

Detection of intervertebral disc lesions with high-resolution MRI @ 11.7 T

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Introduction: Low back pain is a major public health problem worldwide. There is evidence that accumulated load of the spine leads to disc lesions, which are related to progressive degeneration of the disc. Therefore, many in vitro studies have been conducted for creating mechanically induced intervertebral disc herniations. Possible tears and fissures have usually been visualized by injecting a radio-opaque substance into the nucleus pulposus prior to or after testing with subsequent X-ray or CT-scans, respectively. This methodology has the drawback, that either the annulus fibrosus or the endplate has to be penetrated to inject the contrast media, which represents a pre-damage. Also, it is doubtful that all tears can be seen with this method, because fissures with no connection to the nucleus cannot be filled with the radio-opaque substance, thus cannot be identified in CT-scans.

We hypothesize that high-resolution MR imaging is an adequate method for evaluating small tears of the annulus fibrosus. The goal was to determine the possibilities and limitations of the technique.

Materials and Methods: One calf lumbar intervertebral disc (L5/L6) was used in this study. The disc with part of the adjacent vertebral bodies was cut from the dissected spine with a handsaw. A lesion was set by using a Kirschner wire with a diameter of 1.5 mm (Fig. 1). A hole with a diameter of 3 mm was pre-drilled into the cranial endplate through which the wire was inserted into the disc, passing the nucleus and penetrating into the inner annulus fibrosus.

Measurements were performed on an 11.7 T small animal MRI (BioSpec 117/16, Bruker Biospin). Images were acquired applying a mildly T2-weighted multi-slice RARE Sequence. Acquisition parameters were as: TE/TR 27.5ms/4000ms, resolution 96²x1000³μm³, BW 100KHz, RARE factor 8, and 4 signal averages. Image acquisition time resulted in 21minutes. All data were received using a 6 cm diameter quadrature body transmit/receive resonator.

After MR imaging, the specimen was cut along the midsagittal plane with a bandsaw (Exakt, Norderstedt, Germany) and a photograph was taken (Fig. 3). The appearance of the lesion in MRI data was visually compared with the photograph.

Results: In the MR images of the disc the artificially set lesion could be clearly identified by irregularities in the inner annulus fibrosus (Fig. 2). The hole drilled through the vertebral body and the endplate can be well appreciated as black region cranial to the anterior nucleus pulposus. The outer annulus is not visible. A very similar appearance of the lesion is visible in the photograph (Fig. 3). Dimension and orientation of the lesions coincide well between the non-invasive and invasive imaging approach.

Discussion and Conclusion: To the authors knowledge, this is the first attempt known to test the capability of visualizing intervertebral disc lesions with MR. The data clearly shows that at 11.7 T, the artificially set lesion in the midsagittal plane can be clearly identified in the image. The MR image is in good accordance with the photograph regarding anatomic structure and lesion. The lesion is more apparent in the photograph, likely due to swelling after cutting the disc.

The study demonstrates that the methodology applied is successful in identifying small annulus lesions non-invasively without the need for any contrast agents. Further quantitative investigations need to be done in order to prove the full potential of the method presented.

With the current still rather low spatial resolution required for visualization of the intervertebral disc, translation of the results to the in-vivo situation appears feasible, in combination with dedicated spine receive coils and high field strengths. This might enable a new unique diagnostic tool for disc degeneration and its structural changes.

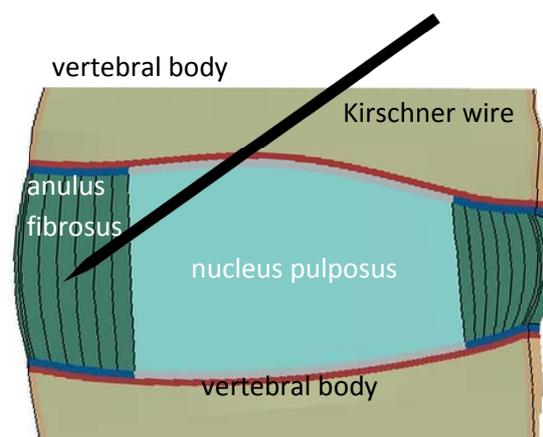


Fig. 1: Preparation of the intervertebral disc. An artificial lesion of the inner annulus fibrosus was set by a Kirschner wire.

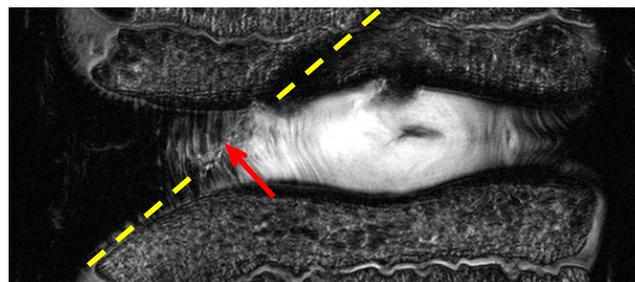


Fig. 2: Midsagittal plane of the intervertebral disc. The red arrow indicates the lesion of the inner annulus fibrosus. The yellow dotted line represents the original direction of the Kirschner wire.

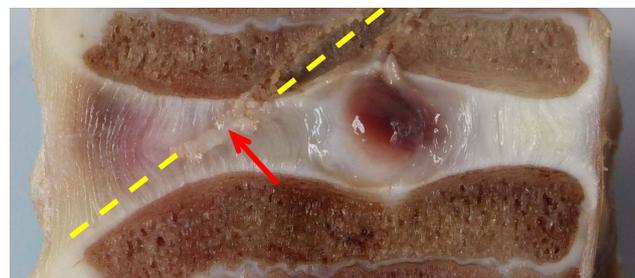


Fig. 3: Photograph of the specimen after cutting through the midsagittal plane. The red arrow and the yellow dotted line represent the same features as in the MR image.