Evaluation of college level athletes articular cartilage using delayed gadolinium-enhanced MRI

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INTRODUCTION:

The prevalence of cartilage lesions is much higher in athletes like football players than the general population [1]. It has been reported that cartilage defects may result in increased cartilage breakdown and development of early knee osteoarthritis (OA). Magnetic resonance (MR) imaging has been developed to go beyond the macro architecture of a cartilage disease visualized on morphological images [2]. Delayed gadolinium-enhanced MRI of cartilage (dGEMRIC) has been shown to quantify regional variations of glycosaminoglycan (GAG) concentrations within the cartilage which is an indicator of early cartilage degeneration [3]. This technique utilizes an injection of the contrast agent $Gd(DTPA)^{2-}$ and its inverse distribution to the concentration of GAGs in cartilage. The goal of this pilot study is to determine whether dGEMRIC can be used to assess potential differences in cartilage GAG concentration due to the cumulative effects of playing college level football.

MATERIALS AND METHODS:

Image Acquisition Twelve college football athletes with no previous knee injuries or surgeries volunteered for this prospective study. The number of years of football played at the college level ranged from one to four. Data was acquired on a 3T MRI system (Achieva, Philips) using an 8-channel knee coil. The dGEMRIC acquisition included a set of five 3D fast field echo sequences with multiple flips angles (4, 8, 12, 16 20 degrees) at pre- and post-contrast periods. 24~30 sagittal slices were acquired covering the whole cartilage region. Other sequence parameters were: TR/TE=6/3ms, resolution $=0.5\times0.5\times4mm^3$, NSA=4. Each athlete was injected intravenously using a standard dose (0.2mmol per kilogram) of the contrast agent $Gd\text{-}DTPA^{2-}$. Prior to the post injection imaging, subjects were instructed to walk stairs for 10 minutes as exercise and to be seated for 90 minutes to help the contrast agent diffuse into the cartilage.

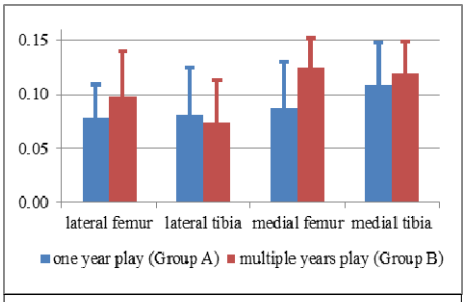

Fig. 1. Contrast concentration in different compartments in the two groups.

Data Analysis All the subjects were divided into two groups: one group with athletes having one year of college level football play (n=6, group A) and the other group having two or more years of play (n=6, group B). Using an in-house developed tool (IDL, Exelis Visual Information Solutions, Boulder, CO), pre- and post-contrast T1 values were calculated in regions of interest (ROI) and pixel by pixel analysis was also performed. ROIs from the lateral and medial femoral, lateral and medial tibial cartilage regions were manually segmented. Contrast agent concentration within cartilage was calculated based on the T1 values using $[contrast]=1/R(1/T_{1Gd}-1/T_1)$ (R is the contrast relaxivity, T_{1Gd} and T_1 are the pre- and post-contrast T1 values) [4].

RESULTS AND DISCUSSION:

Fig. 1 shows the contrast concentration from the two groups in the four different cartilage regions. For the longer playing group, higher contrast concentration was observed in the lateral femoral region (0.10±0.04mM in group B, 0.08±0.03mM in the group A) and the medial femoral region (0.12±0.03mM and 0.09±0.04mM), while slight differences were seen in the medial tibial region (0.11±0.04mM and 0.12±0.03mM) and the lateral tibial region (0.08±0.04mM and 0.08±0.04mM). This may indicate a loss of GAG concentration in the femoral cartilage of players who have more years of play, which is due to their heavy use of the knees during their athletic career. An example of post-contrast T_1 maps for the two groups (A, left; B, right) is shown in Fig. 2. T_1 value decreases ~100ms more in the subject of group B after the contrast injection. Fig. 3 displays the contrast distribution difference between lateral and medial femur and between lateral and medial tibia for the two groups. Relative higher contrast concentrations were found in the medial femoral and tibial regions compared to the regions on the lateral side. The data in the group B show larger difference (0.01mM between lateral and medial femur, 0.03mM between lateral and medial tibia for the group A; 0.02mM and 0.05mM for the group B).

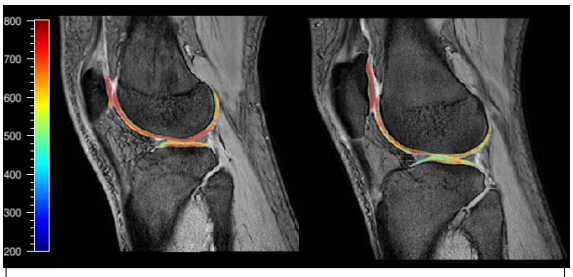

Fig. 2. An example of post-contrast T1 maps at the lateral cartilage of the group A (left) and B (right) was shown.

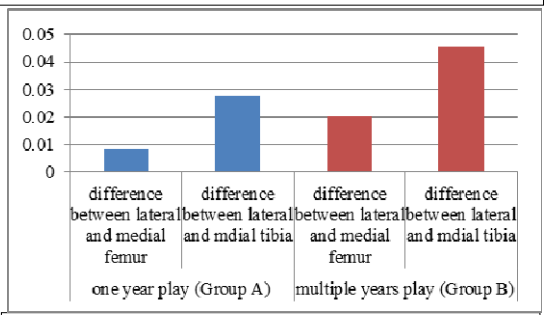

Fig. 3. Contrast concentration difference comparing lateral and medial sides in the two groups.

CONCLUSION:

This trial demonstrates that dGEMRIC is capable of evaluating GAG content in different regions as well as the apparent differences related to cumulative years of playing football. The decreased GAG concentration may be indicative of a higher risk for articular cartilage degradation and potentially OA.

REFERENCES:[1] Curl WW et al. Arthroscopy. 1997;13:456-460; [2] von Engelhardt LV et al. Arthroscopy. 2007;23:496-502; [3] Burstein D et al. MRM 2001;45:36-41; [4] Bashir A et al. MRM 1996;665-673.

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