Improved Cartilage Contrast with Driven Equilibrium at 3.0 T

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Introduction: Current clinical MRI evaluation of articular cartilage injury relies heavily on turbo-spin echo (TSE) proton density-weighted images either with or without fat suppression (1). Because detection of surface lesions with these techniques can be limited by contrast resolution, newer techniques such as driven equilibrium have been proposed to enhance cartilage to fluid contrast (2). The purpose of this study is to determine the effect of a TSE- PD weighted driven equilibrium technique on cartilage contrast and diagnosis of cartilage injury at 3.0 T.

Methods: Axial 2D fat suppressed PD-weighted TSE images (SPIR) of the patellofemoral joint in 20 subjects were obtained using a Philips 3.0 T Intera scanner with the following acquisition parameters: TR/TE: 3000 ms/30 ms, ETL: 5, ST: 4 mm, in-plane resolution 0.31 mm, fat/water shift: 2 pixels, SENSE factor 1.4. Driven Equilibrium (DRIVE) images were obtained with identical acquisition parameters by adding an additional rf pulse after the TSE train to restore longitudinal magnetization. The signal difference to noise ratio (SDNR) for fluid to cartilage and bone to cartilage for the two techniques was compared using a 2-tailed paired t-test. Blinded comparison of the two techniques was performed by 4 musculoskeletal radiologists with regard to ability to resolve cartilage surfaces, and internal cartilage architecture. The SPIR and DRIVE images of patellar cartilage were independently graded using a Modified Outerbridge Score (0=normal, 1= increased signal, 2= surface irregularity < 50% of cartilage, 3=surface irregularity extending to deep 50% of cartilage, 4=lesion extending to bone). Diagnostic degree of confidence was evaluated using a 5-point Likert scale (1= very confident 5 = very unsure). Inter and intra-observer scores were compared using weighted kappa analysis to determine the effect of cartilage contrast on diagnostic reproducibility.

Results: Representative images for the SPIR and DRIVE sequences are presented in *Figure 1*. As demonstrated in *Figure 2*, SDNR for fluid to cartilage and bone to cartilage was significantly greater for the driven equilibrium (DRIVE) images compared to standard fat suppressed PD-TSE images (SPIR). In subjective evaluation, the DRIVE sequence was preferred for evaluation of the articular surface (74 ± 14%), bone cartilage interface (58 ± 3%), and internal cartilage architecture (64 ± 9%). There very good intra-observer agreement in the Outerbridge scoring of cartilage lesions using the two techniques (mean weighted κ =.81 ± .12), although there was better inter-observer reproducibility with DRIVE compared to the SPIR images (mean κ =.51 ± .11 for DRIVE vs κ =.43 ± .08 for SPIR). Diagnostic confidence was uniformly higher for evaluation of DRIVE images compared to SPIR (DRIVE = 1.9 ± .2, SPIR = 2.5± .2).

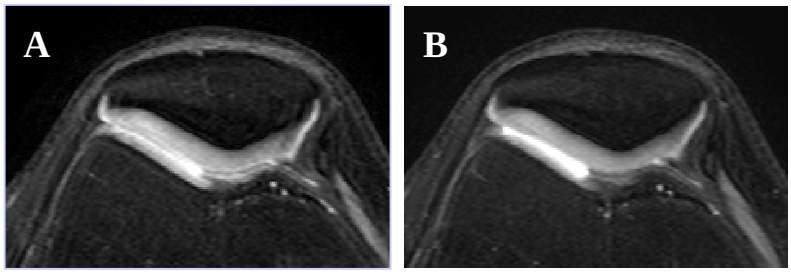

Figure 1: Representative 3.0T images of **(A)** standard fat suppressed PD weighted TSE (*SPIR*) and **(B)** fat suppressed PD weighted TSE Driven Equilibrium (*DRIVE*) images. Greater cartilage contrast to noise is observed with the DRIVE technique.

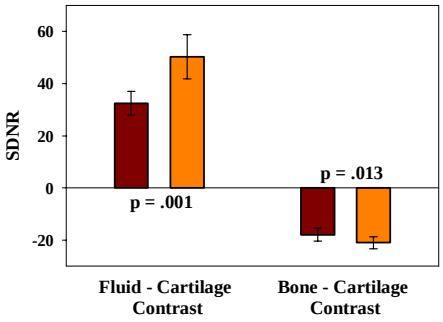

Figure 2: Comparison of signal difference to noise (SDNR) for SPIR (■) and DRIVE (■) techniques (Mean ± SEM). Statistically significant greater cartilage contrast is obtained with the DRIVE technique (fluid - cartilage p=.001, Bone - cartilage p=.013)

Discussion: The addition of the driven equilibrium pulse at the end of the TSE readout train enhances signal from tissues with long T2 such as synovial fluid. Compared to conventional fat suppressed PD-weighted TSE images; the driven equilibrium technique significantly increases the contrast of cartilage to fluid and adjacent bone marrow. These results at 3.0T agree well with prior studies on 3D gradient echo DEFT imaging of cartilage performed at 1.5T (2, 3). The improved contrast decreased inter-reader variability and increased reader confidence in diagnosis of cartilage injury.

References:

1. Potter HG, Linklater JM, Allen AA, Hannafin JA, Haas SB. J Bone Joint Surg Am 1998;80(9):1276-84.
2. Hargreaves BA, Gold GE, Lang PK, Conolly SM, Pauly JM, Bergman G, et al. Magn Reson Med 1999;42(4):695-703.
3. Hargreaves BA, Gold GE, Beaulieu CF, Vasanawala SS, Nishimura DG, Pauly JM. Magn Reson Med 2003;49(4):700-9.