Age Related Changes in T1ρ and T2 relaxation Times of Knee Cartilage

[1]Wu, S; [1]Kumar, D; [1]Karupppasamy, S; [1]Jungmann, P; [1]Nardo, L; [1]Luke, A; [1]Link, TM; [1]Majumdar, S; [1]X, Li; [+1]Souza, RB
[1]University of California San Francisco, San Francisco, CA
Richard.Souza@ucsf.edu

INTRODUCTION:

Knee osteoarthritis (OA) is a degenerative disease affecting the articular cartilage. Early disease is characterized by loss of proteoglycan and disruption of the collagen network. Advances in quantitative Magnetic Resonance Imaging (MRI), $T_{1\rho}$ and T_2 relaxation time mapping, allow for the detection of proteoglycan and collagen compositions, respectively, where increases in these values are correlated with increased cartilage degeneration. While these previous studies provide insight on cartilage composition at various stages of life as well as changes through the progression of OA, there remains a lack of understanding on how cartilage develops from adolescence into young adulthood. The purpose of this study is to observe how articular cartilage composition changes from puberty through adulthood. We hypothesize that a decrease in $T_{1\rho}$ and T_2 of the articular cartilage will be observed accompanying the closure of the growth plates due to ossification of the cartilage after puberty and a subsequent increase in $T_{1\rho}$ and T_2 times related to normal aging on the cartilage.

METHODS:

A total of 96 healthy subjects (51 female, age = 35.8±12.9 years, range = 13-64 years) with no diagnosed presence of OA were included in this study. Inclusion criteria for subjects were no self-reported symptoms of knee pain, osteoarthritis or history of traumatic knee injury. Subjects were recruited from the clinics at the Orthopaedic Institute, and the greater UCSF Mission Bay campus. Informed consent, approved by the institutional review board at UCSF, was obtained from all subjects prior to participation. Unilateral images were acquired using a 3T GE Signa MRI scanner and an 8-channel phased-array knee coil. The following sequences were obtained: high-resolution fat-saturated SPGR, and $T_{1\rho}$ and T_2 relaxation time sequences. Relaxation time maps were created using established fitting routines (Figure 1). [1] Cartilage segmentation was performed on registered SPGR images and overlaid on relaxation time maps for quantification. $T_{1\rho}$ and T_2 were quantified for lateral and medial aspects of the femoral condyles (LFC, MFC) and tibial plateau (LT, MT). Subjects were first stratified into groups based on decade of life and images were graded for growth plate closure by a single radiologist (PJ). A single factor analysis of variance (ANOVA) and post-hoc t-tests were used for statistical analysis to determine differences.

RESULTS:

Subjects were grouped into 5 age ranges: 10-20, 20-30, 30-40, 40-50 and 50-60 years. All subjects in the 10-20 age range were found to have open growth plates in the femur, tibia or both. ANOVA revealed statistical differences ($p<.05$) between age groups in T_2 for all segmented compartments and in the MFC for $T_{1\rho}$. Post-hoc t-tests revealed statistical difference ($p<.05$) between the adolescents and young adults between 20-30 years in T_2 for all compartments except MFC. From the open growth plate cohort to the young adults, the lateral compartments were observed to have larger decreases in $T_{1\rho}$ (LFC: -4.1ms, MFC: -.5ms, LT: -2.7ms, MT: -1.0ms). Additionally, knee cartilage compartments were observed to decrease from the second decade of life to the third, but increase in subsequent decades of life.
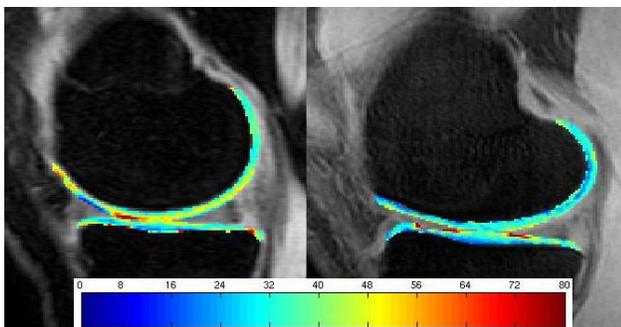

Figure 1 $T_{1\rho}$ color map of females, 14 years old (left) and 23 years old (right).

DISCUSSION:

These data suggest that there is a compositional change in the articular cartilage of the knee during puberty that is different from the changes after skeletal maturation. Decrease in quantitative MRI variables may be related to a strengthening of the articular cartilage while increases in qMRI variables after the third decade of life suggest gradual cartilage degradation as part of the normal aging process. The differences in T_2 but not $T_{1\rho}$ times between pre and post pubertal images suggest that these changes are more related to improved collagen composition than proteoglycan composition. Additional laminar analysis is necessary to determine whether the changes are driven by changes in specific layers of cartilage. A current limitation of the study is the relatively small sample size for pre-pubertal subjects. Additional effort is necessary to clarify these relationships with larger sample sizes in the adolescent population.
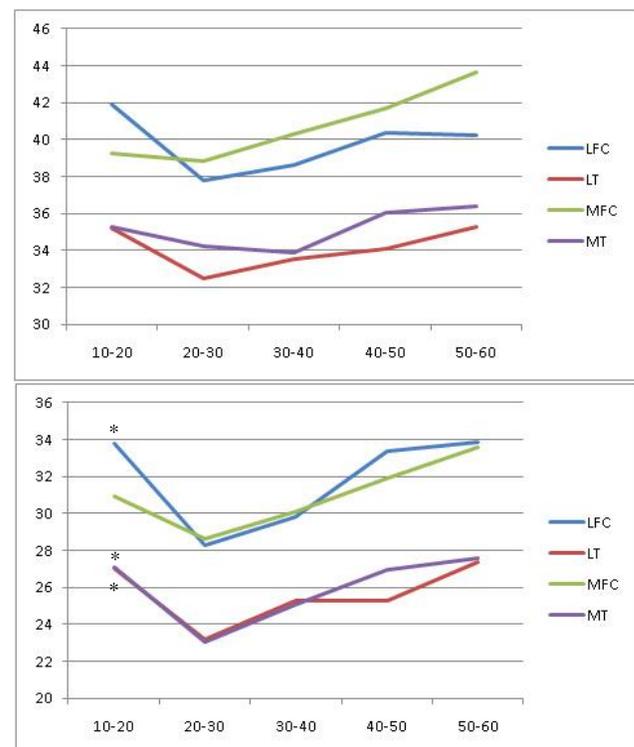

Figure 2 (Top) $T_{1\rho}$ compartment changes. (Bottom) T_2 compartment changes

SIGNIFICANCE:

Understanding the development of cartilage in healthy knees from adolescence and throughout adulthood enables us to better identify how cartilage responds over its lifetime. The results of this study will help to elucidate the compositional changes of the cartilage in healthy knees and can be used to better differentiate normal cartilage development from pathological OA conditions.

REFERENCES:
[1] Li et al, *Osteoarthritis and Cartilage*. 2007, 7:789-797

ACKNOWLEDGEMENTS: