

Feasibility of Magnetization Transfer Ratio of the Patellar Articular Cartilage at 3T

S. Nagata^{1,2}, D. W. Stanley³, S. L. Williams², M. M. Wood², J. P. Felmlee², H. Nishimura⁴, N. Hayabuchi¹, and K. K. Amrami²

¹Radiology, Kurume University Hospital, Kurume, Fukuoka, Japan, ²Radiology, Mayo Clinic, Rochester, MN, United States, ³GE healthcare, United States, ⁴Saiseikai Futsukaichi Hospital, Fukuoka, Japan

Introduction: Magnetic resonance imaging (MRI) has been established as the standard cartilage imaging modality, and techniques have been developed and optimized to visualize cartilage morphology and to analyze its biochemical composition [1]. Magnetization transfer ratio (MTR) is a biochemical analysis technique and several investigators have concluded the structure and concentration of the collagen matrix are the predominant determinants of the magnetization transfer process in articular cartilage with little or no contribution from proteoglycans [2, 3]. Chondromalacia is one of the most common causes of knee pain in adolescents and young adults, and patellar cartilage abnormalities are common in older adults. The primary abnormality in the cartilage is a decrease in sulfated mucopolysaccharides within the ground substance, which leads to an unstable collagen framework [4]. The aims of this study were to evaluate the feasibility of MTR with a 3T clinical MR imager, to measure MTR at different places of patellar cartilage, and to compare MTR with degree of chondromalacia in vivo.

Methods: Experiment- Nine young adults (5 men, 4 women; 21-35 years, mean 27.1) and ten mature adults (2 men, 8 women; 47-57 years, mean 51.6) were imaged on a 3.0-T GE Twin Speed MRI scanner, HDx 14.0 (General Electric Healthcare, Waukesha, WI, USA) using an 8-channel transmit/receive phased array knee coil (HD TR knee coil PA: General Electric Healthcare, In vivo Corporation, Gainesville, FL, USA). Fast spin-echo T2-weighted spin-echo with fat suppression (FS-FSET2) (Figs. 1A, 2A) and three-dimensional spoiled gradient-echo (3D-SPGR) with and without MT pulse were acquired. The scan parameters for the FS-FSET2 sequence were as follows: TR/TE 2675/50, 320 × 256 matrix, 16 cm FOV, section thickness of 4.0 mm, 2 average, receive bandwidth of ± 31.25 kHz, and 30 axial sections over the patella, scan time 2 minutes 42 seconds. Scan parameters for 3D-SPGR were as follows: TR/TE 35/14, a flip angle of 15°, 256 × 160 matrix, 16cm FOV, section thickness of 1.0 mm, 1 average, receive bandwidth of ± 31.25 kHz, fat suppression, and 72 axial sections over the patella, scan time 8 minutes 9 seconds. Magnitude of MT pulse was 1200 Hz frequency offset, flip angle 670, and duration of 9928 microsecond. 1st level SAR limitations were used.

Image Evaluation- 3D-SPGR images with and without MT pulse were transferred to a workstation (Advantage Windows 4.4, GEHC, Waukesha, WI) to calculate MTR map (Figs. 1B, 2B). The patellar cartilage was divided into three parts (medial facet, median ridge, and lateral facet). We totally evaluated MTR at 57 individual parts. Moreover, each part was separated into two zones (deep and superficial zone). Cartilage was graded with a modified Noyes scoring system [5]. We analyzed MTR about the followings. 1) Differentiation of MTR among three parts. 2) Differentiation of MTR between young adult and mature adult group at whole cartilage, lateral facet, median ridge, and medial facet. 3) Differentiation of MTR between deep and superficial zone. 4) Correlation of MTR with grade based on modified Noyes scoring system. The mean MTR obtained from at different part of patellar cartilage and from grade based on modified Noyes scoring system were compared by analysis of variance (ANOVA) with Scheffé post hoc analysis. The two-group comparisons were analyzed using a two-tailed unpaired *t* test. A value of *p* < 0.05 was considered significant.

