3D-$T_{1\rho}$-weighted MRI of the Hip Joint at 3T

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Introduction

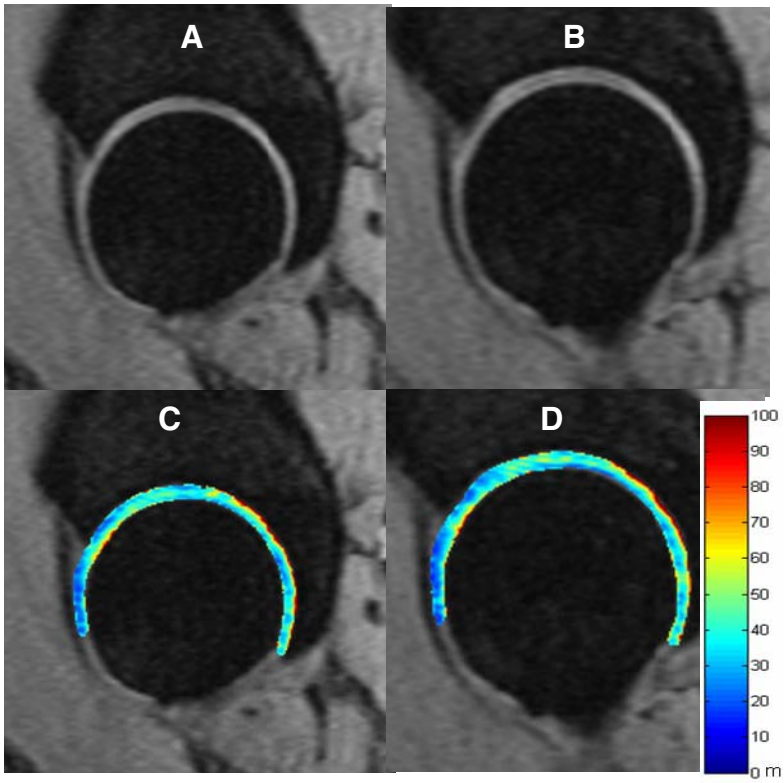
Osteoarthritis (OA) is the most common form of arthritis. Of the joints affected by OA, the hip is the second most commonly affected. Hip OA is not limited to the elderly and can be found in young adults, especially those with hip dysplasia or femoroacetabular impingement. Cartilage degeneration is considered to be the instigating event in the OA cascade. The earliest cartilage changes occur at the molecular level with loss of proteoglycans (PG), changes in collagen structure and water content. $T_{1\rho}$-weighted MRI has been shown to be sensitive to early biochemical changes in cartilage, especially PG content [1]. Moreover, it has been reported that $T_{1\rho}$ elevates in OA patients when compared to age matched healthy subjects [2, 3]. Noninvasive assessment of cartilage's earliest biochemical changes is desirable in order to prevent progression of the disease and would have potential clinical applications in the development of chondroprotective drugs. To our knowledge, no previous studies employing 3D- $T_{1\rho}$ relaxation mapping for the hip cartilage has been reported. The main purpose of this study is to demonstrate the feasibility of measuring the spatial variation of $T_{1\rho}$ (global and regional assessment) and establish the baseline values of healthy femoral and acetabular cartilages *in vivo* employing 3D -$T_{1\rho}$ mapping at 3T.

Methods

5 asymptomatic volunteers were imaged after Institutional Review Board (IRB) approval. The study group consists of 1 female and 4 male volunteers whose mean age was 29 years (between 22 and 36 years). All MRI experiments were performed on the right hip joint at 3.0T clinical MR scanner (Magnetom Trio scanner, Siemens Medical Solutions, Erlangen, Germany), using an 8-channel phased-array body coil. 3D-$T_{1\rho}$ -weighted images were acquired with a 3D GRE sequence with $T_{1\rho}$ magnetization preparation (TR/TE=175/3.2ms; flip angle, 25°; total number of sections, 16; section thickness, 3 mm; matrix size, 256x128, bandwidth 350 Hz/pixel, one signal acquired, FOV=20x20). The magnetization preparation is achieved by using a "self-compensating" spin-lock pulse-cluster which minimizes the effects of B_1 field inhomogeneities (Duration of each 90° pulse=200μs; the amplitude of the spin-lock pulse=250Hz). In order to construct $T_{1\rho}$ map, four 3D-$T_{1\rho}$ -weighted images were acquired with TSL values of 2, 10, 20, and 30 ms. The total acquisition time for entire 3D-$T_{1\rho}$ map was ~24 minutes (16 slices). Since Spin-lock imaging pulse sequences deposit considerable RF energy to the imaged body due to the long spin-lock RF pulse used for magnetization preparation, we used the results of SAR simulations performed by Collins *et al* to determine the sequence parameters that would ensure the satisfaction of SAR limits mandated by FDA. The femoral and acetabular cartilages were segmented manually at each slice of the 3D images. Since they are very thin structures, a single ROI in each slice including both cartilages was acquired. It was assumed that their T_1 at 3.0T was 1.24s, the same relaxation time of the patellar cartilage [4]. Additional regional analysis was performed by dividing the cartilages into anterior/posterior and lateral/medial regions.

Results & Discussion:

Representative sagittal 3D-$T_{1\rho}$ weighted images (A and B) of hip joint and the corresponding relaxation maps (C and D) are shown in Fig.1. The global average $T_{1\rho}$ value of the hip cartilages varied from 38.381 to 42.0049 ms. The average regional $T_{1\rho}$ values varied from 34.7239 to 39.4343 ms, and from 42.1434 to 45.0563 ms for anterior and posterior regions, respectively. The global average $T_{1\rho}$ values of the hip cartilages that we obtained were very similar to the previously reported values of the patellar cartilage, as expected. Therefore this technique shows promise for the assessment of early cartilage loss in the second most commonly effected joint.



Conclusion:

We demonstrated the feasibility of 3D $T_{1\rho}$ -weighted MRI of the hip joint at 3.0T clinical scanner, without exceeding the SAR limits. Using four 3D images with different $T_{1\rho}$ -weights by using different TSL's, we were able to acquire a 3D $T_{1\rho}$ map in ~24 min. Currently we are exploring the parallel imaging methods in order to reduce the acquisition times significantly. The establishment of such baseline values will be important to future studies where the potential of the 3D $T_{1\rho}$ –weighted MRI to diagnose and monitor early hip cartilage lesions will be accessed.

References:

1) Akella SVS *et al* Mag Reson Med 2001;26:419-423. 2) Regatte RR *et al*., Acad Radiol 2004;11:741-749.3) Li et al MRM 2005;54: 929-36. 4) Gold GE *et al*, AJR 2004;183:343–351.