A new model to predict in vivo human knee kinematics under physiological-like muscle activation

Abstract:
Although a number of approaches have attempted to model knee kinematics, rarely have they been validated against in vivo data in a larger subject cohort. Here, we assess the feasibility of four-bar linkage mechanisms in addressing knee kinematics and propose a new approach that is capable of accounting for lengthening characteristics of the ligaments, including possible laxity, as well as the internal/external rotation of the joint. MR scans of the knee joints of 12 healthy volunteers were taken at flexion angles of 0 degrees, 30 degrees and 90 degrees under both passive and active muscle conditions. By reconstructing the surfaces at each position, the accuracy of the four-bar linkage mechanism was assessed for every possible combination of points within each cruciate ligament attachment area. The specific set of parameters that minimized the deviation between the predictions and the in vivo pose was derived, producing a mean error of 1.8 and 2.5 mm on the medial and 1.7 and 2.4 mm on the lateral side at 30 degrees and 90 degrees flexion, respectively, for passive motion, significantly improving all the models that did not consider internal/external rotation. For active flexion, mean medial errors were 3.3 and 4.7 mm and lateral errors 3.4 and 4.8 mm. Using this best parameter set, a generic predictive model was created and assessed against the known in vivo positions, producing a maximum average error of 4.9 mm at...
90 degrees flexion. The accuracy achieved shows that kinematics may be accurately reconstructed for subject specific musculoskeletal models to allow a better understanding of the load distribution within the knee. (c) 2007 Elsevier Ltd. All rights reserved.