# CORRELATION BETWEEN FOCAL CARTILAGE THICKNESS AND FEMUR CARTLIAGE CONTACT REGIONS DURING RUNNING

William Anderst, Eric Thorhauer and Scott Tashman
University of Pittsburgh, Department of Orthopaedic Surgery, anderst@pitt.edu

## INTRODUCTION

The relationship between tibio-femoral cartilage thickness and cartilage contact during dynamic knee loading is unknown. It was hypothesized that cartilage is thicker in regions that are habitually loaded during walking and running.

The purpose of this study was to determine the correlation between focal cartilage thickness on the femur and cartilage contact location during the impact phase of running.

## METHODS

Four subjects (3M, 1F) received bilateral, sagittal, 3T knee MRIs using a 3D SPGR sequence. All knees were asymptomatic for OA. MRI field of view was 160 x 160 mm with 2 mm slice spacing. Cartilage was segmented using both Mimics software (Materialise) and manual segmentation. Sagittal slices were interpolated to produce (0.312 x 0.312 x 0.333) mm voxels.

Segmented MRI slices were reconstructed into 3D volumetric models by applying a marching tetrahedra algorithm to the 2D slice data (Treece, Prager and Gee, 1999).

Cartilage volumes were grouped into focal regions within the medial and lateral compartment (Figure 1) to include surfaces likely to be loaded during running. Average thickness of each focal region was determined by 3D distances from the outer to inner cartilage surface.

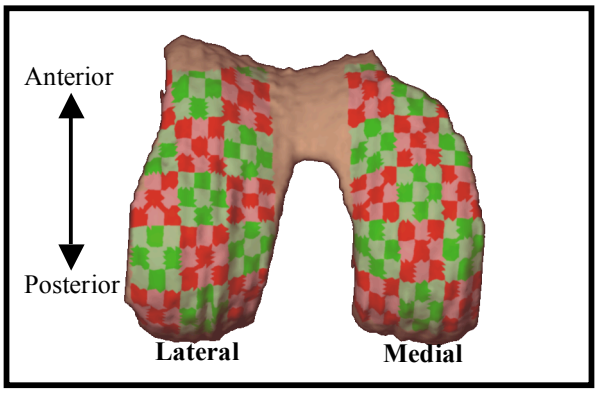


***Figure 1**: Femur (above) cartilage regions of interest (red-green checkerboard). Regions of interest were divided into focal regions of approx. 6 mm$^2$.*

Cartilage surfaces were co-registered with bone surfaces, and animated according to bone motion recorded with a high-speed

biplane x-ray system (Tashman and Anderst, 2003). Precise in-vivo knee kinematics were acquired at 250 frames/s during downhill treadmill running for 3 trials per subject.

Contact areas were estimated from femur-to-tibia cartilage distances, which were calculated for each frame of the loading phase of each running trial (approx. 200 ms after foot strike). The average distance between cartilage surfaces over this time period was determined for each focal region, with average distances below 7 mm included in the analysis to exclude non-contacting regions.

Cartilage thickness within each focal region was correlated to average distance between cartilage surfaces within each focal region during the running trials, and the average correlation for each subject was determined.

## RESULTS

Correlation between focal cartilage thickness and distance between cartilage surfaces was low within both the medial (average $R^2$ = .10; $R^2$ range .03 to .30) and lateral (average $R^2$ = .12, $R^2$ range .02 to .36) compartment on the femur.

Cartilage thickness in relation to minimum distance was similar, but not close enough to result in a high focal region correlation (Figures 2 and 3).

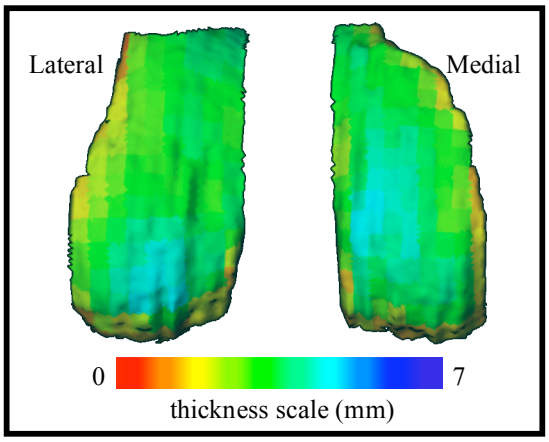


***Figure 2:*** *Cartilage thickness for the medial and lateral compartments of the femur of one subject. Focal regions (as defined in Figure 1) are color-coded according to average thickness within each region.*

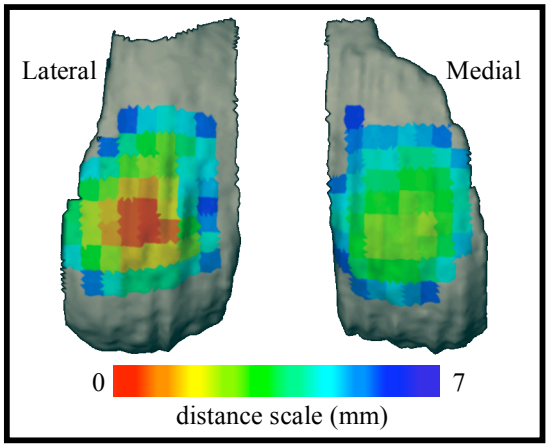


***Figure 3:*** *Average distance from femur to tibia cartilage surfaces during the loading phase of running for the same subject shown in Figure 2. Focal regions are color-coded according to average distance between cartilage surfaces for 200 ms after footstrike.*

## DISCUSSION

These findings do not support the hypothesis that cartilage thickness in the femur is related to cartilage contact regions during dynamic loading.

These results contradict previous reports that cartilage contact location during static loading was related to cartilage thickness (Li, Park, DeFrate, et al., 2005). It should be noted that sample size was small for both studies, and Li, et al. correlated cartilage thickness on one group of subjects with static contact locations from another group of subjects. Also, the focal region size used by previous authors (Li, Park, DeFrate, et al., 2005) was large compared to the present study. As Figures 2 and 3 show, the regions of close cartilage contact on the lateral condyle are only slightly anterior to the thickest cartilage regions, while medial close cartilage contact was located slightly lateral to the thickest focal regions. Increased focal region size may improve the correlation between contact regions and cartilage thickness.

## REFERENCES

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