Changes in the disc space after fractures of the thoracolumbar spine

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We have studied the intervertebral discs adjacent to fractured vertebral bodies using MRI in 63 patients at a minimum of 18 months after injury. There were 75 thoracolumbar fractures of which 26 were treated conservatively and 37 by posterior reduction and fusion with an AO internal fixator. We identified six different types of disc using criteria based on the morphology and the intensity of the MRI signal. The inter- and intraobserver variability of this system was good. Most of the discs showed predominantly morphological changes with no variation in signal intensity. Some disc types were associated with progressive kyphosis in patients treated conservatively. In those managed by operation, recurrent kyphosis appeared to result from creeping of the disc in the central depression of the bony endplate rather than from disc degeneration. Changes in the disc space after posterior fixation should not be seen as a form of chronic instability but as a redistribution of the disc tissue in the changed morphology of the space after fractures of the endplate.

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Narrowing of the disc space has commonly been observed after fractures of the thoracolumbar spine and has been associated with progressive kyphosis and pain in patients treated conservatively, or with recurrent kyphosis after posterior reduction and fixation.1-7 It is unclear whether this narrowing is a result of biochemical changes, such as are seen in degenerative disc disease, or represents an adapta-

Patients and Methods

Patients with a history of fracture of the thoracolumbar spine attending regular follow-up in our outpatient department between 1994 and 1997 were asked to participate in the study. We excluded those with psychotic conditions. When seen each had standing AP and lateral radiographs taken. A total of 63 patients (33 men and 30 women) with a mean age of 36 years (17 to 60) was studied. All had more than two years of follow-up (24 to 51 months). Of these, 26 had been treated conservatively and 37 by operation. Conservative treatment consisted of immobilisation in a cast for 12 weeks. In patients in whom the fractures were classified as unstable, the first six weeks were spent recumbent. MRI was carried out in this group at a minimum of 18 months after injury. Those undergoing operation had posterior reduction and stabilisation with an AO/ASIF internal fixator and a posterior fusion using autologous iliac bone. The fixators were removed between 12 and 18 months later. MRI was carried out at a minimum of six months after this and 24 months after the injury. It was performed according to the standard discopathy protocol of our radiology department (T1: TR: 525 TE: 22; TSE: TR: 200 TE: 30; T2: TR: 3362 TE:150).

The fractures were classified according to the AO system on the basis of the initial radiographs and CT.17 For the
changes in the sagittal contour of the spine, we used the local angle of kyphosis, which was defined as the angle between the inferior endplate of the superior uninvolved vertebra and the superior endplate of the inferior uninvolved vertebra, and the wedge angle, which is the angle between the superior and inferior endplates of the fractured vertebra on lateral radiographs. These measurements were made on the radiograph taken immediately after injury and on the first standing and the last standing films taken at review. In the conservatively treated group, the progression of local kyphosis and the wedge angle were defined as the difference between the first and last standing radiographs. In the operatively treated group the recurrent kyphosis and progression of the wedge angle were defined as the difference in these angles between the first postoperative standing radiographs and those taken after the removal of the internal fixation.

Statistical analysis was performed with SPSS/PC+, version 5.0.1. The non-parametric Mann-Whitney U test was used to compare two groups with extension to the Kruskel-Wallis test with more than two groups. Pearson’s correlation test was used for the relationship between different parameters and multiple regression analysis for the effect of different parameters on independent variables. We used Cohen’s kappa test to determine inter- and intraobserver variability.

**Development of a classification of disc changes.** MR scans of the first 35 patients with a total of 38 fractures were evaluated by two different observers, using a scheme derived from the system of Battié et al. This uses a combination of morphological and biochemical changes in the anterior, middle and posterior thirds of the disc space. We assessed each of these three sections grading three aspects on a scale of 0 to 3 in comparison with the adjacent discs not involved in the fracture. These were:

1) Desiccation, a change in the signal intensity on T2 images.
2) Bulging or herniation. This was evaluated according to Battié et al. and we also recorded herniation of the nucleus pulposus into the endplate. T1 and TSE images were used for this analysis.
3) Decrease in the disc space graded on T1 and TSE images.

