# Degenerative Disk Disease

## 1) Degenerative Disk Disease

- Degenerative disk disease (DDD) is related to dehydration particularly in the nucleus pulposus and clefts within the annulus leads to height loss of the intervertebral disc with bulging of the outer fibers of the annulus fibrosus and to modification involving adjacent endplates.
- Plain films demonstrate disk space narrowing, vacuum phenomenon, reactive sclerosis of the vertebral bodies and osteophytes (anterior and lateral in the lumbar spine, anterior and posterior with uncovertebral hypertrophy in the cervical spine); degenerative disk calcifications are mainly located in the lower thoracic and upper lumbar spine.
- CT has a higher sensitivity for demonstrating vacuum phenomenon and disk calcification particularly on sagittal and frontal reformations; the diffuse bulging disk is clearly demonstrated on axial scans and sagittal reformations; spondylosis deformans with degenerative lumbar scoliosis leads to anterior and anterolateral protrusion of disk material.
- On MRI the signal of the normal intervertebral disk is lower than that of the vertebral body on T1-weighted images; on T2-weighted images the disk appears with a higher signal intensity than that of the vertebral body. According to Pfirrmann et al, disk degeneration can be classified in five different grades. In normal young patients the high signal on T2-weighted images appears homogeneous in the central area of the disk; the peripheral annulus appears with a low signal on T2-weighted images (grade 1). Loss of the signal intensity of the nucleus pulposus on T2-weighted images is in close correlation with disk dehydration related to alteration of the proteoglycans; gradient echo images are more sensitive to the presence of water and the loss of signal intensity is more apparent on SE T2-weighted images. During the second decade of life an horizontal linear hypointense band on T2-weighted images appears within the nucleus pulposus because of the development of collagen fibers within it (grade 2). Latter appears a diffuse signal loss on T2-weighted images associated with mild narrowing of the intervertebral space (grade 3). At this stage posterior radial tears (High Intesity Zone HIZ) may be detected as an area of high signal intensity on T2-weighted images in posterior and peripheral annulus. A black disk with significant narrowing of the disk space (grade 4) or with collapsed disk space (grade 5) corresponds to severe disk degeneration. Intradiskal gas appears hypointense on T1 and T2-weighted images. Intradiskal calcifications may also appear hypointense on T1 and T2-weighted images, however diskal calcifications may appear hyperintense on T1-weighted images. Enhancement after intravenous administration of gadolinium may be observed in radial tears of the posterior annulus.
- According to Modic et al three types of signal intensity changes involving the bone marrow of the adjacent vertebral body may be associated with DDD. Type 1 bone marrow changes are visualized as low T1 signal intensity and high T2 signal intensity with enhancement after administration of gadolinium chelates and are in

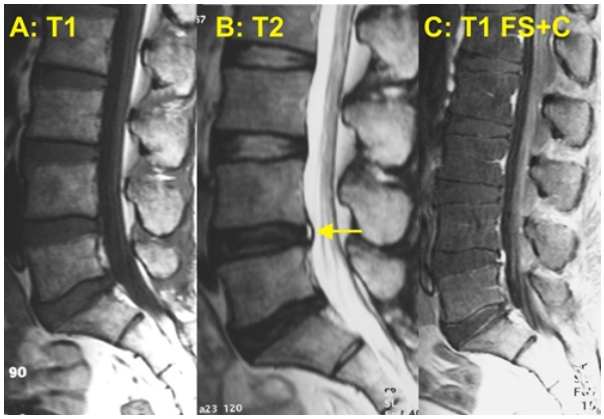
close correlation with back pain. Type 1 changes may regress or progress to type 2 changes. Type 2 bone marrow changes are visualized as high T1 and T2 signal intensity without enhancement; the type 2 changes represent fatty marrow. Type 3 changes correspond to low signal intensity on both T1- and T2-weighted images and represent hyperostosis.

- MR imaging and CT may demonstrate degenerative changes in the facet joints, ligamentous degeneration, alignment abnormalities (segmental instability, degenerative spondylolisthesis, degenerative retrolisthesis) and spinal canal stenosis. Dynamic plain films and dynamic myelography may confirm segmental instability.
- Degenerative disc disease can cause a disk bulging. A bulging disk represents a disk that extends diffusely beyond the adjacent vertebral body margins in many directions. This occurs due to multiple tears in the annular fibers producing a diffuse laxity of the annulus. The MR appearance of disk bulging is symmetric uniform extension of the outer disk margin on a very large circumference.
- Degenerative disc disease can cause an intraannular disk protrusion due to an annular radial tear. When the tear conducts to subtotal annular disruption it produces usually a focal cone shaped protrusion with a wide waist. This is usually reported as a disk protrusion in clinical practice and can cause a true nerve root compression and leg pain but either CT nor MRI can actually differentiate small protrusions extended into the inner annulus from small true hernias with a tiny extruded disk part penetrating all layers of the annulus.
- Degenerative disc disease can cause a subtle endplate enhancement.

