

CONTACT DIFFERENCES BETWEEN MEDIAL AND LATERAL TIBIAL PLATEAU COMPARTMENTS ACCOMPANY WEIGHT-BEARING

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INTRODUCTION

A number of studies have previously shown that lower-body muscle activity and knee joint loading in the supine, or recumbent positions, is quite different from that in fully upright, physiological load-bearing stance [1,2]. The use of MR imaging during upright, weight-bearing stance provides the benefits of identifying loading and contact position differences in a pathologic knee during functional activity. For example, after injury to the ACL, an investigation into knee kinematics and tibial plateau contact positions during functional loading may help identify why these injuries predispose individuals to the early onset of osteoarthritis (OA). Injury to the ACL is linked to the initiation and progression of OA, possibly by *changes in the local loading and contact area between joint cartilage surfaces* [3]. We recently reported significant changes in tibiofemoral positioning and cartilage contact locations accompanying the transition to weight-bearing in subjects with healthy knees [4]. In the current study, we further explored these relationships and how they may relate to functional anatomy.

METHODS

Six subjects (5m, 1f, age 32.83 ± 7.36 years) without orthopaedic knee issues gave informed consent to participate in the MR imaging for this study. Scanning was performed in a 0.6T vertically open scanner (FONAR Corp., Melville, NY). Scans were acquired bilaterally at two levels of weight-bearing: *high weight-bearing* (HWB), during which the patient is nearly vertical, and *low weight-bearing* (LWB), during which the patient is reclined (85° and 20° from horizontal, respectively). Scanning protocols, image digitization, model creation, and data analysis have been previously described [4]. Anterior/posterior (A/P) translational displacement of the joint was calculated between tibial and

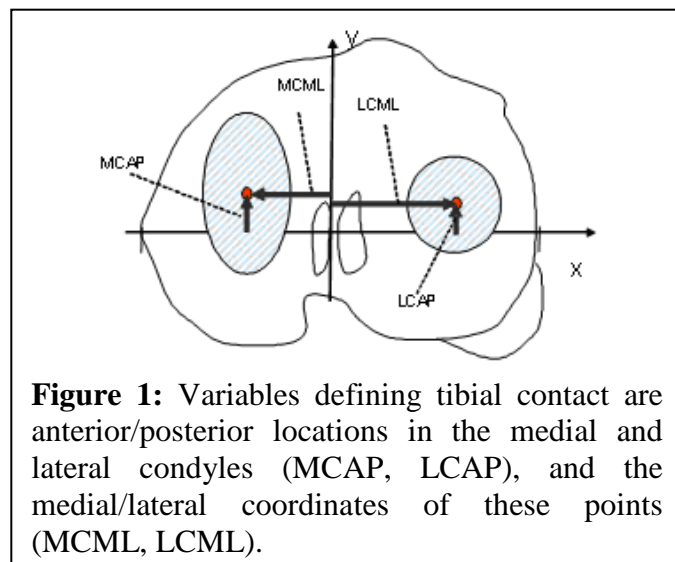


Figure 1: Variables defining tibial contact are anterior/posterior locations in the medial and lateral condyles (MCAP, LCAP), and the medial/lateral coordinates of these points (MCML, LCML).

femoral coordinate systems. Contact positions were calculated as the centroids of contact regions defined as areas of femoral cartilage lying within a threshold distance from tibial cartilage [4]. The positions of the centers of contact were calculated relative to the tibial plateau coordinate system (Figure 1). A mixed procedure repeated measures analysis of variance (ANOVA) was first run to investigate the effect of weight-bearing on kinematics and contact positions during the transition from LWB to HWB ($\alpha=0.05$). We then explored the relationship between changes related to weight-bearing in joint kinematics and contact positioning in each compartment of the tibial plateau using linear regression analysis to calculate correlation and slope coefficients.

RESULTS AND DISCUSSION

As previously reported, we observed significant anterior positioning of the tibia accompanying the transition to weight-bearing ($p<0.01$). Concomitantly, a medial ($p<0.05$) and posterior ($p<0.05$) shift in the lateral compartment contact points was observed. In the medial compartment, there were similar trends mimicking the lateral

compartment contact shift, although there was no significance in either the medial/lateral (M/L, $p=0.16$) or the A/P ($p=0.50$) directions.