Six different patterns were recognised (Figs 1 and 2):

*Type 1.* Normal or near normal disc. There was no significant loss of height or signal or evidence of herniation in any of the three segments.

*Type 2.* A black disc which was morphologically similar to type 1 with diffuse loss of signal on T2 images.

*Type 3.* A Schmorl-type change with no significant loss of height or signal. There was a small herniation of the nucleus pulposus into the endplate.

*Type 4.* Anterior collapse. There was disproportional loss of height in the anterior third but the middle and posterior sections remained unchanged. Anterior bulging of the disc or herniation of the nucleus pulposus into the endplate was seen in the anterior third. There was no change in the signal intensity of the nucleus pulposus.

*Type 5.* Central herniation. There was a massive herniation of the nucleus pulposus into the central endplate. As a result of this herniation loss of height in the anterior and posterior sections resulted in almost complete bony contact between the adjacent endplates. The nucleus pulposus in this type has a normal signal intensity.

*Type 6.* Degenerated disc. There was loss of disc height and signal intensity in all three sections.

We then used this classification to evaluate the entire group of 63 patients with 75 fractures and 137 associated discs. The radiologist (LMPR) and the orthopaedic surgeon (FCO) categorised the MR images and decided separately on the type of each disc. The orthopaedic surgeon reassessed the MR images after a minimum of three months.
Results

The inter- and intraobserver variabilities of the classification of the disc types were good (kappa 0.77, SEM 0.056, 95% CI 0.66 to 0.88 and kappa 0.79, SEM 0.055, 95% CI 0.68 to 0.9, respectively).

A total of 75 fractures was observed in 63 patients with four having three and four two (Fig. 3). The 137 discs adjacent to fractured vertebrae were studied. Fracture types, according to the AO classification, are shown in Figure 4. The distribution of the disc types is shown in Figure 5.

Progression of kyphosis of more than 10° was seen in seven of the 26 patients treated conservatively. There was a corresponding increase of 10° in the wedge angle in only one of them. Four of these patients had a type-4 disc, one a type-5 disc, and two a type-6 disc adjacent to the fractured vertebra. None of the patients with type-1, type-2 or type-3

Fig. 2a  Fig. 2b  Fig. 2c
Fig. 2d  Fig. 2e
Photographs of discs showing a) type 1 (cranial), b) type 3 (cranial) and type 2 (caudal), c) type 4 (cranial), d) type 5 (cranial), and e) type 6 (cranial).

Fig. 3
Histogram showing the distribution of fracture levels.
discs had more than 10° of progression of the kyphosis. The mean progression of the angle of kyphosis in this group was 1.6 ± 2.0°. In the group with type-4, type-5 or type-6 discs the mean was 8 ± 6°. The distribution of disc types in the conservative group is shown in Figure 6.

In the group treated by operation, 25 of the 37 patients had a recurrence of kyphosis of more than 10°. One of these patients had an increase of the wedge angle of more than 10°. The average mean recurrence of kyphosis for the group with type-1, type-2, or type-3 discs was 13 ± 6° and for the group with type-4, type-5 or type-6 discs 12 ± 4.3°. None of the patients treated by operation had a final angle of kyphosis greater than that measured on the initial radiographs after injury. Statistical analysis showed no clear relationship between the degree of recurrence of kyphosis and disc type. The distribution of disc types in the operated group is shown in Figure 7.

The types of fracture and the corresponding disc types observed are summarised in Table I. The caudal disc with type 6 in one of the A1.1 fractures was cranial to a second fracture. Two of the patients with an A1.2 fracture had a type-6 disc. Both of these patients had been conservatively treated and showed more than 10° progression of the kyphosis. In the A3 fractures, types 4 and 5 predominated in the discs cranial to the fractured endplate. Only five of the 29 cranial discs involved in such a fracture were of type 6. Two of the caudal discs of type A3.2 fractures had also a type-6 disc. No type-B fractures showed extensive

![Fig. 4](image1.png)

Histogram showing the distribution of fracture types according to the AO classification.

![Fig. 5](image2.png)

Histogram showing the percentile distribution of disc types in the entire group. Cranial and caudal denote the discs cranial or caudal to the fractured vertebral body.
disc degeneration other than that expected from the injury.

