Short time T2 variability of the lumbar intervertebral disc – in vivo MRI study at 3 Tesla

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Introduction:

Since early observations of body height loss during the day, the variable diurnal water content of the intervertebral disc (IVD) compartments has been considered as the main cause.(1) MRI makes it possible to observe changes of disc water content, represented by changes of the transverse relaxation time T2, in vivo.(2) The purpose of our study is to evaluate the short-time variability of T2 values in the supine position in different compartments of the lumbar IVD.

Methods:

The study was approved by an ethics committee, oral and written informed consent was obtained from all patients. We analyzed 215 lumbar intervertebral discs of 43 patients (mean age of 40.5 years ± 11.4 standard deviation, range 15-64) with single or recurrent episodes of low back pain. Exclusion criteria were radicular pain, neurological deficits of the lower limb or previous spine surgery.

All MR examinations were performed on a 3 Tesla MR unit using a multi-element spine coil. For T2 relaxation time measurement a multi echo-spin echo sequence was performed with a TR of 1200 msec, TE 13.8, 27.6, 41.4, 55.2, 69.0 and 82.8 msec, pixel matrix 256 x 256, voxel size 0.9 x 0.9 x 5 mm, 10 sagittal slices, interslice gap 1 mm and examination time was 7:45 min. T2 maps were obtained using a pixel-wise, mono-exponential non-negative least squares (NNLS) fit analysis. Two serial T2 relaxation time measurements with a delay of 40 minutes were performed to assess changes of T2 relaxation time values during the patient in the supine position. All patients had a standard foam plastic lower leg support, which resulted in slight bending of hip and knee joints. Patients were investigated either in the morning (8-12 am) or the afternoon (1-6 pm), to consider possible diurnal differences in short-time T2 change. The five intervertebral discs (L1-S1) of the lumbar spine were analyzed. We evaluated five equally sized rectangular regions of interest (ROIs) on two adjacent central slices on sagittal T2 maps (see Figure 1). Each ROI measured 20% of the midline disc diameter in the sagittal plane. The most anterior and most posterior ROIs (ROI1 and ROI5) were interpreted as annulus fibrosus (AF) tissue, the space in between (ROI2, ROI3 and ROI4) was interpreted as nucleus pulposus (NP) tissue. The mean number of pixels for each ROI was 42.8 (SD 11.6). Statistical and graphical analysis was performed with SPSS 15.0, paired t-tests were used to assess changes of T2 values. Subgroup analysis concerned morning-afternoon-comparison and discs with low and high NP T2 values.

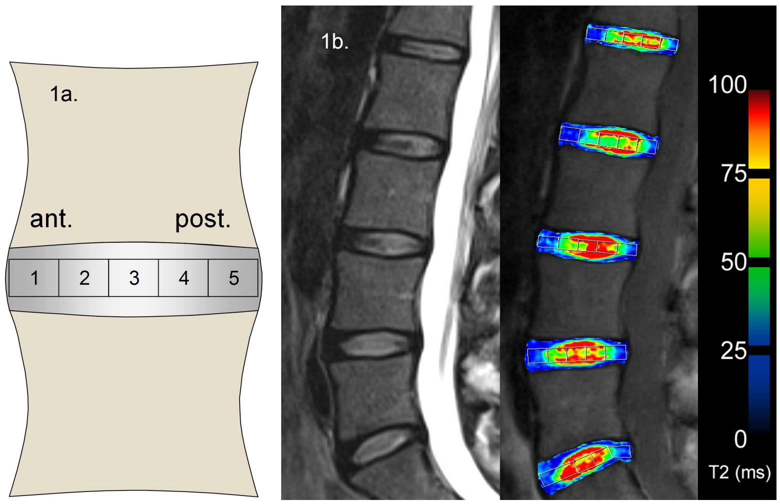
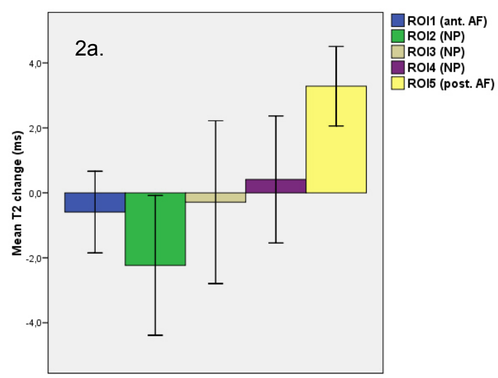


Figure 1a,b. ROI evaluation on color coded T2 maps.

