# T1RHO MAPPING OF THE ENTIRE FEMORAL CARTILAGE USING NOVEL DEPTH AND ANGLE DEPENDENT ANALYSIS

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## INTRODUCTION

T1rho-weighted MR imaging has recently been proposed as an attractive biomarker to existing conventional morphological MRI methods (1), and has been shown to be more sensitive to biochemical change in cartilage than T2 mapping. It enables us to detect early cartilage degeneration in early osteoarthritis (OA) patients before appearing morphological change (2). However for the methodology of segmentation, the number of slices measured is only one or several slices, not all slices from the knee in most of reports. There is also no previous publication about normal entire femoral T1rho map profiles for analyzing regional or cartilage layer variations. These unresolved problems and limitations make diagnosis of early OA with T1rho mapping difficult clinically. The objective of this study was to create normalized T1rho profiles of healthy entire femoral cartilage with 3 dimensional (3D) angular and depth dependent analysis, and evaluate their usefulness.

## MATERIALS AND METHODS

20 healthy volunteers (mean: 28.9 y.o., range: 19-38) were enrolled in this study. The study was approved by IRB, and written informed consent was obtained from each person. Sagittal T1rho images of each subject were acquired with spoiled gradient echo (SPGR) sequence. All MR studies were performed on a 3.0-T unit (Achieva, Philips Healthcare, Netherland) utilizing an 8-channel knee receive-only RF-coil. The acquisition parameters were as follows. SPGR: mode = 3D, fat-saturation method = PROSET, TR/TE = 6.4/3.4msec, Band width = 475Hz, ETL = 64, NEX = 1, FOV = 140*140mm, Slice thickness/gap = 3/0mm, Flip angle = 10 degree, Image-matrix = 512*512mm, number of slices = 31, Time of spin-lock (TSL) = 20/40/60/80msec, acquisition time = 4min09sec *4. Entire knee cartilage segmentation was performed by two raters independently slice by slice with Matlab. T1rho depth/angle-dependent profile was investigated by partitioning cartilage into two layers (deep; 51-100% and superficial; 0-50%) and angular segmentations in step of 4-degree over the length of segmented cartilage (the angle 0 defined along B0) (Fig.1). After manual segmentation, we normalized the entire femoral cartilage with 23 new slices of all subjects. We calculated the average T1rho values of every layer in representative angles of -54,-30, 0, +34, +54 degrees to evaluate angular dependent changes including magic angle effects. We also compare T1rho values between weight bearing and non-weight bearing portion. Finally we created 3D-graph by thin-plate spline method.

## RESULTS AND DISCUSSION

Table1 showed average T1rho values in representative angles. There was no influence of magic angle effect, although there was angular variation in each layer. Average T1rho values in the superficial layer were higher than in the deep layer over the entire knee, medial condyle, and lateral condyle with significant difference on SPGR ($p<0.05$) (Fig.2). T1rho values of the weight-bearing portion were lower than the non weight-bearing portion over the medial and lateral condyles in the deep layer with significant difference ($p<0.05$), while there was no significant difference in the superficial layer (Table2). The 3D-graph demonstrated cartilage T1rho values were not homogeneous over the entire knee (Fig.3).

## CONCLUSIONS

T1rho values of the femoral cartilage demonstrate regional and depth variations with no significant magic angle effect. We should know normal T1rho profiles from the entire knee cartilage to diagnose local or early T1rho abnormality and OA in clinical application.

## REFERENCES

(1)Wang L, et al. Eur J Radiol. 2012; 81(9):2329-36. (2) Choi JA, et al. Magn Reson Imaging Clin N Am. 2011; 19(2):249-82.

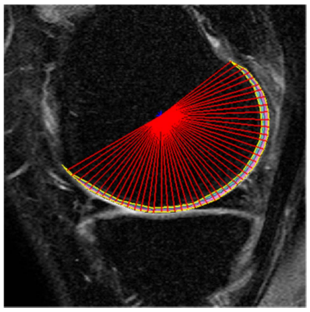

Fig.1 Sagittal SPGR images from T1rho sequence of knee MRI after manual segmentation with post-processing. Two observers segmented the entire femoral cartilage of the both images slice by slice independently. After manual segmentation, angular analysis in step of 4-degree and depth analysis with superficial and deep layers was performed automatically.

