Extensor Malalignment Arising from Femoral Component Malrotation: Effect of Rotating Bearing

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INTRODUCTION

Patellofemoral complications are among the important reasons for revision knee arthroplasty.(1,2) Abnormal patellar tracking has been implicated as one of the major reasons. Femoral component malrotation affects mediolateral knee balance in flexion and can also alter patellofemoral biomechanics, which is associated with anterior knee pain, subluxation, fracture, wear, and aseptic loosening. Rotating-platform mobile bearings compensate for malrotation between the tibial and femoral components. It has been suggested that rotating bearings may also reduce the patellofemoral maltracking resulting from femoral component malposition.(3) However, we could not demonstrate that a rotating-platform bearing improved patellofemoral maltracking in a model of open-kinetic chain knee extension.(4) Since the biomechanics of weight-bearing closed-kinetic chain knee extension are significantly different and clinically more relevant, we studied patellofemoral maltracking during a deep knee bend.

METHODS

We constructed a dynamic musculoskeletal model of weight-bearing knee flexion in a knee implanted with posterior cruciate-retaining arthroplasty components (LifeMOD/KneeSIM, LifeModeler Inc). KneeSIM is a musculoskeletal modeling environment that uses rigid body dynamics to compute knee kinematics and forces during a deep knee bend. The model was validated using tibiofemoral and patellofemoral kinematics and forces measured in six cadaver knees on an Oxford knee rig. Knee kinematics and patellofemoral forces were measured after simulating axial malrotation of the femoral component (±3° relative to the transepicondylar reference line). Differences in patellofemoral kinematics and forces between the fixed- and rotating-bearing conditions were analyzed.

Fig 1 (Right): KneeSIM model. A knee implanted with tibial, femoral, and patellar components. The model includes ligaments and incorporates wrapping of quadriceps around the trochlea and patellar tendon over the tibial insert.

Fig 2 (Below): Model validation. Lateral shear forces on the patella predicted by the model were similar to those measured in 6 cadaver knees during deep knee bend activity.

RESULTS

Rotational malalignment of the femoral component affected tibial rotation near full extension and tibial adduction at higher flexion angles. In the fixed-bearing conditions, external rotation of the femoral component increased patellofemoral lateral tilt, patellofemoral lateral shift, and patellofemoral lateral shear forces. Up to 6° of bearing rotation relative to the tibia was noted in the rotating-bearing condition. However, the rotating bearing had minimal effect in reducing the patellofemoral maltracking or shear induced by femoral component rotation.

Fig 3: A: Lateral patellofemoral shear forces increased with femoral component malrotation in internal rotation in the Fixed-Bearing condition. B: No significant differences were noted between the Fixed- and Rotating-Bearing conditions. (FemER = external rotation of femoral component)

DISCUSSION

The rotating-bearing design does not appear to be forgiving of malalignment of the extensor mechanism resulting from femoral component malrotation. Rotating-bearing designs may correct tibiofemoral axial malrotation near full extension but not at higher knee flexion angles. These results are consistent with our previous report simulating an open-kinetic chain knee extension (4). Our study provides the biomechanical rationale for a clinical report that could not detect significant improvement in patellar tracking with a rotating-platform design (5). It is important to improve existing methodologies for accurate femoral component alignment especially in rotation.

References