The Degenerative Spine

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KEYWORDS

• Spine • MR imaging • Degenerative • Arthrosis • Intervertebral disc • Herniation • Modic

KEY POINTS

- MR imaging has a key role for exploration of spine degenerative disease.
- Intervertebral disc fissures are optimally depicted on T2-weighted imaging.
- Spine MR imaging should systematically be performed for cases of back pain associated with neurologic deficit.
- MR imaging is the best imaging modality for the exploration of spinal canal stenosis.

INTRODUCTION

Degenerative disease of the spine is a leading cause of back pain and radiculopathy, and a frequent indication for spine MR imaging.[1] Disc degeneration, disc protrusion/herniation, discarhtrosis, spinal canal stenosis, facet joint arthrosis as well as interspinous processes arthrosis may require an MR imaging workup. This review presents the MR imaging patterns of these diseases and describes the benefits of the MR imaging in these indications compared with the other imaging modalities like plain radiographs or computed tomography (CT) scan.

INDICATIONS FOR SPINE MR IMAGING/ IMAGING PROTOCOLS

In most cases, back pain does not require imaging if no neurologic deficit is observed on clinical examination. However, when pain lasts for more than 4 weeks despite analgesic medications, imaging of the spine is required. The first line imaging technique is the conventional spine radiograph or spine CT scan, except in case of neurologic deficit.

In some cases, spine MR imaging should, however, be performed:

- Low back pain complicated by radiculopathy (cruralgia, sciatica);
- Symptoms related to spinal canal stenosis;
- Radiculopathy with neurologic deficit; and
- Cauda equina syndrome.

Compared with conventional radiographs, MR imaging of the spine offers the possibility to directly visualize the intervertebral disc, as well as the nerve roots and the spinal cord.

Compared with spine CT scan, MR imaging of the spine has the advantage of being a nonirradiant examination. Additionally, it helps to see the spinal cord clearly and may help to distinguish recurrent disc protrusion versus fibrosis in a postoperative condition or to detect an inflammatory lesion or tumor disease.[2] The major limitation of this imaging modality is that the acquisition may be long and may be hampered by motion artifacts, especially in patients who are in a good deal of pain. CT of the spine presents some other advantages compared with MR imaging, like better visualization of osteophytes, intradiscal gas (vacuum disc), and calcifications.

It is accepted commonly that a MR imaging protocol of the spine should contain at least 2 orthogonal plans. The surface coils are the most

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commonly used. The most widely used protocol for exploration of degenerative disease of the spine includes: sagittal T1- and T2-weighted images (WI) and sagittal (or coronal) short tau inversion recovery (STIR)-WI. The latter sequence helps in the characterization of edema of the medullary bone.[3] Axial T2-WI acquisitions are systematically performed on the 3 to 4 last lumbar disc levels to depict potential foraminal or extraforminal disc herniation. Axial T2-WI also helps to pinpoint the precise relationship between the disc bulging/herniation and the surrounding nervous structures (nerve roots and spinal cord). For cervical spine exploration, a 3-dimensional gradient echo sequence provides a slice thickness of less than 1 mm, helping to see more precisely the intervertebral foramina and the nerve roots. CUBE T2 acquisition may also be valuable because it allows for multiplanar reconstructions, offering a better visualization of nerve roots compression. Finally, contrast media injection should only be performed postoperatively to distinguish recurrent herniation from fibrosis[2] or to help in distinguishing a disc-free fragment from a nerve root tumor.[4] The whole spinal cord should be explored by the MR imaging acquisition when neurologic symptoms related to spinal cord compression are observed on clinical evaluation. Indeed, compressive disc herniation may be multifocal.[5]

DISC DEGENERATION

The intervertebral discs are located between the endplates of adjacent vertebral bodies; they have a cushion shape and allow the mobility of one vertebral body over another. They are cartilaginous structures; their composition is divided into the nucleus pulposus in the central aspect of the disc and the annulus fibrosus at the peripheral aspect. The annulus fibrosus and the nucleus pulposus are both made of collagen (type II for the nucleus pulposus and type I for the annulus fibrosus) and proteoglycans.[6] The nucleus pulposus is made of more than 80% of water and has a gelatinous texture. The annulus fibrosus consists of concentric rings or lamellae, with fibers in the outer lamellae continuing into the longitudinal ligaments and vertebral bodies. The collagen lamellae are denser at the peripheral aspect of the annulus. The Sharpey fibers are dense collagen fibers located on outer aspect of the annulus that attach the intervertebral disc to the adjacent endplates.[6–9] The intervertebral disc is also attached ventrally and dorsally to the anterior and posterior longitudinal ligaments (PLL), respectively.

Disc changes may be related to aging or to degeneration if repeated, clinically significant mechanical constraints are exerted on the intervertebral disc. With aging, disc cells biological changes are observed, mainly cell type alteration within the nucleus pulposus, cell death, and alteration of cell phenotype compromising their ability to synthetize normal matrix components.[10] Additionally, increased inflammatory response and enhanced catabolic metabolism leading to breakdown of the extracellular matrix are observed in the degenerated disc.[11]

The term “disc degeneration” include the following pathomechanisms and imaging patterns: desiccation, disc space narrowing, disc bulging, disc herniation, disc tears or fissures, intradiscal gas, disc calcification, inflammatory/sclerotic changes of the vertebral endplates, and marginal osteophytes.

Progressive loss of disc water is called “desiccation” and appears on T2-WI imaging as a more or less marked reduction of the normal hyperintense signal within the intervertebral disc.[12] This decrease in signal intensity on T2-WI is thus an early surrogate marker of intervertebral disc degeneration.

In 2001, Pfirrmann and colleagues[13] proposed a 5-level grading scale for the evaluation of disc degeneration on T2 SE-WI (**Box 1**).

Before the advent of MR imaging, the reference imaging modality to visualize spinal disc

Box 1
Five-level grading scale for evaluating disc degeneration on T2 spin echo–weighted imaging

- *Grade I:* disc is homogeneous with bright hyperintense white signal intensity and normal disc height
- *Grade II:* disc is inhomogeneous, but keeping the hyperintense white signal. Nucleus and *annulus* are clearly differentiated and a horizontal gray band could be present at the central aspect of the disc; eight is normal
- *Grade III:* disc is inhomogeneous with an intermittent gray signal intensity. Distinction between *nucleus* and *annulus* is unclear; disc height is normal or slightly decreased
- *Grade IV:* disc is inhomogeneous with a hypointense dark gray signal intensity. There is no more distinction between the *nucleus* and *annulus*; disc height is slightly or moderately decreased
- *Grade V:* disc is inhomogeneous with a hypointense black signal intensity. There is no more distinction between the *nucleus* and *annulus*; the disc space is collapsed