Discussion

Our main finding was the lack of a consistent change in signal in the disc space after fractures of the endplate. This was also noted by Rudig et al.\textsuperscript{19} Only two of the types defined in our study showed major changes in signal intensity (types 2 and 6). Roaf\textsuperscript{20} observed that under compression the discs are always stronger than the endplate and that compression forces create a fracture of the endplate before damage to the intervertebral disc. Holdsworth\textsuperscript{21} in his concept of a two-column spine, maintained that after compression fractures the disc remains intact, which is why he called ‘burst fractures’ stable injuries. Our study seems to confirm these earlier observations. In most of our cases the signal intensity of the discs seemed to be preserved and most changes were related to morphological alterations in the disc space. This does not seem to be a result of posterior fixation, because the difference in the distribution of disc types between the conservative and operative groups is largely due to the difference in the incidence of different fracture types in the two groups (Figs 6 and 7).

Our identification of different types of disc suggests...
common traumatic patterns which result in different types of morphology in the disc space relatively independent of the fracture classification. The effects of these common patterns seem to vary according to treatment. In posteriorly stabilised fractures the different disc types did not result in a discernible variation in the radiological appearances, whereas there was a relationship in the conservatively treated group. Posterior stabilisation may have neutralised the effects of different patterns of trauma.

Recurrent kyphosis after posterior reduction was commonly seen and appears to be a result of creeping of the nucleus pulposus back into the depressed central area. Posterior reduction probably reduces only the periphery of the endplate with its strong annular attachments while the central area remains depressed. After removal of the internal fixation, the disc settles in this depressed area causing narrowing of the disc space and amplifying the residual kyphosis. The wedge angle on the radiograph can be deceptive when used to measure the degree of reduction of the segment. Once the fracture of the endplate has healed resettlement does not cause progression of the kyphosis to a degree greater than the original deformity. Transpedicular spondioplasty may restore depression of the endplate and prevent creeping of the disc. Transpedicular discectomy has also been proposed to prevent the recurrence of kyphosis, but our results show that discs are intact in most cases and thus probably provide stability to the damaged segment. Any attempt to remove the disc may further destabilise the injured segment and cause failure of fixation. In our view, changes in the disc space after posterior fixation should not be seen as a form of chronic instability, but as a redistribution of the disc tissue in the changed morphology of the disc space without endangering the mechanical stability of the involved motion segment.

In the conservatively treated group, changes in the disc have more influence on the progression of kyphosis. No attempt had been made to reduce the fractures. Injuries leading to disc types 1, 2 or 3 did not cause progression of the kyphosis, while those giving rise to types 4, 5 or 6 were associated with progression in some cases. Our conservatively-treated group was too small to reach any conclusions about the effects of disc types 4, 5 or 6 separately, since the more severe cases were treated by operation. Our scheme of classification can be useful for further study. If progression of kyphosis can be predicted, the decision as to whether to treat conservatively or by operation can be rationalised. We should not forget, however, that fractures of the thoracic lumbar spine are complex injuries of an intricate structure and the changes in the disc space are only one of many possible parameters involved. The final clinical and radiological results depend on many factors such as the morphology of the resulting deformity of the endplate, the amount of comminution, the degree of osteoporosis, or involvement of ligament structures. Changes in the disc space may only amplify the effects of some of these factors.

It can be argued that eventually all discs adjacent to fractures will degenerate, but the degree of kyphosis observed after longer follow-up does not seem to be greater than that at two years.

Our study also questions the nature of ‘degenerative’ disc disease. This is accompanied by desiccation of the nucleus pulposus, which is related to biochemical changes in the entire disc space. Animal experiments have shown rapid desiccation and biochemical changes in the nucleus pulposus after a lesion of the annulus fibrosus. Traumatic injuries to the disc have been regularly proposed as a cause of the disc degeneration. In our study, lack of consistent signal changes after a major traumatic event to the motion segment does not support the idea of a traumatic origin to degenerative disc disease. Fracture of the endplate alone was not sufficient to cause disc degeneration in the period observed in our study.

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