Results: The MTR of average, lateral facet, median ridge, and medial facet were 0.54 ± 0.02 , 0.55 ± 0.02 , 0.54 ± 0.02 , and 0.55 ± 0.02 , respectively (not shown). There was no significant difference among them. The MTR of whole cartilage (*p* < 0.05), lateral facet (*p* < 0.01), median ridge (*p* < 0.01), and medial facet (*p* = 0.11) at young adult group were tended to higher than mature adult group (Fig. 3). In young adult group, the MTR of deep zone was significantly higher than that of superficial zone (*p* < 0.001). In mature adult group, although the MTR of deep zone was higher than that of superficial zone, there was no significant difference between them (*p* = 0.28) (Fig. 4). The MTR of grade 0 was the highest in all groups. The MTR of grade 0 was significantly higher than that of grade 2 (*p* < 0.01) and grade 3 (*p* < 0.05). The MTR of grade 1 was significantly higher than that of grade 2 (*p* < 0.05) and grade 3 (*p* < 0.05) (Fig. 5).

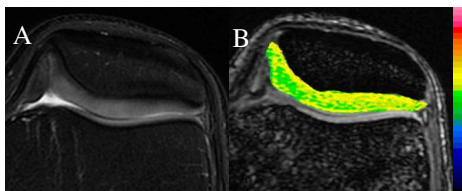


Figure 1. 35-year-old male

Patellar cartilage is considered grade 1 chondromalacia at three parts on FS-FSET2 (A). MTR map looks mainly two layers and MTR value of deep zone, which ranges from 0.58 to 0.59 is higher than that of superficial zone, which ranges from 0.48 to 0.56 (B).

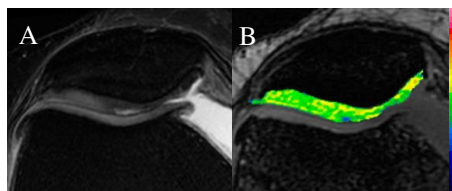


Figure 2. 50-year-old female

Lateral facet of patellar cartilage is considered grade 2, and median ridge and lateral facet are considered grade 3 chondromalacia on FS-FSET2 (A). MTR map looks homogenous and MTR value, which ranges from 0.50 to 0.54 is relatively low (B).

Conclusion: Calculating MTR of patellar cartilage is feasible on the 3T MR imager within clinical scan time. There was a relatively good correlation between MTR and grades of chondromalacia. MTR would be sensitive to alterations in collagen structure and could be used as an indicator of prediction of cartilage degeneration in vivo.

Reference

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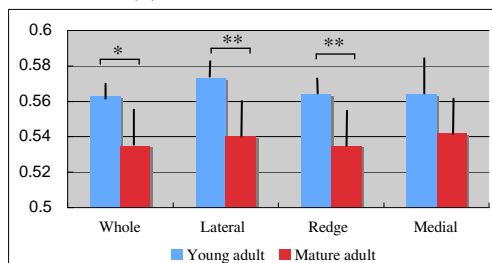


Figure 3

In young adult group, the MTR of whole cartilage, lateral facet, median ridge, and medial facet were 0.56 ± 0.01 , 0.57 ± 0.01 , 0.56 ± 0.01 , and 0.56 ± 0.02 , respectively. In mature adult group, the MTR of whole cartilage, lateral facet, median ridge, and medial facet were 0.53 ± 0.02 , 0.54 ± 0.02 , 0.53 ± 0.02 , and 0.54 ± 0.02 , respectively.

* *p* < 0.05, ** *p* < 0.01

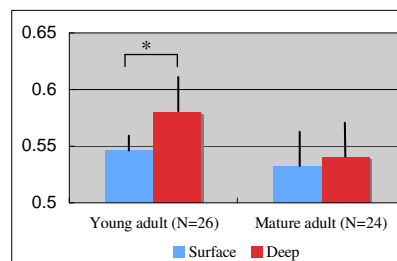


Figure 4

In young adult group, MTR of deep zone was 0.58 ± 0.02 and superficial zone was 0.54 ± 0.01 . In mature adult group, MTR of deep zone was 0.54 ± 0.02 and superficial zone was 0.53 ± 0.02 .

* *p* < 0.001

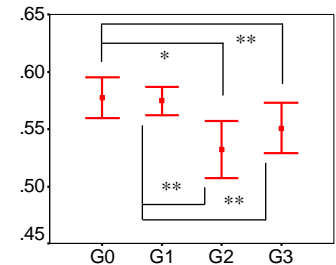


Figure 5

The MTR of grade 0, grade 1, grade 2, and grade 3 were 0.57 ± 0.01 , 0.53 ± 0.02 , 0.53 ± 0.02 , and 0.54 ± 0.02 , respectively.

* *p* < 0.01, ** *p* < 0.05