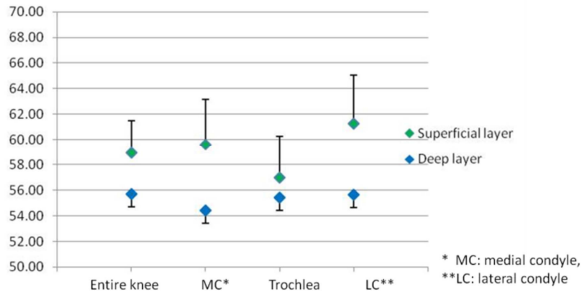


Fig.2 The difference of average T1rho values between the superficial and deep layers on each anatomical landmark. Average T1rho values in the superficial layer of the femoral articular cartilage were higher than in the deep layer over the entire knee, medial condyle, and lateral condyle with significant difference ($p<0.05$)

| | | Angle | | T1rho value |
|---|---|---|---|---|
| Entire knee | | (-180 ~ 180) | Whole | 56.97 ± 2.82 |
| | | | Superficial | 58.94 ± 2.56 |
| | | | Deep | 55.68 ± 3.55 |
| MC* | Non-weight bearing | (<-30, 30<) | Whole | 57.50 ± 4.06 |
| | | | Superficial | 59.51 ± 4.07 |
| | | | Deep | 55.67 ± 5.42 |
| | Weight-bearing | (-30 ~ 30 ) | Whole | 54.91 ± 1.33 |
| | | | Superficial | 59.81 ± 1.85 |
| | | | Deep | 51.13 ± 2.11 |
| LC** | Non-weight bearing | (<-30, 30<) | Whole | 58.64 ± 2.47 |
| | | | Superficial | 60.92 ± 2.95 |
| | | | Deep | 56.96 ± 3.56 |
| | Weight-bearing | (-30 ~ 30 ) | Whole | 55.51 ± 3.34 |
| | | | Superficial | 62.11 ± 5.35 |
| | | | Deep | 52.46 ± 4.36 |

* MC: medial condyle
**LC: lateral condyle

Table2 Average T1rho values of weight-bearing and non weight-bearing portion in entire femoral cartilage, medial femoral condyle, and lateral femoral condyle

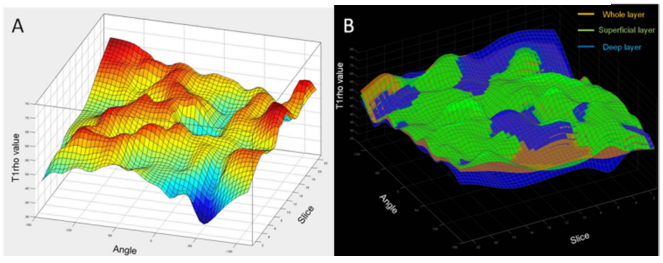


Fig.3 3D-graph of T1rho mapping of femoral cartilage based on thin-plate spline. (A) 3D-graph of one layer which was colored on the basis of the difference of T1rho values (B) 3D-graph applied a single color tone per layer with simultaneous expression with superficial, deep, and whole layers

| | Angle | | T1rho value |
|---|---|---|---|
| Entire knee | -54 | Whole | 54.58 ± 6.23 |
| | | Superficial | 55.02 ± 6.94 |
| | | Deep | 54.48 ± 5.37 |
| | -30 | Whole | 53.58 ± 2.84 |
| | | Superficial | 56.84 ± 4.22 |
| | | Deep | 50.79 ± 3.39 |
| | 0 | Whole | 55.92 ± 3.74 |
| | | Superficial | 61.01 ± 5.47 |
| | | Deep | 53.47 ± 4.65 |
| | 30 | Whole | 58.12 ± 3.13 |
| | | Superficial | 61.48 ± 3.98 |
| | | Deep | 55.56 ± 3.33 |
| | 54 | Whole | 59.24 ± 2.83 |
| | | Superficial | 60.81 ± 3.70 |
| | | Deep | 58.37 ± 2.69 |

Table1 Average T1rho values in representative angles