

# MEASUREMENT OF PATELLOFEMORAL JOINT CONTACT AREA USING MAGNETIC RESONANCE IMAGING

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**RELEVANCE TO MUSCULOSKELETAL CONDITIONS:** Non-invasive quantification of patellofemoral joint contact area can provide information regarding the influence of load distribution on patellofemoral joint pathology.

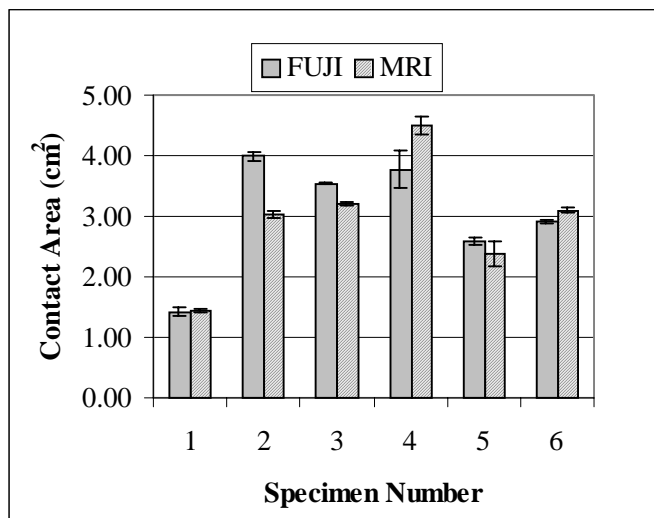
**INTRODUCTION:** Patellofemoral joint contact area is essential for evaluating load distribution and its role in patellofemoral pathology.[4] A previous investigation qualitatively demonstrated in-vivo contact area techniques using magnetic resonance (MR) imaging, finding favorable comparison with in vitro contact area.[2] However, quantification of the contact area was not determined. The purpose of this study was to 1) develop a clinical tool for quantifying contact area using MR imaging and 2) to assess the reliability and validity of this method.

**METHODS:** Patellofemoral contact area was simultaneously quantified using pressure sensitive film and MR imaging in 6 fresh-frozen cadaver knees. Each specimen was prepared with minimal dissection to allow a small slit in the suprapatellar pouch sufficient to insert a packet of pressure sensitive film (5cm X 5cm). A custom loading jig was designed of non-ferromagnetic materials to permit a compressive load through the patella. The jig was anchored centrally on the anterior patella using a plastic screw. A tensile load was also applied to the quadriceps tendon, along the axis of the femur, by inserting a second plastic screw into the distal femur and suturing a small circle of surgical tubing (3 cm diameter) to the posterior surface of the quadriceps tendon approximately 10cm superior to the proximal patellar border. Following preparation, each specimen was placed on a wooden base in approximately 30° of flexion with the distal femur and tibial secured to prevent knee extension during loading. The pre-scale (ultra super low) pressure sensitive film (Fuji Photo Film Co., Tokyo, Japan) was inserted into the suprapatellar pouch and the tensile then compressive loads were applied. Two dual array receive only extremity coils were positioned vertically on either side of the patellofemoral joint and strapped into position. 3D spoiled grass (SPGR) MR imaging was completed in a 1.5 Tesla magnet (GE Medical Systems, Milwaukee, WI) using the following parameters: time to repeat=60ms; time to echo=20ms; flip angle=30°; NEX=1.5; Matrix= 512 x 224; Field of view= 20 cm x 20 cm; 2mm slices with 0 skip; chemical fat suppression; scan time 10:49. **Data Analysis:** Contact area was determined from the Fuji film using NIH Image software.[3] Contact area was determined from the MR images using the MR data analysis software (GE Medical Systems, Milwaukee, Wisconsin). For each image slice, contact area was visually identified as 'the patellar and femoral cartilage surfaces approximating each other with no evidence of separation between them' or "white on white". For the obtained scans, the cartilage image is bright (white); any separation is evident as a dark line between the bright cartilage surfaces. The presence of the Fuji film created an indistinct thin gray line that was assessed as contact. The contact surfaces were measured as one or more straight-line segments, integrated over the slice thickness to obtain area per slice, and summed over all slices for total area. Validity was assessed with direct comparison of the contact area from pressure sensitive film and MR image. Two series of MR images were collected simultaneously with pressure sensitive film. Contact area from each was measured twice and the values were averaged. An intraclass correlation coefficient ICC(2) [1] was used to assess agreement between the two methods. Reliability was assessed with repeated measures in one specimen. Three pairs of MR images were obtained, each pair consisting of one MR image collected simultaneously with pressure sensitive film and one MR image collected without the film. Each image and film were measured three times for contact area. An ICC(1) [1] was determined to assess repeatability of measurements for three and then two averaged measures.

**RESULTS:** An ICC(2) value of 0.95 was obtained for the comparison of contact area from pressure sensitive film and MR images, means and standard errors are presented (Figure 1). Overall mean contact area assessed by pressure sensitive film was 3.04cm<sup>2</sup> and for MR images 2.94cm<sup>2</sup>. The ICC(1) values for repeated measures are presented (Table 1).

**DISCUSSION AND CONCLUSION:** The correlation between MR contact area and Fuji film contact area was 0.95 indicating excellent agreement.

Comparison of the grand mean contact area for Fuji film and MR image methods reflects about 3% difference between the two measures, with MR imaging slightly less than Fuji film. The ICC(1) for Fuji film contact area measurement reflects the highest reliability (.99) for both two and three measures. Reliability of MR image contact area measures without Fuji film also show excellent repeatability (.93). ICC's for MR image contact area data with Fuji film (.87, .85) still show good repeatability, yet slightly lower than the Fuji film alone and MR alone. These results indicate that one contact area measure from any method is about the same as a second or repeated measure, and reliability does not improve with subsequent measures. This study demonstrates that MR imaging technology allows non-invasive assessment of contact area with results comparable to that obtained from pressure sensitive film. Future investigations should consider direct assessment of pathological joints for etiological studies of patellofemoral pathology. This method may also be utilized to determine age specific, pathology specific, or activity level specific contact areas for relevant study populations.



**Figure 1. Comparison of contact area from Fuji film and from Magnetic Resonance Imaging (Means and standard error). ICC = 0.95**

**Table 1. Intraclass Correlation Coefficients (ICC) for two and three averaged measures of contact area.**

number of averaged measurements	MR WITHOUT Fuji Film	MR WITH Fuji Film	Fuji Film
2	0.93	0.87	0.99
3	0.93	0.85	0.99

**REFERENCES:** 1. Bartko, Psych Bull. 83:762-5, 1976. 2. Cohen, et al, Trans ORS 1997. 3. Lee, et al. CORR 340:257-66, 1997. 4. Seedhom, et al., Ann. Rheum. Diseases, 38:307-16,1979.

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