image before surgery. The L4-L5 disc expresses low-intensity. C. The herniated disc that was obtained surgically was dark-brown-colored. D, E, Photomicrograph of Prussian blue-stained herniated disc. The abundant iron particles are observed in the cytoplasm of the cells. The photographs were taken at a magnification of 10 (D) and at a magnification of 40 (E). The scale bar is 100 µm.

The lumbar intervertebral disc is a relatively avascular tissue that contains no nerve fibers, except in the outermost part of the annulus fibrosus. However, it is well known that blood vessels and nerve fibers increase in degenerated discs. Thus, we suggest that bleeding may be induced in degenerated discs by even minor trauma.

Because the intensity of the intervertebral disc in T2-weighted images varies with the level of the disc and the age of the patient, T2-weighted images may not be the most effective tool for detecting changes in discs of patients with vertebral fractures. It has been reported that signal intensity of the disc in T2-weighted images was increased after spinal trauma in some cases. We examined MR images of elderly patients, and found that, in some cases, a high-intensity zone was observed in low- or iso-intensity discs in T2-weighted images. This finding was frequently observed in the fracture group, but only rarely observed in the stenosis group. Although we had insufficient follow-up data to analyze statistically, we did observe that, in some cases, the intensity changes in the discs disappeared after three to six months. From these observations, we suggest that the high-intensity in T2-weighted images appeared subsequent to vertebral fractures.

The present study showed acute intensity changes in the MR images of intervertebral discs adjacent to the fractured vertebra, suggesting that a relatively high proportion of adjacent discs could be injured in patients with vertebral fractures due to minor trauma. However, we did not examine the correlation between these findings and clinical outcomes, such as persistent back pain. Thus, there is no evidence that the changes in intensity observed in the discs by MRI predict clinical outcome. Further investigation is needed to ascertain if MRI can be utilized to determine the prognosis of disc injury in patients with thoracolumbar fractures due to minor trauma.

References
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