Comparison of *in vivo* patellofemoral contact patterns under passive and active loading

Jarred Kaiser[1], Arezu Monawer[1], Kwang Won Choi[1], Richard Kijowski[2], Darryl Thelen,[13]
University of Wisconsin-Madison, Mechanical Engineering[1], Radiology[2], Biomedical Engineering[3]

Introduction

Patellofemoral cartilage loading patterns are important to consider when assessing potential causes of anterior knee pain. However, prior studies have primarily relied on indirect measures (e.g. EMG) or kinematic metrics to assess *in vivo* patellofemoral behavior. The objective of this study was to use recent advances in 3D dynamic imaging (1) to assess patellofemoral contact in passive and active motion.

Methods

Five subjects lay supine on a loading device within a 3T MRI scanner. A dynamic MRI sequence (SPGR-VIPR) then imaged passive and active knee flexion-extension (~30° at 0.5Hz). In the passive condition, the researcher cyclically rotated the subject's knee. In the active condition, the subject actively moved their knee against an inertial load, which induced quadriceps activity with flexion. High-resolution static MR images were segmented to obtain bone and cartilage models. Bone models were registered to each dynamic image frame (1). We evaluated contact patterns by measuring the distance between patellofemoral cartilage surfaces, with overlap indicative of contact. Patellar center of contact (CoC) was defined as the weighted-average contact location. We statistically compared (paired t-test) the maximum flexion/extension, average and excursion of the CoC between loading conditions.

Results

Contact was more pronounced on the lateral patella facet (Fig. 1). During knee extension, active loading induced an inferior shift in the average CoC ($p<0.05$). Active loading induced a medial shift in CoC at peak flexion ($p<0.05$) and a non-significant tendency for greater superior-inferior CoC excursion (active:17.2±3.2mm, passive:13.1±4.6mm) but less medial-lateral excursion (active:13.0±2.8mm, passive:18.3±9.2mm).

Discussion

This study demonstrates the potential for using dynamic MRI to assess *in vivo* patellofemoral cartilage contact under physiological loading conditions. The loading device induces peak quadriceps activity with knee flexion, as seen in stance phase of gait. Interestingly, this study shows a medial shift in the patellar CoC location as a result of active quadriceps loading in flexion, which could arise from preferential pull of the vastus medialis. This noninvasive imaging technique could be employed on individuals with patellofemoral pain to assess hypothesized relationships between patellar maltracking and cartilage loading. Such information may prove useful for assessing the effect of rehabilitation strategies on patellofemoral mechanics.

Reference: Kaiser, J., Bradford, R., Johnson, K., Wieben, O., Thelen, D., 2013. Measurement of Tibiofemoral Kinematics Using Highly Accelerated 3D Radial Sampling. Magnetic Resonance in Medicine, 7.

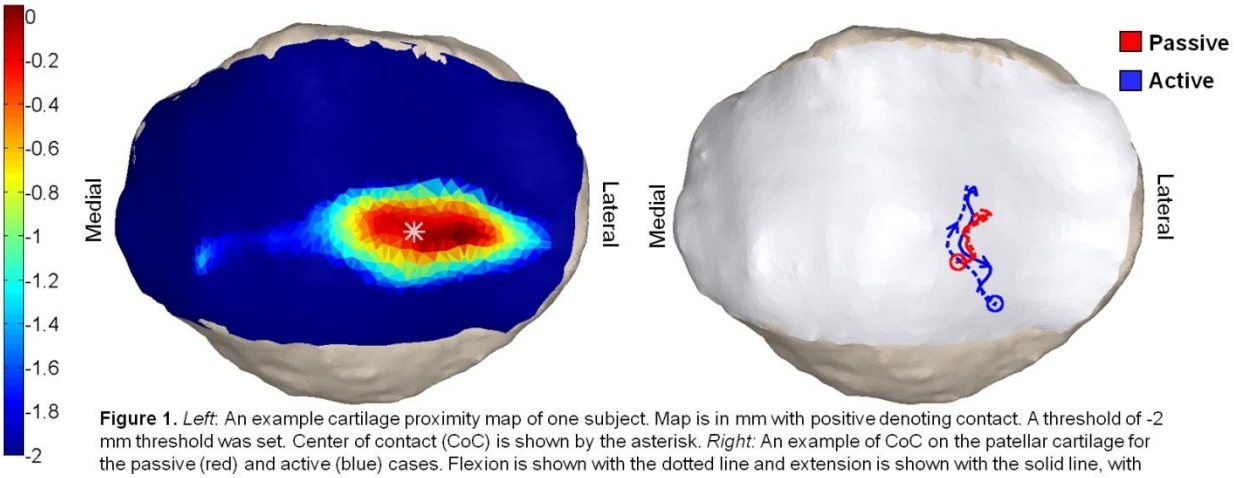

Figure 1. *Left*: An example cartilage proximity map of one subject. Map is in mm with positive denoting contact. A threshold of -2 mm threshold was set. Center of contact (CoC) is shown by the asterisk. *Right:* An example of CoC on the patellar cartilage for the passive (red) and active (blue) cases. Flexion is shown with the dotted line and extension is shown with the solid line, with the circle denoting the maximum extension.