Introduction
Disc degeneration can be induced by introducing needles of defined sizes into the rat caudal disc in a convenient, less invasive and cost-effective way [1,2]. However, previous studies only reported results from short-term follow-ups. Long-term progression of the disc degeneration and delineation of the mechanisms participated in this animal model requires more clarification. Therefore, the aim of this study was to investigate the long-term progression of disc degeneration induced by needle puncture at rat caudal disc and the mechanisms participated in this animal model.

Materials and Methods
Animals Male Sprague-Dawley rats (3 months old) were used in this study.
Surgical Technique With the aid of fluoroscopy, 21G needle was inserted in the middle of the nucleus pulposus (NP) of Co5/Co6 or Co7/Co8, rotated 180°, and held for 5s. Depth of penetration was controlled at 5 mm from the needle. Co6/7 remained intact.
MRI Procedures and Processing In vivo MRI was serially scanned post-surgery using a 7.0T Varian MR scanner. T2-weighted midsagittal images were processed and analyzed qualitatively using Analyze 7.0 and an IDL code.
Quantitative real-time polymerase chain reaction (PCR) Type I and II collagens, aggrecan, bone morphogenetic protein-2 (BMP-2), matrix metalloprotease-3 (MMP-3) and glyceraldehyde 3-phosphate dehydrogenase (GAPDH) gene expression in the NP were quantified by real-time PCR using Gene Amp 7700 Sequence Detection.
Biochemical analyses The proteoglycan, mainly sulfated glycosaminoglycan (sGAG), and the deoxyribonucleic acid (DNA) contents in the papain-digested NP solution were assayed using the dimethyl-methylene blue method and Hoechst dye 33258 method, respectively.
Histologic Analysis Samples were processed and sectioned. Sections were stained with H&E and safranin O.
Statistical analysis: Data were expressed as mean ± SEM. Two-tailed t-test were used to determine the significant difference.

Results
MRI showed progressive decrease in T2 density and MRI index throughout the whole investigation, starting from day 1 after needle puncture (Fig 1). However, histological scores revealed a bimodal pattern showing that severity increased in the first 17 days, declined thereafter, and rose again by week 30 (Fig 2). Gene expression analysis showed a transient up-regulation in gene expressions of aggrecan, type II collagen, and BMP-2 and inhibition of type I collagen was observed. MMP-3 mRNA levels were up-regulated at all the tested time points within 6 weeks post-injury. The degeneration process appeared to involve an imbalance between anabolism and catabolism with an initial attempt, followed by cellular exhaustion and dysfunction of the injured NP.

Conclusions
This study demonstrates needle puncture into the rat tail disc induced a rapid and progressive disc degeneration process without spontaneous recovery. A transient up-regulation in gene expressions of aggrecan, type II collagen, and BMP-2 and inhibition of type I collagen was observed. MMP-3 mRNA levels were up-regulated at all the tested time points within 6 weeks post-injury. The degeneration process appeared to involve an imbalance between anabolism and catabolism with an initial attempt, followed by cellular exhaustion and dysfunction of the injured NP.