

# The relationship between MRI and histology in a rat model of intervertebral disc degeneration

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**Introduction:** Intervertebral disc degeneration (IDD) related diseases are the main reasons of low back pain, which is a major health and medical concern [1-3]. With many novel potential therapies to be tested, there is a need for simpler and quicker animal models that could be used to screen them effectively. Our study aimed to investigate a slowly progressive, reproducible rat model of disc degeneration, suitable for studying the participating mechanisms induced by needle puncture, and the relationship between MRI and histology in the long-term progression of disc degeneration.

**Methods:** The Co7-8 and Co8-9 intervertebral discs of the caudal spine in 48 Sprague-Dawley rats were punctured laterally, using 20-gauge sterile needles, 5 mm depth from skin to the middle of the appropriate disc, controlled by the handmade stopper [4]. Signs of degeneration in the disc of the tail were analyzed before surgery and at 4, 8, 12, and 24 weeks post-surgery by in vivo MRI and histology. MRI scans were obtained using a 3.0 T MRI scanner and following parameter settings: spin echo repetition time, 2275ms; echo time, 80ms; field of view, 5 cm; slice thickness, 1.5 mm; spacing, 0mm; no phase wrap; echo train length, 16; band width, 41.76; number of excitations, 8; matrix, 288 × 224; Scan Time, 4:18. MRI index (the area of nucleus pulposus multiplied by average signal intensity)<sup>[5]</sup> was used to assess the alteration of nucleus pulposus (Figure 1). Histopathologic analysis was presented by hematoxylin and eosin (H&E) staining and evaluated by using a grading scale [4].

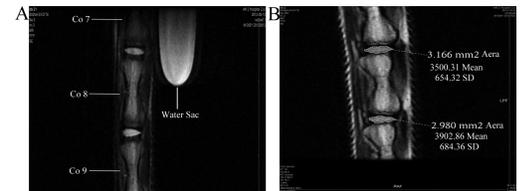


Figure 1 The Schematic diagram of measured area of interest in NP, mean signal intensity, and standard derivation.

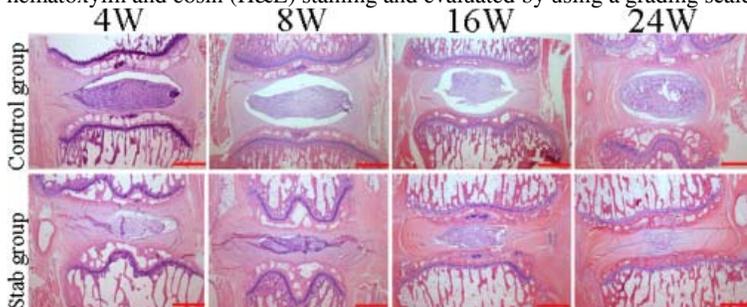


Figure 2 Representative H&E (25x, A) of disc samples from two groups at weeks 4, 8, 16 and 24 post-injection. The bar indicates 1 mm.

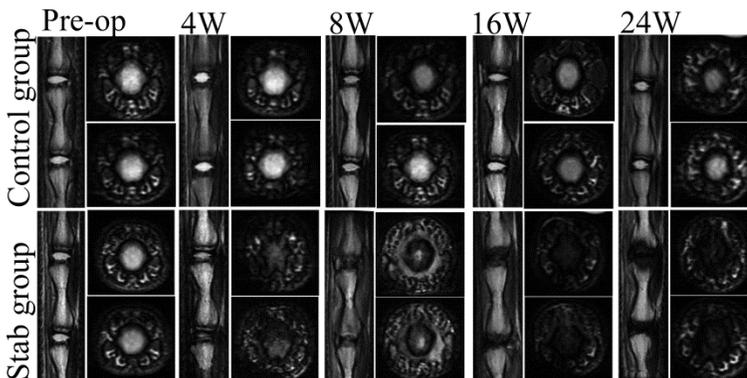


Figure 3 Representative T2 MRI scans of disc samples from two groups before surgery and at all-time points after stab

**Results:** The discs of two groups were all categorized as normal, moderately degenerated, and severely degenerated, and the histologic score of stab group discs was significantly correlated with the time post-stab ( $p < 0.01$ ,  $r = 0.79$ ) (Figure 2 and Table 1). Meanwhile, MRI measurements showed a progressive decrease in T2 density and MRI index throughout the entire investigation, starting at 4-week post-puncture. Furthermore, the degenerated disc did not recover spontaneously, as shown by decreases in T2 density and MRI index (Figure 3). Moreover, the apparent relativity was found between the grade scale of histological score and MRI measurements, including MRI T2 intensity ( $p < 0.01$ ,  $r = 0.89$ ) and MRI index ( $p < 0.01$ ,  $r = 0.92$ ) (Table 2).

**Discussion:** MRI is a high degree of specificity and sensitivity method in the diagnosis of IDD [6, 7]. Previous studies concluded that the MRI signal intensity of NP was positively related to chondroitin sulfate, among which could retain abundant water [8]. Based on our study, as the increase of IDD severity, the T2 intensity and MRI index accordingly decreased, and there was a significant correlation between IDD severity with T2 density or MRI index respectively. A significant correlation between time post stab and T2 density or MRI index respectively, too. The results showed MRI T2 signal intensity and MRI index can be used for quantitative analysis of normal/degenerated discs and the level of degenerated discs on rat.

**Conclusion:** This study demonstrates that needle puncture into a tail disc in the rat induces a rapid and progressive disc degeneration process without spontaneous recovery. The apparent correlation was found between the grade scale of histological score and MRI measurements. Therefore, MRI could provide a convenient, less invasive, reproducible, and cost-effective, option to monitor the progression of the intervertebral disc degeneration.

**Reference:** 1. Adams MA, Spine, 2006. 2. Kandel R, Eur Spine J, 2008. 3. Katz JN, JBJS Am, 2006. 4. Han B, Spine, 2008. 5. Sobajima S, Spine, 2005. 6. Bowles RD, NMR Biomed, 2012. 7. Moon CH, Spine, 2012. 8. Nagashima M, Acta Radiol, 2012.

Table 1 The mean histologic score of moderately or severely degenerated disc in rat degeneration disc model respectively

Table 2 Relation between MRI T2 intensity/MRI index and histologic score in rat model

Group (No. of discs)	Time Post-stab (Week)	Histologic score (5-16)
Moderately degenerated disc (16)	5.5 ± 2	8 ± 1.9
Severely degenerated disc (24)	16.33 ± 6.76	13.7 ± 1.08

Group (No. of discs)	T2 Intensity	MRI Index	Histologic score (5-16)
Control group (40)	4935.26 ± 789.67	16515.38 ± 2317.25	5 ± 0
Moderately degenerated disc (16)	2824.04 ± 474.83	8440.85 ± 1995.82	8 ± 1.9
Severely degenerated disc (24)	651.89 ± 195.48	1610.18 ± 658.27	13.7 ± 1.08