Effect of Component Malrotations in Several TKA Designs during Squatting: A Numerical Study

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Introduction

Total knee arthroplasty (TKA) alters the biomechanics of the physiologic knee by replacing the articular surfaces of the joint with artificial implant components. Both the design and the surgical positioning of these components could influence patient outcomes. The effect of independent malrotations of femoral and tibial components on patellar kinematics and contact forces has been extensively studied; however, the effect of combined malrotations has been rarely reported. To evaluate the influence of component malrotations on patello-femoral (PF) contact forces during squatting, a numerical analysis was performed. In this study three different TKA designs were investigated. Femoral and tibial component flexion/extension and internal/external rotation were varied individually and in combination.

Methods

An anatomic knee model consisting of CT-derived bone models and ligament insertion/origin locations was developed from one human cadaveric leg specimen. Three different TKA designs were considered in this study: conventional fixed bearing Genesis II PS (Smith&Nephew, Inc.), a fixed-bearing high flex design, Journey BCS (Smith&Nephew, Inc.), and mobile bearing EPP design (Smith&Nephew, Inc.). Each total knee replacement was virtually implanted according to normal surgical alignment. Relative to normal (neutral) alignment, femoral and tibial component flexion/extension and external/internal rotations were varied ± 3°. A deep squat of 120° was simulated with a constant hip load of 45 lbs (~200 N) using LifeMOD/KneeSim 2007.0.5 (LifeModeler, Inc., San Clemente, California), a validated, dynamic, musculoskeletal modeling system (Figure 1). The maximum PF contact force was recorded during each simulation.

Results

Figures 2-4 illustrate, with color-code illustrations, the sensitivity of the maximum PF contact force to changes in femoral and tibial component orientation for the PS, BCS and MB designs, respectively. The maximum change in PF contact force to any combination of malrotations was within 0.2 BW for the PS and BCS design, and 0.4 BW for the MB design. In general malrotation of the femoral component influenced the maximum PF contact force more than tibial malrotation. Femoral component extension increased PF contact force while femoral component flexion reduced PF contact force. The MB design was less sensitive to internal/external malrotations, but more sensitive to tibial component flexion/extension malrotations.

Discussion

Both femoral and tibial component alignment affect PF contact forces in TKA. This numerical study presented the effects of small component malrotations on PF contact forces in three different TKA designs. Understanding the sensitivity of PF contact forces to femoral and tibial component alignment for a specific TKA design can help to avoid those configurations that may increase the risk of PF complications.