IN VIVO DETERMINATION OF NORMAL AND ACL DEFICIENT KNEE KINEMATICS

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INTRODUCTION: Understanding the in vivo motions of human joints has become increasingly important. Researchers have used in vitro (cadavers), non-invasive (gait labs), and in vivo (RSA, fluoroscopy) approaches to assess human knee motion. Unfortunately, previous attempts have been unable to track the in vivo bearing surface motion of the medial and lateral condyles of the normal and anterior cruciate ligament deficient (ACLD) knees in three dimensions (3D). The objective of this study was to use fluoroscopy and computer tomography (CT) to accurately determine the 3D, in vivo, weight-bearing motion of normal and ACLD knees.

METHODS: Ten normal knees, clinically assessed as having no pain or ligamentous laxity, and five ACLD knees, clinically diagnosed using MRI, were analyzed. Using CT scanning, slices were obtained six inches proximal to the joint line on the femur and of 150 mm of the proximal tibia (1.0 mm slices near the bearing surfaces and 3.0 mm elsewhere). Three-dimensional CAD models of each subject’s femur and tibia were recreated from the 3D bone density data. Under fluoroscopic surveillance, each subject was then asked to perform a deep knee bend and normal gait. The computer-generated 3D models of each subject’s femur and tibia were overlayed onto the 2D fluoroscopic images, and subsequently analyzed to determine anteroposterior contact positions and axial rotation. Femorotibial contact anterior to the tibial midpoint in the sagittal plane was denoted as positive, and posterior a contact was denoted as negative.

RESULTS: During a deep knee bend, there was significantly more motion of the lateral condyle compared to the medial condyle for both normal and ACLD knees (p<0.01). The normal knees did experience more lateral condyle motion (Normal = -22.0 mm, ACLD = -15.6 mm) and less medial condyle motion (Normal = - 1.5 mm, ACLD = -4.7 mm). During gait, the average lateral condyle motion was -5.1 and -3.1 mm for the normal and ACLD knees, respectively. The average medial condyle motion was minimal for both knee types. Two normal knee subjects experienced more medial condyle and less lateral condyle motion than the other subjects and the ACLD subjects experienced greater variability. During gait the average axial rotation was 5.7° and 2.0° for the Normal and ACLD subjects, respectively, but one ACLD subject experienced -19° of axial rotation. During a deep knee bend all ten normal knee subjects experienced internal rotation of the tibia, while 2/5 ACLD subjects experienced external tibial rotation.

DISCUSSION: This present study is the first analyses to accurately determine the in vivo, weight-bearing kinematics for normal and ACLD knees. The results from this study have determined that 80% of normal subjects experience similar kinematic patterns and ACLD subjects experience more variable kinematic patterns.