Results:

We observed a decrease in the anterior NP (ROI2, -2.3 ms, SD: ± 21.7, 95%-confidence interval: -4.4, -0.1, p=0.04) and an increase of T2 values in the posterior AF (ROI5, +3.3 ms, SD: ± 12.7 ms, 95%-CI: 2.1, 4.5, p<0.001). Although these differences were significant, the effect size was small compared to the standard deviation. No T2 changes were observed in discs of the lowest tertile (i.e. 33% of discs with lowest basal NP T2 values), whereas a decrease in the anterior NP (-8.5 ms, SD: ± 32.7, 95%-CI: -14.7, -2.3, p=0.007) and T2 increase in the posterior AF (+6.0 ms, SD: ± 16.6, 95%-CI: 3.0, 8.9, p<0.001) was seen in the highest tertile.

No T2 changes were observed in discs of the morning-patient group, but T2 changes in discs of the afternoon group. Similar to the pooled analysis, there was a decrease in the anterior NP (ROI2, -6.7 ms, SD: ± 19.6, 95%-CI: -9.7, -3.7, p=0.001).and an increase in the posterior AF (ROI5, +6.9 ms, SD: ± 13.1, 95%-CI: 5.0, 8.9, p<0.001). The total T2 change of all ROIs (ROI1 to ROI5) was +0.42 ms (SD: ± 13.3, 95%-CI: -0.9, 1.7), with similar results for the subgroups.



Conclusion:

T2 mapping of the lumbar IVD at 3.0 Tesla seems to be able to detect short time T2 changes in vivo, which can be interpreted as changes in water content. Our report represents the first description of short time T2 relaxation time changes in different compartments of the lumbar IVD at 3.0 Tesla. Our results can be interpreted as a fluid shift from anterior to posterior compartments of the disc, rather than a global change in disc water content. This is possibly a result of supine position with slight hip flexion, which leads to a relative compression of the anterior part of the disc. This effect seems to be pronounced in discs investigated in the afternoon and in discs with high nucleus T2 values.

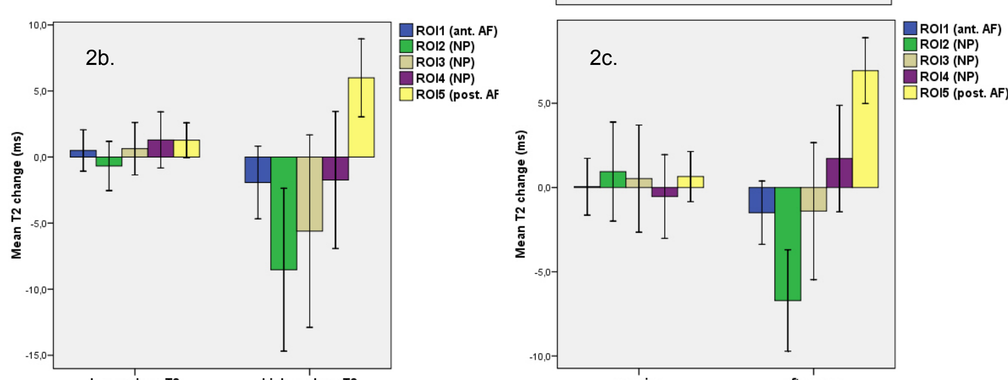


Figure 2a-c. Bar chart of mean T2 value changes in different disc compartments. a. All IVDs. b. Comparison of IVDs with low and high nucleus T2 values. c. comparison of IVDs of patients investigated in the morning and the afternoon. Error bars represent 95%-confidence intervals.

References:

1. De Puky, Acta Orthop. 1935; 6:338–48
2. Boos et al, Radiology. 1993; 188(2):351-4.