| Description of cases : Magnetic Resonance (MR), Computed Tomography (CT), plain films. | |
|---|---|
| 1 | MR. Annular tear. |
| 2 | MR. Modic et al. Type 1 bone marrow changes. |
| 3 | MR. Modic et al. Type 2 bone marrow changes. |
| 4 | MR. Evolution in one year from Type 1 to Type 2 bone marrow changes. |
| 5 | Plain film. Disk degeneration. |
| 6 | MR, CT. Severe disk degeneration. Annular disk bulging. |
| 7 | MR, CT. Atypical mixed bone marrow changes in degenerative disk disease. |
| 8 | MR, CT. Modic type 1 bone marrow changes. |

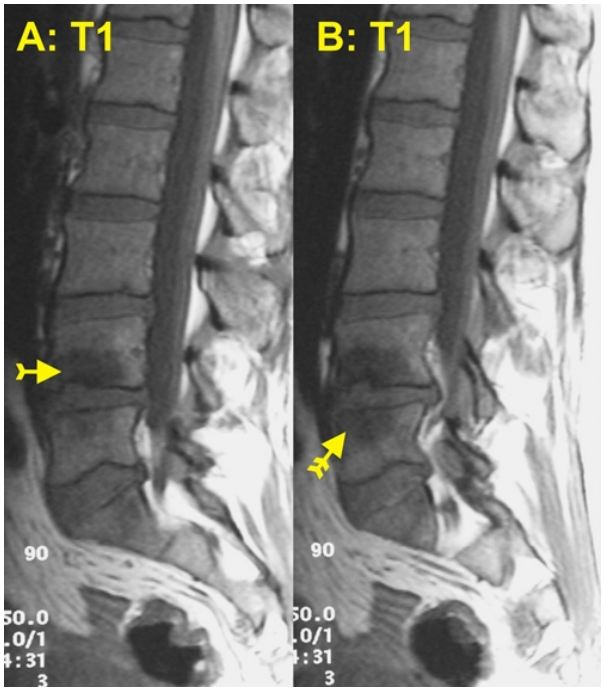
## 2) Cases

### Case 1 : Asymptomatic 30-year-old man.

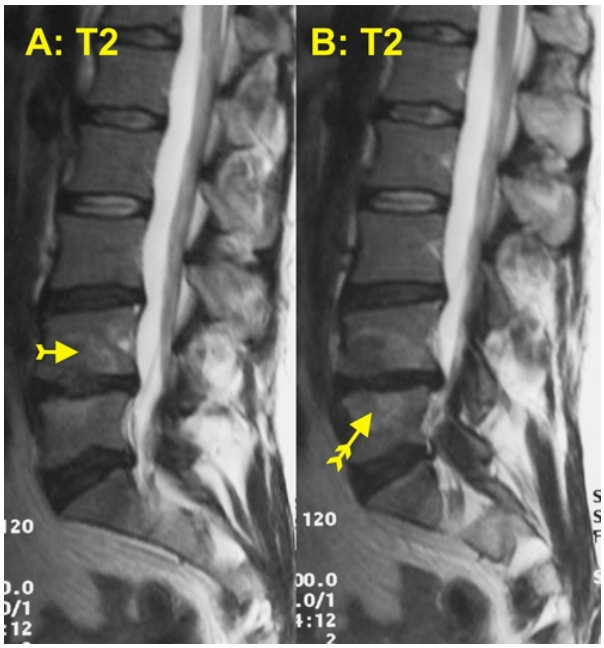



A: T1 SE weighted image. B: T2 SE weighted image. C: T1 SE weighted fat suppressed image after contrast medium injection. Tear in the posterior annulus at L4-L5 level with high-signal intensity zone (HIZ) in sagittal T2 SE weighted image. Degenerative disc disease at L4-L5 and L5-S1 levels with signal loss on T2- weighted image associated to mild narrowing of the intervertebral space at L5-S1 (grade 3).

