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Quantitative MRI Correlates with Histological Grade in a Percutaneous Needle Injury Mouse Model of Disc Degeneration

Matthew Piazza, MD, Sun Peck, PhD, Sarah Gullbrand, PhD, Justin Bendigo, BS, Toren Arginteanu, Yejia Zhang, MD, PhD, Harvey E. Smith, MD, Lachlan J. Smith, PhD, Neil R. Malhotra, MD

UPenn Translational Spine Research Lab
Disclosures

- None
Introduction

- Lumbar disc degeneration is a major cause of morbidity, lost productivity, and health care expenditures worldwide.
- Stem cell based therapies serve as a potential novel strategy to not only alleviate painful symptoms but also to restore disc structure and function. The development of physiologically relevant *in vivo* animal models to validate these therapies is critical.
- The objectives of this study were to 1) optimize a percutaneous needle injury model of intervertebral disc degeneration in the mouse caudal spine, and 2) compare two, non-invasive quantitative imaging techniques, microcomputed tomography (microCT) and magnetic resonance imaging (MRI), as effective surrogates for disc degeneration in this model.
Methods

- Percutaneous, fluoroscopic guided needle injury of mouse caudal discs at the C7-8/C9-10 levels was undertaken using varying needle sizes (27G, 29G, and 31G) and either single annulus fibrosus (AF) puncture or double AF puncture through NP and contralateral AF (n=10 levels/injury group); intervening levels served as controls. Mice were euthanized at 4 weeks.

- T2 relaxation constants and disc height index (DHI) were determined via MRI and microCT, respectively.

- A semi-quantitative histologic grading scale was used to assess degree of degeneration. Annulus fibrosus (AF) organization, nucleus pulposus (NP) matrix, NP cellularity, and AF/NP border were each assessed independently by 3 blinded reviewers on a scale from 0 to 100 and combined for a total score. Greater scores indicate more severe degeneration.
Results – Quantitative MRI

- Overall, NP T2 relaxation constants were significantly different among injury groups (p=0.001).
- 27G and 29G double puncture groups demonstrated significantly lower T2 relaxation times compared to intact controls (p<0.05).
- 31G double puncture trended toward significance (p=0.06).
Results - MicroCT

- Neither disc height nor DHI were significantly affected by any injury type (p>0.05).
Semi-quantitative histologic grade was significantly worse in the 27G and 29G double puncture group compared to control (p<0.001).
Results – Histologic Grade

- There was a strong, inversely linear relationship between histological grade and T2 scores ($r = 0.7$, $p < 0.001$).
Discussion

- Quantitative MRI can detect degenerative changes after percutaneous needle puncture, specifically after 29G and 27G double annulus fibrosus puncture, when compared with uninjured controls.
- DHI as assessed by microCT was not significantly affected by injury type. The lack of significant disc height changes may reflect a milder degree of disc degeneration that may be ideal for studying cell based therapies, compared with severely degenerated disc with complete loss of disc height and minimal residual viable NP tissue.
- Moreover, the strong correlation between T2 relaxation values and histologic score suggests that quantitative MRI may be useful in assessing disc degeneration in vivo in longitudinal animal studies of cell based therapies for disc degeneration.
Key Points

- Quantitative MRI may be a useful *in vivo* marker of disc degeneration in murine models.
- Double annular percutaneous puncture with 27G and 29G needles of caudal mouse tail may serve as threshold injury for inducing mild disc degeneration.
- Future longitudinal studies are needed to validate utility of *in vivo* quantitative MRI at detecting changes of the intervertebral disc in this percutaneous mouse model of disc degeneration.