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Anterior Cruciate Ligament Reconstruction Affects Tibiofemoral Subchondral Bone Congruency during Dynamic Functional Movement

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Summary:
This novel study investigating the effect of anterior cruciate ligament (ACL) reconstruction on the tibiofemoral subchondral bone congruency during running demonstrated that the lateral compartment congruency was higher in ACL reconstructed knees than the contralateral knees.

Abstract:
INTRODUCTION: Anterior cruciate ligament reconstruction (ACL-R) has been shown to alter knee kinematics, which may influence joint congruency, potentially leading to abnormal loading of the articulating cartilage and joint degeneration. Previous studies characterized the knee joint congruency using static images, but there are no reports on congruency during dynamic functional activities. The purpose of this study was to investigate the effect of ACL-R on tibiofemoral subchondral bone congruency during downhill running. It was hypothesized that the congruency in the medial compartment would be higher than the lateral compartment in both ACL reconstructed and contralateral knees, and that dynamic joint congruency would decrease in both compartments after ACL-R.
METHODS: Forty unilateral ACL injured patients (21±7 y.o.) underwent ACL-R. Six months after ACL-R, patients performed downhill running on a treadmill (3.0 m/s, 10° slope) while Dynamic Stereo X-ray system (DSX) images were acquired at 150Hz. Subject specific bone models were generated from computed tomography images and matched to the biplane radiographs using a previously validated model-based tracking process in order to determine tibiofemoral kinematics. Magnetic resonance imaging cartilage models were registered to the tracked bone models to calculate the cartilage contact patch which was projected onto the subchondral surface model. The principle curvatures of the subchondral surfaces, and the congruency index (CI; unit 1/m) between them were calculated. The CI indicates how well the curvatures of the two joint surfaces match each other. A lower value of CI indicates higher joint congruency. Repeated measures ANOVA was used to test for differences in CI between medial and lateral compartments, and between reconstructed and contralateral knees. The significance level was set at $P < 0.05$.
RESULTS: The local average principle curvatures of both the medial and lateral femoral condyles decreased after ACL-R (both $P < 0.05$), while the local principle curvatures of the tibial plateaus did not change significantly. Medial compartment congruency was significantly higher than lateral compartment congruency in the reconstructed (23.4 ±10.6 vs 27.8±7.9, $P = 0.048$) and contralateral knees (25.7±8.7 vs 36.1±6.4, $P < 0.01$) during downhill running. Congruency in the lateral compartment was significantly higher in the reconstructed knee than in the contralateral knee (27.8±7.9 vs 36.1±6.4, $P < 0.01$). No significant differences in congruency were found in the medial compartment between the reconstructed and contralateral knees.
DISCUSSION: The main findings of this study were that the lateral compartment congruency in the reconstructed knees was greater than that in the contralateral knees, and that femoral condyles were significantly flatter at contact location after surgery. Previous work describing subchondral bone curvature changes in osteoarthritic patients suggests that there might be a relationship between increased congruency and early onset of osteoarthritis. The fact that both medial and lateral femoral condyles flattened postoperatively with significant changes of congruency in the lateral compartment, suggests that both bony changes and kinematic differences may affect subchondral congruency

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after ACL-R.