Can T2 predict who will develop ROA?: Data from the OAI

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INTRODUCTION: Knee OA has a substantive impact on quality of life and its early detection is essential for development of efficient interventions. Radiological MRI scores of cartilage damage have shown some predictive power in detecting which subjects may develop radiological OA as defined by KL scores. Further, T2 weighted imaging has been routinely used to detect cartilage lesions

OBJECTIVE: The purpose of this study was to 1) evaluate whether the cartilage T2-relaxation-parameters are different at the time of detection of radiological OA (ROA) in the incidence group compared to those in a control group for radiological OA (ROA) incidence; and 2) to determine if cartilage T2-relaxation-parameters can predict which subjects will develop ROA.

METHODS: In the Osteoarthritis Initiative (OAI), only right knees were imaged with T2. Cases included knees with baseline X-ray KL scores of 0 or 1 and which developed incident ROA (KL>=2) at the 12 through 48 month visits. Control knees were KL = 0 or 1 at baseline that did not develop ROA by the 48 month visit. Controls contained about 50% gender-age-KL exact matches to cases supplemented with roughly similar non-matches to the remaining cases. The MESE T2 series at the time of incidence of ROA (P0), the 1 year prior to incidence (P-1) and the BL images were segmented and T2 maps were computed at the femur, tibia, cMF, cLF, MT, LT, medial trochlea and lateral trochlea using atlas-based segmentation software (Figure 1) (Qmetrics, Rochester, NY). Descriptive T2 parameters (mean, variance, skewness, top 5% value) and Gray-Level Co-Occurrence Matrix (GLCM) texture parameters (entropy, mutual information, ASM, and contrast) were extracted for each cartilage region at three cartilage layers: superficial, medial and deep. All T2 features were adjusted by gender, BMI and age, and then standardized using a rank-inverse-normal procedure. Finally, each parameter was categorized as being low (<10%), high (>90%) or mid-range (10% to 90%) based on the control group values. A forward parameter selection algorithm based on Integrated Discriminant Improvement (IDI) on logistic regression models was used to select internally cross-validated multivariable models that characterized the differences between cases and controls at BL, P-1 and P0. All logistic models included height and baseline KL status as covariates.