## Case 2 :Occasional low back pain in a 37-year-old woman.

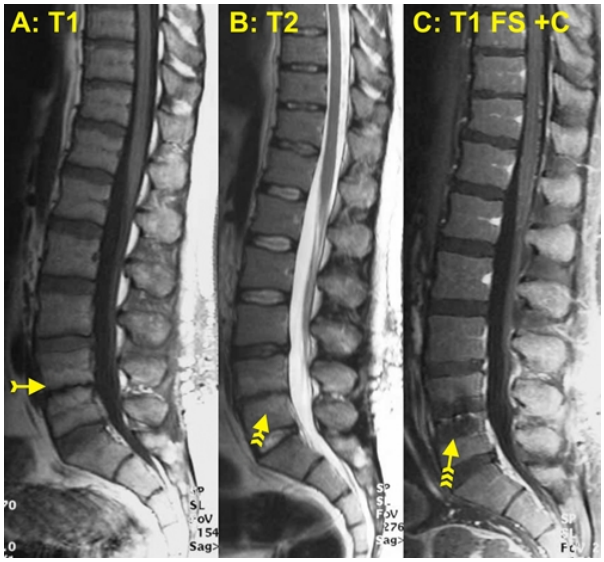



A and B: T1 SE weighted images. Bone marrow changes are visualized as low T1 signal intensity (arrows I and II) and high T2 signal intensity: Modic Type 1 .



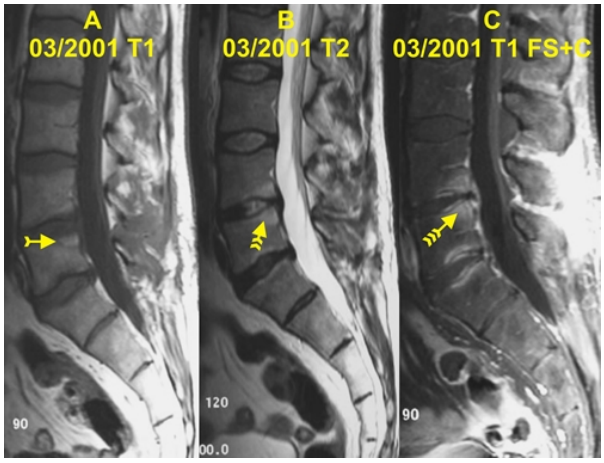

A and B: T2 SE weighted images. B: Bone marrow changes are visualized as low T1 signal intensity and high T2 signal intensity (arrows I and II): Modic Type 1 .

## Case 3 : Occasional mild low back pain  in a 32-year-old man.

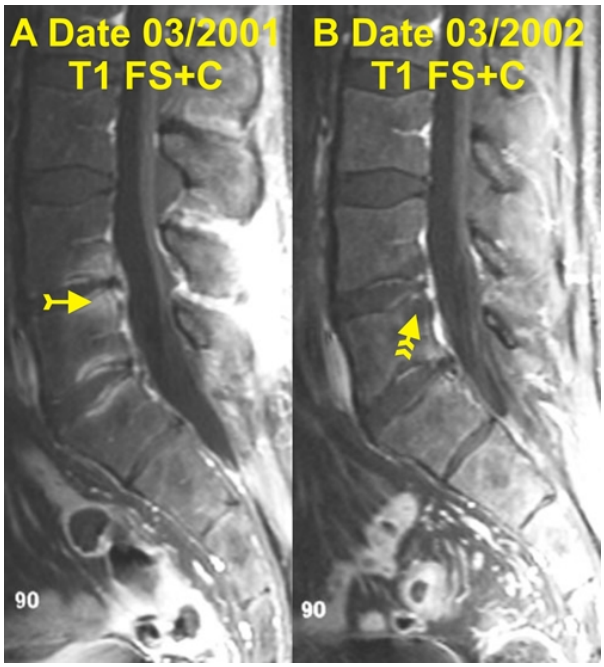



A: T1 SE weighted image. B:  T2 SE weighted image. C: T1 SE weighted fat suppressed image after contrast medium injection. Modic Type 2 bone marrow changes are visualized as high T1 (arrow I) and T2 (arrow II) signal intensity without enhancement (arrow III) ; the type 2 changes represent fatty marrow.

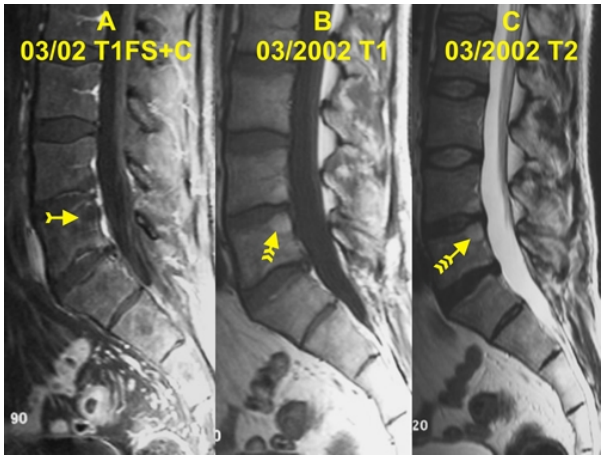
**Case 4 : Mild low back pain in a 35-year-old man. Spontaneous pain relief one year later.**




A: T1 SE weighted image. B: T2 SE weighted image. C: T1 SE weighted fat suppressed image after contrast medium injection. Modic Type 1 bone marrow changes are visualized as mixed T1 signal intensity (arrow I) and high T2 signal intensity (arrow II) with enhancement after administration of gadolinium (arrow III).

