Quantitative MRI of articular cartilage of the knee: correlation with severity of medial OA and self-assessment

INTRODUCTION:
The most commonly used radiographical grading method is the Kellgren Lawrence (KL) classification (Schiphof et al. Ann Rheum Dis 2008). This method defines severity of osteoarthritis (OA) primarily by the amount of joint space narrowing, the presence of osteophytes and the condition of the underlying bone. While KL grade assesses the condition of the joint, self-assessment questionnaires, such as WOMAC and SF-36, are often used to determine a patient’s level of discomfort. There is currently little research which compares the condition of the cartilage itself to the KL grade and WOMAC scores. Therefore, in this study we used magnetic resonance imaging of patients with various stages of osteoarthritis to determine if thickness and volume mapping of the cartilage would correlate with KL grade and WOMAC scores.

METHODS:
This retrospective study included 50 cases with primary medial OA randomly selected from the R01 NIH study AR052873. As part of enrollment in this study, patients had undergone T1 weighted fat suppressed 3D gradient echo 7T MRI scans (Siemens, Malvern, PA). There were 18 males and 32 females, with a mean age of 60.8 ± 10.6 and mean body mass index (BMI) of 26.8 ± 3.6. The study also included 12 normal cases selected from a department funded study at our centre. As part of that study volunteers had undergone T1 weighted fat suppressed 3D gradient echo 7T MRI scans (Siemens, Malvern, PA). All normal cases were male with a mean age of 29.1 ± 3.2 and a mean BMI of 24.9 ± 2.9. All MRI scans were reviewed by an experienced musculoskeletal radiologist and classified using the Kellgren-Lawrence (KL) scale.

In order to create the thickness maps, 3D models of the cartilage were first constructed from the MRI scans. The femoral and tibial cartilage was manually outlined on each slice in the sagittal plane of the scans using 3D-Doctor (Able Software Corp., Lexington, MA). Surface rendering was then used to create polygon-based 3D surface models from the defined contours. The models were then imported into Rapidform (INUS Technology, Inc., Seoul, Korea), and quantitative data from the defined contours. The models were then segmented into sub-regions (Figure 1) and finding the volume for the individual compartments. The femoral cartilage was divided into medial (MF) and lateral (LF) compartments by a plane through the Whiteside’s line and further the anterior (AMF, ALF), distal (DMF, DLF) and posterior (PMF, PLF) volumes. The distal region is the tibiofemoral cartilage contact area during the stance phase of gait, and is defined from a distance 5 mm anterior to the intercondylar fossa and 10 mm posterior to the respective, medial or lateral, end point of the circular axis. DMF was further segmented into inner (iDMF), central (cDMF), and outer (oDMF) bands. The tibial cartilage was segmented into lateral (LT) and medial compartments (MT), and the medial compartment was further segmented to the region uncovered (Unc.) and covered (Cov.) by the medial meniscus using the measurements shown in Figure 1. All volumes were normalized as follows: iDMF/DMF, cDMF/DMF, oDMF/DMF, Unc/MT, Cov/MT, MT/LT, Unc/Cov, DMF/PLF, PMF/PLF, DLF/PLF, DMF/DLF.

PMF/DLF, DMF/ALF, PMF/ALF, and DLF/ALF. These ratios represent the relative wear of the cartilage models. A repeated measures ANOVA test was then performed comparing the aforementioned volume ratios to KL grades. Statistical significance was determined for a probability value < 0.05. Pearson’s Correlation was also used to compare the volume ratios to the WOMAC and SF-36 scores.

RESULTS:
The 12 normal cases were classified as having a KL grade of 0. Symptomatic cases were classified as follows: 7 cases were a KL grade of 1, 9 cases were a KL grade of 2, 19 cases were a KL grade of 3, and 6 cases were a KL grade of 4.

Comparing the volume ratios obtained from the models to the KL grades the following ratios were found to be statistically significant: DMF/DLF, PMF/DLF, PMF/PLF, iDMF/DMF, cDMF/DMF, and MT/LT (Table 1). According to Table 2, there was no statistical correlation between pain or physical function when compared to the volume ratios as well as KL grade. The only positive correlation found was for KL grade and stiffness.

**DISCUSSION:**
The results above confirm that KL grade is a valid metric for describing the state of cartilage especially for the volumes of the medial distal femur, medial posterior femur and medial tibia when compared to their lateral counterparts. However, comparing the volume ratios to the WOMAC scores indicated that self-assessment may not indicate the status of the cartilage and extent of osteoarthritis. Therefore, although they are important to learn more about the patients perception of pain, etc., self-assessment should continue to be considered secondary to KL grade when determining the extent of a patient’s osteoarthritis.