In the lateral compartment, there is a clear association between tibial plateau contact and joint positioning (Figure 2, $R^2=0.796$). Upon weight-bearing, as the tibia moved anterior relative to the

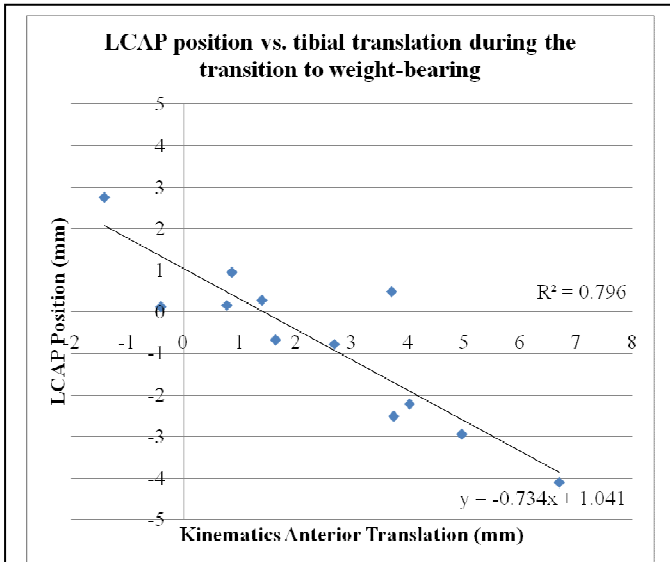


Figure 2: Relationships between anterior translation of the tibia and the posterior shift of the lateral femoral condyle contact on the tibial plateau during the transition to weight-bearing.

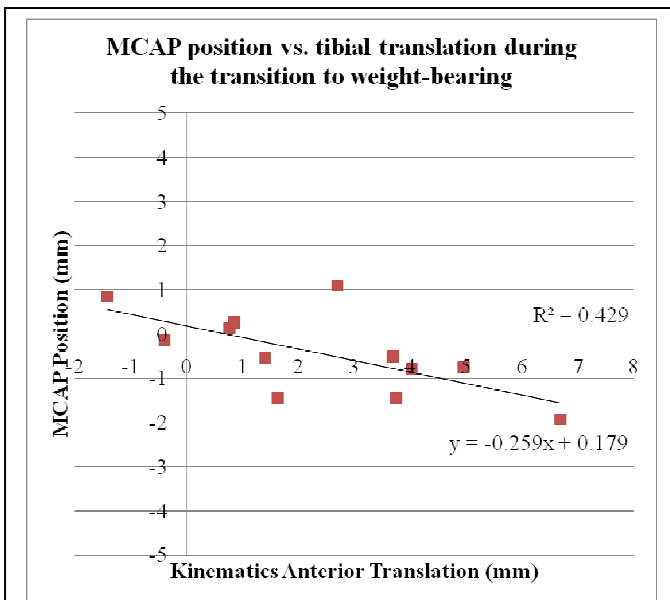


Figure 3: Relationship between anterior translation of the tibia and the posterior shift of the medial femoral condyle contact.

femur, the contact position on the tibial plateau shifted posteriorly (slope=-0.734). This relationship in the medial compartment of the tibial plateau is substantially less (Figure 3, $R^2=0.429$, slope = -0.259). The differences between compartments may be explained by the contact relationships between the curved geometry of the femoral condyles and the surface of the tibial plateau. The medial side of the tibial plateau has a shallow concave shape, conforming to the medial femoral condyle. Upon weight-bearing, compression between these two curved surfaces may result in a decreased translation in this compartment. However, the lateral side of the tibial plateau is flatter than the medial side. The lower congruency may allow greater motion between the two during the transition to weight-bearing.

CONCLUSIONS

During the transition to weight-bearing, significant differences in tibiofemoral kinematics and contact positions have been observed. Weight-bearing MRI and computational modeling demonstrated that for a given amount of tibial translation, change in contact location differs between medial and lateral compartments. Differences in functional anatomy appear to offer an explanation for these differences. Such relationships are likely to be disrupted by ligamentous damage, and future explorations may shed light on why ACL injury predisposes an individual to the early development of OA.

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