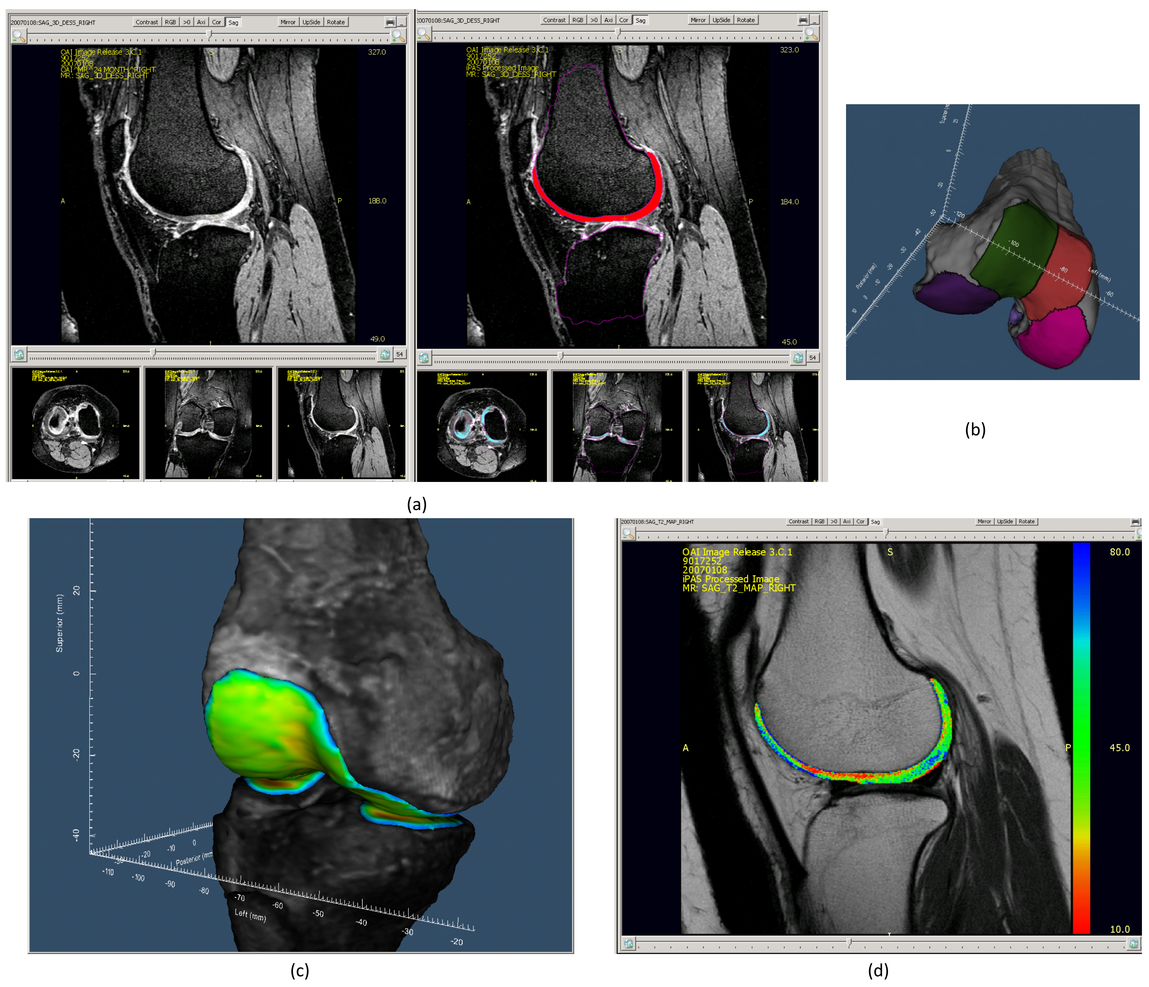

Figure 1: (a) DESS images were automatically segmented to extract the cartilage tissue. (b) Regions of interest of the MRI analysis. (c) 3D visualization of the segmented cartilage tissue. (d) The DESS segmentation was co-registered to the 2D MESE OAI T2 series where colors show the T2 Values of femur cartilage.

RESULTS: 179 incident ROA right knees with T2 Map series developed ROA, and 175 control subjects did not. Cases and controls had similar age and gender (60.7±8.7 and 60.0±8.7, respectively, and 62% and 64% females, respectively.) At baseline, there were 139 that were KL zero and 215 knees that were KL one. Table 1 shows the T2 parameters that discriminate between cases and controls at BL, P-1 and P0. At baseline, abnormal T2 texture parameters at tibia and trochlea separated cases and controls with odd ratios ranging from 1.73 to 2.47. At P-1 adjusted odds ratios (aORs) ranged from 1.74 to 2.44, and were from the lateral femur, lateral trochlea and the entire femur. At P0 the heterogeneity of T2 values at medial trochlea, lateral tibia, and entire tibia separated cases and controls (aOR 2.37, 2.44, 2.04, respectively). Detailed analysis of the predictive power of the P1 model indicated that T2 parameters can only be used to identify 22% of the subjects that will develop ROA with a 95% specificity. At P0, 34%, of the case subjects have a different T2 behavior than controls.

Table 1: qMRI T2 Features that are concordant with the development of ROA (P0), that predict ROA one year before (P-1) and features that predict the development of ROA at the baseline observation (BL)

Time Point	Description	Control Mean(std)	Case Mean(std)	Odds Ratio
BL:	Lateral Tibia Texture ASM	0.004(0.002)	0.004(0.002)	2.47(1.25-3.57)(-)
	Lateral Trochlea Texture Correlation	0.58(0.029)	0.58(0.04)	2.50(1.59-4.00)(-)
	Medial Trochlea Texture Entropy	9.73(0.31)	9.81(0.37)	1.73(1.14-2.62)(+)
	Texture Contrast at Tibia	389.52(118.94)	404.13(152.23)	0.53(0.35-0.79)
P-1:	High Signal Value at cLF	116.81(27.63)	109.00(23.44)	2.44(1.59-3.70)(-)
	Texture MI at Lateral Trochlea	0.21(0.06)	0.20(0.05)	2.13(1.37-2.33)(-)
	Texture Energy at cLF	0.014(0.001)	0.014(0.001)	1.89(1.25-2.86)
	T2 Mean of the Femur Superficial Layer	54.38(4.41)	55.17(5.05)	1.74(1.17-2.60)(+)
P0:	Medial Trochlea MI	0.61(0.11)	0.65(0.14)	2.37(1.56-3.58)(+)
	Medial Trochlea Skewness	1.46(1.13)	1.17(0.99)	0.49(0.31-0.79)
	Superficial Layer T2 STD value at cMF	19.44(3.57)	20.53(4.01)	2.08(1.36-3.17)
	Texture ASM at LT	0.009(0.066)	0.004(0.001)	2.44(1.54-3.85)(-)
	Entire Tibia MI	0.22(0.06)	0.23(0.07)	2.04(1.29-3.23)
	Superficial Layer T2 Mean value at cLF	54.78(5.93)	53.33(6.22)	0.53(0.35-0.81)

CONCLUSIONS: A combination of various T2 map parameters from different parts of the TF cartilage was able to distinguish between those that developed incident ROA at time of incident ROA and the year prior to developing incident ROA.

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