Effect of Knee Alignment on T2 Relaxation Time of Articular Cartilage

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INTRODUCTION

Varus and valgus malalignment of the knee increases the risk of medial and lateral osteoarthritis (OA) progression, respectively [1]. T2 relaxation time correlates with collagen content [2] and water content [3] of cartilage, as well as with the integrity [4] and arrangement [5, 6] of the collagen network. It may provide a sensitive tool to detect early degenerative changes in articular cartilage before they are seen on clinical MRI. In the present study, we aimed to assess the influence of knee alignment on T2 relaxation time of femoral and tibial cartilage, and whether cartilage T2 would increase in the medial compartment in varus alignment and in the lateral compartment in valgus alignment, respectively.

MATERIALS AND METHODS

Thirty patients (17 male, 13 female; mean age 49.9 yrs) with knee symptoms and 20 young asymptomatic volunteers (10 male, 10 female; mean age 22.5yrs) were enrolled in the study. For patients, alignment of the knee was measured from standing extended view digital radiographs using a radiological workstation. The anatomical axis was defined from the middle of the shaft of bone, 10 cm from the knee joint to the center of the tibial spines [7]. The angle was used to divide the patients into varus (angle <2.2°) and valgus (angle ≥2.2°) groups.

MRI was conducted using two GE Signa 1.5T scanners (GE Healthcare, Milwaukee, WI) equipped with a transmit/receive knee coil. T2 relaxation time was determined using a sagittal multi-slice multi-echo spin echo sequence (TR/TE=1000/10-80ms, ETL= 8, FOV=140mm, 256×256 matrix, 0.55-mm in-plane resolution, 3-mm slice thickness) with an improved slice profile. T2 relaxation times were determined from the weight-bearing femoral and tibial cartilage at the center of the condyles (Fig. 1). Tibial cartilage was further divided into anterior, central and posterior regions of interest (ROIs). Superficial and deep parts of the cartilage were separately analyzed. The non-parametric Mann-Whitney -test was used to compare the T2 values of the varus and valgus groups with those of asymptomatic volunteers.

RESULTS

19 patients had varus and 11 patients had valgus alignment. Varus alignment resulted in significantly longer T2 values in the deep part of medial femoral condyle when comparing to the control group (Table 1). Varus alignment also contributed to higher T2 values in all ROIs of the medial tibial cartilage. Additionally, the varus group had longer T2 values at all deep ROIs of the lateral compartment and anterior superficial ROI of the tibia as compared to controls.

Valgus alignment showed a longer T2 laterally in deep part of the central tibial cartilage, but no changes were seen in femoral cartilage. Longer T2 values were also observed medially in all ROIs of the tibial cartilage.

DISCUSSION

OA of the knee is a major cause of chronic disability. MRI provides an accurate assessment of lesions of the articular cartilage [8]. However, its sensitivity to detect early cartilage degeneration occurring prior to morphological changes is not fully understood. Eckstein *et al.* [9] have shown in a one year follow-up study that in symptomatic OA the mean cartilage loss was greater in the medial than in the lateral compartment. In the medial compartment of the knee, cartilage loss was greater in femur than in tibia, and in the lateral compartment greater in tibia than in femur. Biochemical MRI techniques, such as T2, can provide information on cartilage macromolecules prior to gross pathological changes.

It is known that alignment of the knee affects the loss of cartilage in OA. In a two-year follow up study, varus alignment caused both femoral and tibial cartilage loss in medial compartment, while valgus alignment caused only tibial cartilage loss [1]. The present study suggests that alignment also affects the internal structure of cartilage. Cartilage changes in our study tended to occur both in femoral and tibial cartilage of the medial compartment in varus alignment, while valgus alignment caused only tibial changes.

OA of the medial compartment is the most common form of knee OA. In the present study the weight-bearing medial compartment was affected both on femoral and tibial side in varus alignment. In valgus alignment there were also changes in medial tibial compartment. In tibia, prolonged T2 values were observed in the same areas (whole medial and deep central parts) both in varus and valgus alignment.

In a study with histological correlation, T2 relaxation time increased with the severity of OA [10]. Previously, Dunn *et al.* [11] showed significantly longer T2 values in femoral and medial tibial cartilage in subjects with OA as compared to group without radiological signs of OA. No differences were noticed in the lateral tibia. In the present study, significantly longer T2 values were observed in the same regions and, additionally, one ROI of the lateral tibia (deep part of central cartilage, cLT_d, Fig.1) was affected, regardless of the alignment.

With T2 relaxation time mapping it is possible to measure intra-cartilaginous structures non-invasively. It may provide a sensitive tool to detect early degenerative changes in OA even before they are seen in MRI.

Table 1: Mean T2 values in each ROI of the weight-bearing cartilages for asymptomatic young volunteers (controls) and varus and valgus groups. For nomenclature of sites see Fig 1.

	Controls	Varus (<2.2°)		Valgus (≥2.2°)	
Site	Mean±SD	Mean±SD	P-value	Mean±SD	P-value
aLT_s	43.8±3.3	49.0±7.8	0.020	44.7±6.9	0.951
aLT_d	41.5±3.0	49.3±9.0	<0.001	46.9±7.4	0.076
cLT_s	44.4±2.7	45.0±7.0	0.613	48.1±6.2	0.069
cLT_d	38.5±3.3	43.9±7.2	0.002	46.9±6.8	0.001
pLT_s	45.7±4.6	47.4±6.6	0.384	45.6±7.5	1.000
pLT_d	41.1±4.5	46.6±6.7	0.004	45.9±8.2	0.127
aMT_s	44.9±4.0	53.2±5.9	<0.001	50.5±8.2	0.026
aMT_d	43.1±2.7	55.2±7.3	<0.001	55.4±8.2	<0.001
cMT_s	46.1±3.8	52.4±5.1	<0.001	50.0±4.3	0.019
cMT_d	41.8±3.0	49.1±5.7	<0.001	47.5±7.8	0.035
pMT_s	45.8±3.0	50.2±4.5	0.001	48.6±3.8	0.039
pMT_d	42.9±3.4	52.8±4.4	<0.001	56.0±5.9	<0.001
$pcLF_s$	53.8±3.9	53.5±5.3	0.844	51.3±2.8	0.063
$pcLF_d$	45.9±2.9	47.3±5.0	0.196	46.2±4.0	0.901
$pcMF_s$	48.4±4.4	52.0±5.5	0.053	49.5±4.4	0.591
$pcMF_d$	41.6±3.1	50.0±4.9	<0.001	44.7±4.7	0.137

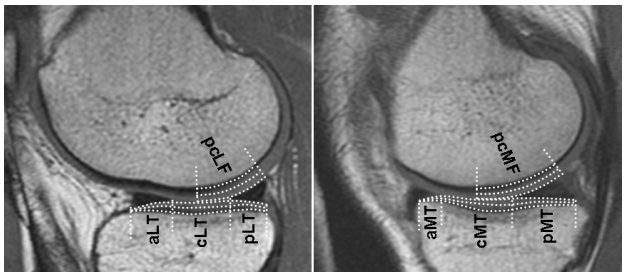

Fig. 1: The division and nomenclature of the cartilage segments. Prefixes are "a" for anterior, "c" for central, "p" for posterior, "L" for lateral, "M" for medial, "F" for femur, "T" for tibia. Suffixes "s" and "d" refer to superficial and deep parts of cartilage.

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