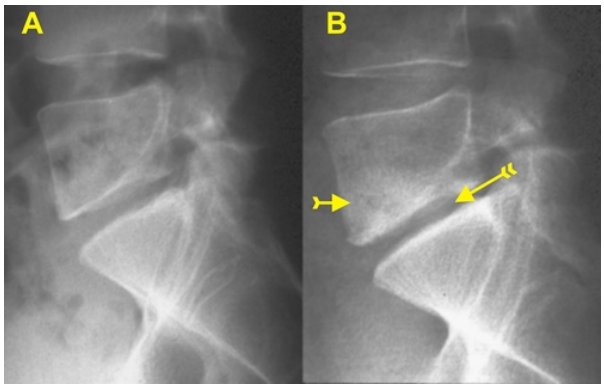



A: T1 SE weighted fat suppressed image after contrast medium injection. B: Same patient one year later. T1 SE weighted fat suppressed image after contrast medium injection. Evolution from Type 1 to Type 2 bone marrow changes. Type 1 bone marrow changes with enhancement after administration of gadolinium chelates (arrow I), Type 2 bone marrow changes are visualized as high T1 and T2 signal intensity without enhancement (arrow II).



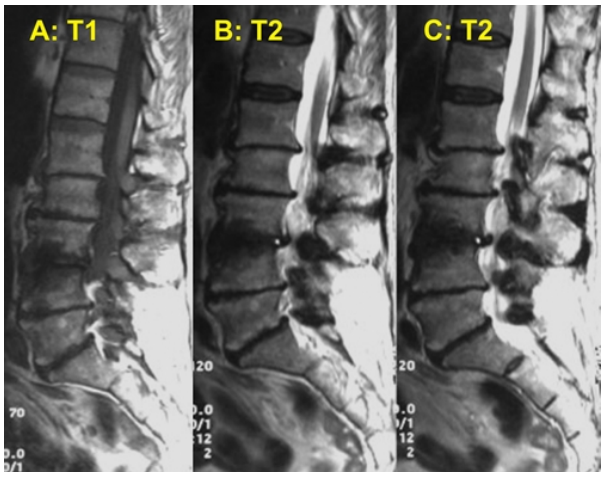

Same patient one year later (03/2002) A: T1 SE weighted fat suppressed image after contrast medium injection. B: T1 SE weighted image. C: T2 SE weighted image. Evolution from Type 1 to Type 2 bone marrow changes, Type 2 bone marrow changes are visualized as high T1 (arrow II) and T2 (arrow III) signal intensity without enhancement (arrow I); the Type 2 changes represent fatty marrow.

## Case 5 : Chronic low back pain in a 41-year-old woman.

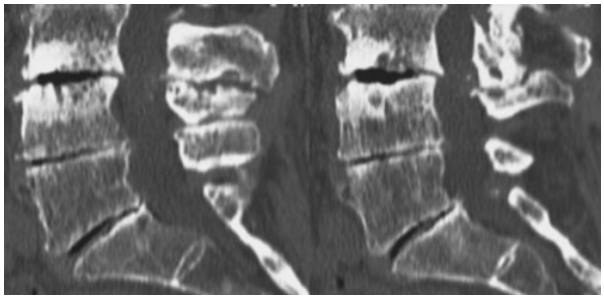



A: Plain film L5-S1. B: Same patient four years later. Narrowing of the disk space (A) (grade 4) or collapsed disk space (B) (grade 5) correspond to severe disk degeneration (arrow II). Modic type 3 changes correspond to hyperostosis

