Weight-bearing MRI of Patellofemoral Joint Cartilage

G. E. Gold[1], T. F. Besier[2,3], C. E. Draper[2], D. S. Asakawa[2], S. L. Delp[2,4], G. S. Beaupre[2,3]

[1]Radiology, Stanford University, Stanford, CA, United States, [2]Biomechanical Engineering, Stanford University, Stanford, CA, United States, [3]Rehabilitation R&D Center, Dept. of Veterans Affairs, Palo Alto, CA, United States, [4]Bioengineering, Stanford University, Stanford, CA, United States

Introduction: Patellofemoral pain syndrome (PFPS) is a common cause of knee pain, occurring during knee loading activities like running and climbing stairs. Examination of patellofemoral cartilage *in vivo* under load with MRI has been difficult. Previous work has focused on joint kinematics [1] and contact area measurements [2] under limited load, or cadaver measurements [3-4]. Measurement of patellofemoral cartilage volume has been done after exercise [5]. Accurate measurement of patellofemoral cartilage contact areas while under load could allow calculation of patellofemoral joint stress and provide insight into the etiology of PFPS.

Methods: We examined six healthy volunteers at thirty degrees of knee flexion in weight bearing and non-weight-bearing conditions. MR scanning was performed in a 0.5T Signa SP open MRI scanner using a custom back support device (Figure 1) that allows subjects to remain motion-free for the duration of the scan. Scanning was done using a transmit-receive surface coil with a sagittal spoiled gradient echo sequence (SPGR) and a 20 cm field-of-view. Imaging matrix was 256x160 with a TR/TE of 33/9ms and a 45-degree flip angle. We acquired 32 sections of 2 mm thickness in a scan time of 2:13m.

Measurement of contact area was done with three independent observers on a cartilage phantom of known area [6] as well as subject data. Contact areas were measured between the patella and femoral cartilage at a flexion angle of 30 degrees. Pixels that showed grey-on-grey cartilage were considered to be in contact. Total contact areas without load and with load (approximately 0.45 times body weight supported by each leg) were compared.

Results: Images acquired without the back support device in knee flexion resulted in considerable motion artifact (Figure 2A). After use of the back support, weight-bearing scans were done free of motion artifact in all subjects (Figure 2B). Contact area measurements (Figure 2C) from three independent observers showed good intra (mean coefficient of variation (CV) 3.2 to 4.2%) and inter-observer agreement (mean CV 3.8%). Mean contact area for our six subjects was greater ($p < .01$) when the limb was loaded (510 $mm^2 \pm 42$) than when it was unloaded (388 $mm^2 \pm 33$).

Conclusion: The increase in contact area we observed under load could be due to repositioning the patella in the trochlear groove and to cartilage deformation from loading. This method may allow assessment of patellofemoral cartilage stress under load.

Figure 1: Schematic drawing of our custom MR-compatible back support. The support is made of plastic pipes, a sliding mesh table, and a counter-weight that fits between the two halves of the "double doughnut" GE Signa SP system. The knee is positioned at isocenter.

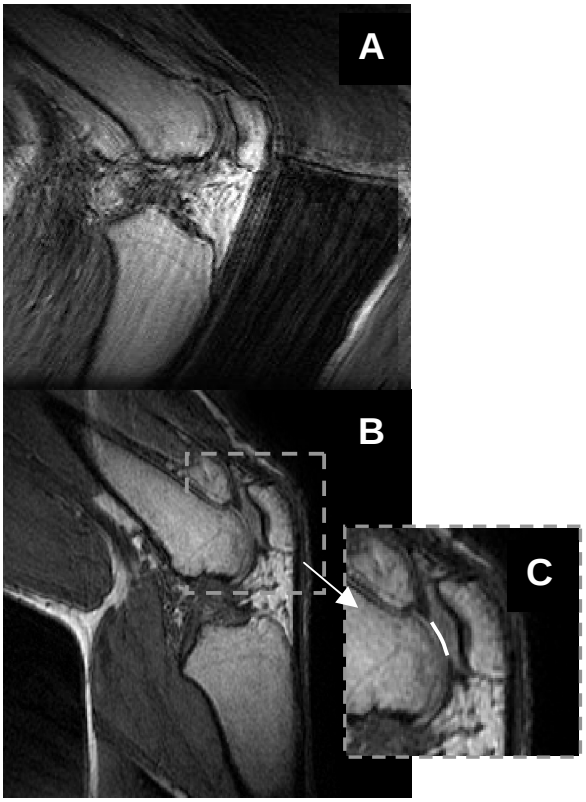

Figure 2: MR Images of the knee joint under load. A) Without back support, motion artifact is seen. B) With back support, contact area can be seen. C) Measurement of contact area (white line) in a section using grey on grey pixels.

References

[1] Ward, et al. J Magn Reson Imaging. 16:69-74 (2002).
[2] Brechter and Powers. Gait Posture. 16: 115-23 (2002).
[3] Powers, et al. Clin Biomech. 13:616-624 (1998).
[4] Hsieh, et al. Am J Sports Med. 30:121-7 (2002).
[5] Eckstein, et al. J Biomech. 33:819-25 (2000).
[6] Gold, et al. Proc 10th ISMRM (2002).

Acknowledgements

We would like to acknowledge funding from the VA Rehabilitation R&D Service (VA RR&D grant #A2592R) and the National Science Foundation. We would like to thank Doug Schwandt for help with design and construction of the back support and Michael Fredericson for subject recruitment.