INTRODUCTION

Although ACL injuries can lead to patellofemoral (PF) arthrosis, few studies have been performed on the effect of ACL deficiency (ACLD) and ACL reconstruction (ACLR) on PF kinematics and PF contact area changes.\(^1\)

The purpose of this study was to test following hypotheses: (1) 3D in vivo PF kinematics and patello-femoral contact area of ACLD knee during simulated weight-bearing are different from those of contralateral uninjured (ACLD) knee; (2) 3D in vivo PF kinematics and PF contact area of ACLR knee during weight-bearing knee flexion are different from those of contralateral uninjured (ACLR) knee.

METHODS

Ten unilateral ACLD subjects (28.3±8.2 years, 5 males, 2.0±2.9 years post injury) and nine unilateral ACLR subjects (33.0±9.2 years, 6 males, 0.9±0.7 years post surgery, arthroscopic transtibial ACL reconstructions by single surgeon) were studied. The study was approved by committee for human research and consent was obtained from patients. Sagittal-plane MR images (proton density weighted, in plane resolution =0.3mm, slice thickness 1.5mm) of both knee joints were taken in a position of full extension and a position of 40° of flexion. (I-S) axis are orthogonally defined (Figure 1A). Patella flexion was defined as the rotation of the center of patella along coordinate system was located at the midpoint of lateral-medial (L-M) axis of the patella and Posterior-anterior (P-A) axis and Inferior-superior (I-S) axis are orthogonalized (Figure 1A). Patella flexion was defined as the rotation of the patella about the femoral M-L axis. Patella tilt was defined as the rotation of the patella about its long axis. Patella valgus rotation was defined as the rotation of the patella about A-P axis. Patella shift was defined as the translation of the center of patella along M-L axis of the femur (Figure 1A). To analyze PF contact, PF cartilage-cartilage contact regions were segmented and sets of triangles made from connecting spline points were integrated (Figure 1B). 6 degree of freedom (DOF) kinematic parameters (patellar flexion, patella tilt, patella rotation, patella lateral translation, patella anterior-posterior translation, patella superior-inferior translation) during extension to flexion and PF contact areas at each position were measured.

To evaluate intraclass reproducibility, one examiner measured PF kinematics and contact area of one knee six times over 2 months. The coefficients of variation for 6 kinematic parameter measures ranged from 0.18 to 4.2%. The coefficients of variation for contact area measurement are 5.46% and 4.25% at extension and flexion, respectively. For each measured parameters, a paired Student’s t-test was performed to compare differences with a significance level of 0.05.

FIGURE 1. A) Patella coordinate system to quantify three rotations and translations. B) Segmenting PF cartilage-to-cartilage contact using a sagittal MR image.

RESULTS

ACLD knees have significantly more lateral from extension to flexion than contralateral knee (*P<0.05*) (Figure 2A). ACLD knee also tended to have more lateral translation but not statistically significant (*P=0.08*). The other four parameters showed no significant difference. After ACL reconstruction, no kinematic parameters were significantly different from their contralateral knees (Figure 2A).

PF contact area of ACLD knee at both extended and flexed positions (72±25mm²:335±53 mm²) were significantly smaller than that of the contralateral knee (69±46mm²:440±114 mm²) (Figure 2B). After ACL reconstruction PF contact area of ACLR knees at extended position (80±44mm²) was significantly larger than that of contralateral knees (41±35mm²), but no difference was observed at flexed position.

DISCUSSION

The results of this study suggest that the ACLD knee has more patella lateral shift when moving from extension to flexion, but ACL reconstruction restores normal PF kinematics.

In addition, this study shows that PF contact area of ACLD knee is significantly smaller both in extended and flexed positions. This reduced contact area agrees with results of a previous cadaver study\(^1\) and may be associated with reduced quadriceps contraction following ACL deficiency.\(^2\) It is interesting to note that PF contact area of ACLD knee is even larger than their contralateral knee at extended position, while no significant difference exists at the flexed position. Altered PF kinematics and PF contact area after ACL injury and reconstruction observed in this study may explain early onset of cartilage degeneration or PF pain in this population.

REFERENCES


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Figure 2. A) Only two PF parameters show significant or marginal difference among 6DOF PF kinematics between ACLD, ACLR, and contralateral knees. Error bars represent mean value ± s.d. B) PF contact areas of ACLD, ACLR, and their contralateral knees. ** indicates significant difference (*P<0.05*). * indicates marginal difference (*P<0.1*).