

Categories: Deformity

Type: Adult

Title: Adult degenerative scoliosis leads to disproportionate loss of mechanical properties of the annulus fibrosus

ABSTRACT:

Objectives:

Degenerative scoliosis (dScoli) is a complex and painful condition. It is yet unknown why the condition occurs, and multiple hypotheses have been proposed, including muscular imbalance. We hypothesized that loss of mechanical properties of the intervertebral disc is involved in the genesis of dScoli, particularly of the annulus fibrosus in shear loading and in interlamellar adhesion strength.

Methods:

Human annulus fibrosus (AF) tissue from L4-5 or L5-S1 was collected from patients undergoing surgery and from organ donors. Subsequently, multi-modality mechanical testing was performed. First, non-destructive shear testing was performed using 5 mm³ blocks of retrieved AF tissue. In this cohort, there were 21 non-degenerate samples (non-DDD) (aged 40±11), 31 samples from non-deformity degeneration (DDD) (aged 46±13) and 11 dScoli samples (aged 63±9). Radial and circumferential shear testing was performed (Bader et al. JOR Spine 2025). In addition, peel testing, as per Gregory et al. (2012) was performed. In this cohort, there were 26 non-DDD (aged 37±14), 36 DDD (aged 44±10) and 7 dScoli samples (aged 66±5). ANOVA with post-hoc testing was performed if data were normally distributed, or alternatively the Kruskal-Wallis test was performed.

Results:

There were significant differences in circumferential shear stiffness between groups (181±97 kPa non-DDD, 52±38 kPa DDD and 35±22 kPa dScoli) ($p < 1.61E-06$). In radial shear, there were also significant differences in stiffness between groups (71±41 kPa non-DDD, 24±23 kPa DDD and 12±6 kPa dScoli) ($p < 8E-06$). In the peel test, there were significant differences in peel stiffness (0.24±0.08 N/mm² non-DDD, 0.19±0.07 N/mm² DDD, 0.11±0.03 N/mm² dScoli) ($p < 1E-04$), peel strength (2.03±1.10 N/mm non-DDD, 1.58±0.75 N/mm DDD, 0.74±0.31 N/mm dScoli) ($p = 0.001$) and peel toughness (30.61±16.64 J/m non-DDD, 17.98±7.79 J/m DDD, 10.47±3.22 J/m dScoli) ($p < 0.001$).

Post-hoc tests with Bonferroni were negative for differences between DDD and dScoli for circumferential and radial shear and were positive for differences between DDD and dScoli for peel stiffness ($p = 0.0009$) and peel strength ($p = 0.0006$), and not for toughness ($p = 0.086$).

Conclusion:

These results provide evidence, for the first time, that degenerative scoliosis IVDs are much less stiff than those of patients with non-deformity degeneration at the time of surgery, which are in turn, less stiff than organ donor IVDs. There are important structure-function relationships in the IVD that could result in dScoli. Importantly, the dScoli IVDs were often caudal to the main curve, which suggests that all lumbar IVDs in these patients are undergoing a disease process. Further characterization is being performed to elucidate the basis for these mechanical differences, with structural, proteomic and cellular characterization.