Degenerative Diseases of the Spine

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Introduction

Degenerative disease of the spine, in particular low back pain (LBP), is one of the most common causes of work disability. Back pain is a pervasive problem that affects two-thirds of adults at some time in their lives. Most often, back pain is benign and self-limited. However, it is occasionally the presenting symptom of systemic diseases such as cancer or infection. Some causes of back pain, especially those with neurologic symptoms, are surgically treatable. Thus, the major diagnostic task is to distinguish the 95% of patients with simple back pain from the 5% with serious underlying diseases or neurologic impairments. In this article, an overview of the spectrum of degenerative disease of the spine is provided. Special emphasis is directed to the magnetic resonance imaging (MRI) appearance of degenerative spine disorders, since MRI has become the standard of reference regarding the evaluation of patients with back pain with or without neurological deficits [1, 2].

Anatomical Considerations

The intervertebral disk is a complex structure consisting of hyaline cartilage, fibrocartilage, and mucopolysaccharide and dense fibrous tissue, which together gives the spine its flexibility and stability. The layer of the hyaline cartilage attached to the vertebral endplate and encircled by the ring apophysis is called the cartilaginous endplate. Within the endplate are numerous vascular channels through which nutrients or contrast medium diffuse into the disk. One of the theories of disk degeneration is that degenerative changes in the vertebral endplate impair diffusion into and out of the disk, impeding the function of chondrocytes and fibroblasts in the disk.

The anulus fibrosus can be divided into outer and inner components, or rings. The outer ring contains the densest fibrous lamellae, which display low signal intensity on T2-weighted MR images due to the absence of ground substance. The cells in the outer ring of the anulus are almost exclusively fibroblasts. Unlike the outer ring of the anulus, the inner ring contains predominantly chondrocytes and has ground substance. Therefore, the inner ring has high signal intensity on T2-weighted images.

The second component of the intervertebral disk is the nucleus fibrosus. The nucleus fibrosus consists of collagen and hydrophilic proteoglycans.

The disk usually lacks innervation and vascularity. The anterior and posterior ligaments, facet joints, vertebral endplates, and the peripheral layer of the anulus fibrosus are innervated. Therefore, the disk is not usually a source of pain, although degeneration in the disk may lead to pain by stretching of ligamentous tissue, nerve compression, or inflammation.

Disk Degeneration

With aging, the nucleus pulposus becomes dehydrated and tears occur in the anulus fibrosus. Increases in collagen and decreases in glycosaminoglycans are believed responsible for a decrease in the water content. Radial or type 3 tears are of special interest in the setting of disk degeneration since these types of anular tears concern the entire anulus fibrosus, and they correlate with shrinkage and disorganization of the nucleus [3]. Hydration and anular integrity seem to be important for the disk to absorb and transmit compressive loads to the vertebral column. As the disk ages and degenerates, it progressively loses this capacity. This results in disk-space narrowing and reduced load-bearing capacity. Occasionally, gas or calcification develops within a degenerating disk.

MRI is the most important method for clinical assessment of disk degeneration. The signal characteristics of the disk in T2-weighted sequences reflect changes caused by aging or degeneration [4]. Pfirrmann et al. [5] proposed a classification system for lumbar disk degeneration based on routine MRI. This classification system uses five grades to describe the different stages of lumbar-disk degeneration. The grading system is based on MR signal intensity, disk structure, distinction between nucleus and anulus, and disk height (Table 1, Fig. 1). The kappa coefficients for intra- and interobserver agreement were excellent for this system; thus it is useful in daily practice.
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When the disk loses its anular integrity, it begins to expand outward, resulting in a variety of morphologic abnormalities. Several classification systems have been proposed to describe disk abnormalities. Currently, the most widely accepted terms are: normal, bulging, protrusion, extrusion and sequestration [6]. A disk is considered normal when it does not reach beyond the border of the adjacent vertebral bodies. Bulging is defined as circumferential, symmetric disk extension around the posterior vertebral border. The anulus fibrosus remains intact. Protrusion is defined as focal or asymmetric extension of the disk beyond the vertebral border, with the disk origin broader than any other dimension of the protrusion. Extrusion is defined as a more extreme extension of the disk beyond the vertebral border, with the base against the disk of origin narrower than the diameter of the extruding material and a connection between the material and the disk of origin (Fig. 2). Sequestration is defined as a free disk fragment that is distinct from the parent disk and has intermediate signal intensity on T1-weighted images but increased signal intensity on T2-weighted images (Fig. 3). The above-mentioned classification system for disk abnormalities does not use the term disk herniation, which is defined as displacement of disk material beyond the normal margins of the intervertebral disk space [6]. The herniated material may include nucleus pulposus, cartilage, fragmented apophyseal bone, or fragmented anular tissue. Some authors use the term disk herniation to collectively designate protrusions and extrusions.

Intervertebral disk herniation or Schmorl’s node represent an intervertebral displacement of nuclear material through a break in the vertebral endplate. Occasionally, it may present as a well-delineated cystic lesion within the vertebral body, the so-called giant cystic Schmorl’s node [7]. Intravertebral disk displacement may be associated with any disease process that weakens or disrupts the endplate or subchondral bone, including intervertebral osteochondrosis, Scheuermann disease, trauma, hyper-

<table>
<thead>
<tr>
<th>Grade</th>
<th>Differentiation of nucleus pulposus</th>
<th>Signal intensity of nucleus pulposus from anulus</th>
<th>Disk height</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Yes</td>
<td>Homogeneously hyperintense</td>
<td>Normal</td>
</tr>
<tr>
<td>II</td>
<td>Yes</td>
<td>Hyperintense with horizontal dark band</td>
<td>Normal</td>
</tr>
<tr>
<td>III</td>
<td>Blurred</td>
<td>Slightly decreased, minor irregularities</td>
<td>Slightly decreased</td>
</tr>
<tr>
<td>IV</td>
<td>Lost</td>
<td>Moderately decreased, hypointense zones</td>
<td>Moderately decreased</td>
</tr>
<tr>
<td>V</td>
<td>Lost</td>
<td>Hypointense, with or without horizontal hyperintense band</td>
<td>Collapsed</td>
</tr>
</tbody>
</table>

Fig. 1. Grading system for the assessment of lumbar disc degeneration. Sagittal T2-weighted images show the different degrees of disk degeneration according to the classification system proposed by Pfirrmann et al. [5]

Fig. 2. T2-weighted images in the sagittal and axial planes demonstrate disk extrusion at the L4/5 disk level with compression of the right-sided L5 nerve root

Fig. 3. Sagittal T1- and T2-weighted images demonstrate a sequestrated disk at the L3/4 level. In addition, high-signal-intensity zones are visible at L3/4, L4/5 and L5/S1 disk levels