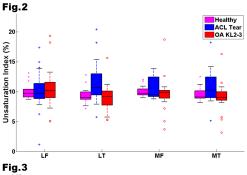# Evaluation of Subchondral Bone Marrow Lipids of Acute Anterior Cruciate Ligament (ACL) Injured Patients at 3T
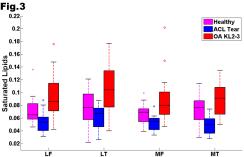
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**Introduction** Proton MR spectroscopic imaging (^{1}H MRSI) enables the examination of the spatial distribution of metabolites (1). MRS measurement offers a non-invasive method to quantify biochemical or metabolic variations in various diseases. Although prior studies have used the MRSI method to measure the major components of bone marrow signals including water and lipids (1, 2), there have been no quantitative assessments of bone marrow lipids alone in different femoral-tibial bone compartments in acute anterior cruciate ligament (ACL)-injured patients at 3T (3). Therefore, the aim of this work was to quantify the compartment-specific lipids changes in femoral-tibial bone of acute ACL injury patients compared to healthy controls and OA patients at 3T.

**Methods** Fifty-five subjects (17 healthy controls, 17 acute ACL injured patients, and 21 OA patients (KL2-3) [4]; 19 females, 36 males, mean age $47\pm20$ years, age range = 18-89 years) were scanned at 3T clinical MR scanner (MAGNETOM Trio, Siemens Medical Solutions, Erlangen, Germany), and an 18-cm diameter, transmit-receive quadrature knee coil was employed for all spectroscopy measurements of subchondral bone marrow lipids in four different compartments of femoral-tibial bone (LF, LT, MF, MT). Representative single voxel locations are show in Fig. 1(a) (lateral femoral bone), Fig. 1 (b) (lateral tibial bone), Fig. 1(c) (medial femoral bone), Fig. 1 (d) (medial tibial bone). All MRS data were obtained using the single-voxel stimulated echo acquisition mode (STEAM) pulse sequence (TE=20 ms, TR=2000 ms, bandwidth=2000 Hz) (3). The MRS data were processed with the Java-based Magnetic Resonance User Interface (JMRUI) (5) software using AMARES (Advanced Method for Accurate, Robust and Efficient Spectral) (6) time domain fitting procedure. The olefinic peak at 5.35 ppm, the methylene peaks at 1.3 ppm and 2.07 ppm and the methyl peak at 0.9ppm were fitted with lorentzian line shapes and unconstrained parameters.


Fig.1


Fig.2


Fig.3

**Results and Discussion** Representative lipids peaks obtained from an acute ACL injured patient are shown in Fig. 1 with Fig. 1(a) (lateral femoral bone), Fig. 1(b) (lateral tibial bone), Fig. 1(c) (medial femoral bone), and Fig. 1(d) (medial tibial bone), respectively. The boxplot for unsaturated index (%) of lipid in different compartments using the same calculation method as in (3) among healthy controls, acute ACL-injured, and KL2-3 OA patients is shown in Fig. 2. The unsaturated indices (median$\pm$interquartile range) were $9.7\pm1.3$, $9.0\pm1.2$, $9.7\pm1.0$, and $9.1\pm1.2$ in LF, LT, MF, and MT compartment of femoral-tibial bone marrow, respectively for healthy controls; $9.7\pm2.5$, $10.7\pm3.6$, $9.5\pm3.3$, and $10.3\pm3.5$, respectively for acute ACL injured patients; $10.1\pm2.6$, $9.1\pm2.4$, $9.9\pm1.3$, and $9.0\pm1.4$, respectively for KL2-3 OA patients. Saturated lipid signals at 2.03ppm in different compartments of femoral-tibial bone marrow among healthy controls, acute ACL injured patients, and KL2-3 OA patients are shown in Fig. 3 with the peak of external reference water phantom used for normalization (3). The normalized saturated lipid signals (median$\pm$interquartile range) at 2.03ppm in LF, LT, MF, MT were $0.065\pm0.024$, $0.077\pm0.04$, $0.069\pm0.02$, and $0.077\pm0.03$, respectively for healthy controls; $0.054\pm0.021$, $0.067\pm0.03$, $0.055\pm0.018$, and $0.049\pm0.023$, respectively for acute ACL injured patients, and $0.086\pm0.043$, $0.104\pm0.057$, $0.08\pm0.035$, and $0.091\pm0.042$, respectively for KL2-3 OA patients. There were statistically significant differences ($P<0.05$) of unsaturation index between LT except LF in KL2-3 OA patients and LT, MF, MT in acute ACL injured patients; statistically significant differences were also identified among different compartments of femoral-tibial bone marrow at 2.03ppm for saturated lipids ($P < 0.02$) between these two groups.

**Conclusion** In this study, we quantified compartment-specific lipid changes in femoral-tibial subchondral bone in acute ACL-injured patients compared to healthy controls and OA patients at 3T. KL2-3 OA patients have the highest saturated lipids at 2.03ppm compared to healthy controls and ACL injured patients. This technique may be useful in future studies to characterize bone marrow lesions among healthy controls, acute ACL-injured patients, and OA patients.

**References** 1) Li X et al, J Magn Reson Imaging 2008; 28: 453-461. 2) Yeung D et al, J Magn Reson Imaging 2005; 22: 279-285. 3) Wang L et al, NMR Biomed 2011; doi: 10.1002/nbm.1770. 4) Kellgren J et al, Ann Rheum Dis 1957; 16: 494-501. 5) http://www.mrui.uab.es/mrui/mrui_homePage.shtml. 6) Vanhamme L et al, J Magn Reson 1997; 129:35–43.