## Case 6 : Chronic low back pain with functional limitation in a 63-year-old man.

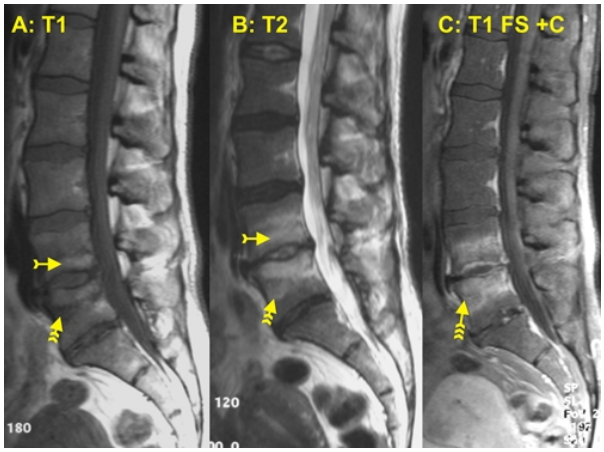



A: T1 SE weighted image. B: T2 SE weighted image. C: T2 SE weighted image. Black disks with significant narrowing of the disk space (grade 4) or with collapsed disk space (grade 5) correspond to severe degeneration. Annular disk bulging. Intradiskal gaz appearing hypointense on T1 and T2-wi. Modic Type 3 changes correspond to low signal intensity on both T1-wi and T2-wi and represent hyperostosis.

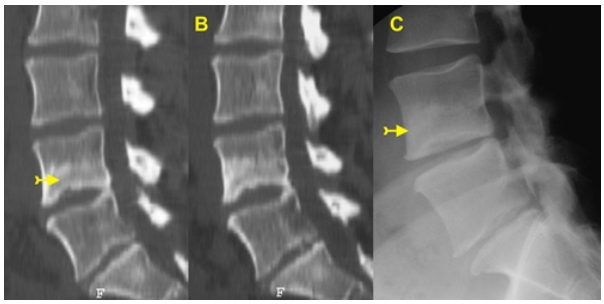


CT scan sagittal reformation. Same patient. Narrowing of the disk space (grade 4) or collapsed disk space (grade 5) corresponds to severe disk degeneration. Intradiskal gaz appears hypodense. Modic Type 3 changes represent hyperostosis.

## Case 7 Back pain in a 52-year-old man.

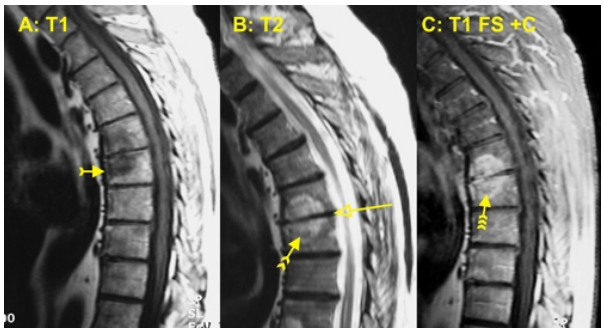


A: T1 SE weighted image. B: T2 SE weighted image. C: T1 SE weighted fat suppressed image after contrast medium injection.  Atypical mixed bone marrow changes in degenerative disk disease. Areas of low T1 signal intensity (A arrow II) and high T2 (B arrow II) signal intensity. Enhancement after administration of gadolinium (C arrow III). Areas of high T1 (A arrow I) and T2 (B arrow I) signal intensity.

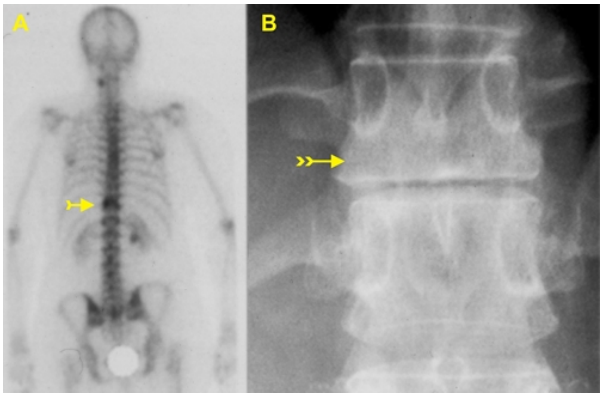



A-B: CT reconstructions. C : Plain film. Same patient as above. Atypical mixed bone marrow changes in degenerative disk disease.  Hyperostosis (arrow I).

## Case 8 : Back pain in a 55-year-old woman.




A: T1 SE wi. B: T2 SE wi. C: T1 SE weighted fat suppressed image after contrast medium injection. Degenerative disk disease: black disk with significant narrowing (hollow arrow) of the disk space (grade 4). Modic type 1 bone marrow changes are visualized as low T1 (arrow I) and high T2 (arrow II) signal intensity with enhancement (arrow III) after administration of gadolinium, and are in close correlation with back pain.




Same patient: degenerative disk disease, Modic type 1 bone marrow changes. A: scintigraphy: increased uptake (arrow I). B: Plain film : hyperostosis (arrow II).