MRI parameters as predictive factors of adolescent idiopathic scoliosis progression

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TARGET AUDIENCE: Orthopaedists will benefit from the evaluation of the intervertebral disc degeneration with scoliosis through quantitative MRI parameters. Physicians will appreciate the multi-parametric MRI protocol used for the first time in adolescent scoliotic patients.

PURPOSE: Scoliosis deformities progress more during skeletal growth, producing asymmetric loading. But the remaining question is why does scoliosis progress in some people but either does not progress or spontaneously corrects itself in others? MRI offers great potential as a sensitive and non-invasive technique for describing the alterations in material properties of intervertebral discs [1-3]. However, in vivo applications are limited. We hypothesized that the distribution of the MRI parameters within the intervertebral disc will be modified in a specific way during scoliosis progression, allowing defining predictive factors of the progression. Thus the aims were to measure in vivo the distribution patterns of the MR parameters in the lumbar intervertebral disc for each level of scoliosis, and investigate these MR parameters as predictive factor of scoliosis progression.

METHODS: Eight patients with adolescent idiopathic scoliosis (5 patients with a simple curve and 3 with a double curve, 5 patients with a Cobb angle <30° and 3 with a Cobb angle >40°, 6 patients have worn the SpineCor brace) who gave their informed consent, were included in our multi-parametric MRI protocol approved by the ethic committee of our institutions. All the MRI acquisitions were performed on a 3T whole-body Phillips Achieva X-Series scanner using a standard spine coil. Images for the quantification of T1rho were acquired using a magnetization-prepared steady-state free-precession sequence with 6 spin-lock durations. Images for the quantification of T2 were acquired using a multi-echo turbo spin-echo sequence. Images for the quantification of MTR were acquired from 2 turbo spin-echo sequences (with and without an off-resonance pulse at 6000Hz). DTI was performed using a spin-echo EPI diffusion-weighted sequence. The total time scan was 45 minutes. The MRI parameters (T1rho, T2, MT, ADC and FA) were extracted from the signal intensity by non-linear regressions to their respective signal expressions [1,2]. The lumbar IVDs were segmented using the Snake algorithm on each MRI parameter map (Figure 2). One way ANOVAs were used to assess the offset was optimized to 6000Hz as suggested in the literature [4].

RESULTS: T1rho values ranged from 45±3ms in the external annulus fibrosus to 197±24ms in the nucleus pulposus. T2 values ranged from 47±9ms in the external annulus fibrosus to 140±41ms in the nucleus pulposus. MTR ranged from 20±5% in the external annulus fibrosus to 7±2% in the nucleus pulposus. The ANOVA showed significant differences between discs located near the scoliotic curve apex and the discs far away from the apex for all MRI parameters. Significant differences were also found between the patients presenting different Cobb angles. The age influences also all the MRI parameters while the effect of the brace was significant except for MTR.

DISCUSSION: This study presents the first multi-parametric MRI acquisition performed in vivo on patients with adolescent idiopathic scoliosis. The results validated our hypothesis: relaxation times T1rho and T2, magnetization transfer ratio MTR and diffusion parameters ADC and FA within the intervertebral disc are modified in a specific way during scoliosis progression and could be used as biomarkers of scoliosis progression. The T1rho sequence we used was too sensitive to the chest air for a thoracic zone acquisition, but more robust sequences could be tested. The semi-automatic segmentation has to be replaced by fully automatic process to improve inter-observator reproducibility [3].

CONCLUSION: The possibility to predict the evolution of the disc degeneration from these MRI parameters will allow to better target the surgical or orthopaedic treatment than what is done today, and thus to prevent the aggravation of this degeneration. The children will benefit from an adjusted treatment and thus an increased quality of life of the patient.

REFERENCES