INTRODUCTION
The decision to resurface the patella during total knee arthroplasty (TKA) remains controversial. Resurfacing the patella may result in a reduction in anterior knee pain, but has associated risks of loosening and fracture. Early procedures with unresurfaced TKA reported poor success rates; however, this was primarily due to the non-anatomic design of femoral components at the time [1]. In recent years, clinical results for unresurfaced TKA have been on par with resurfaced TKA [2]. Differences in congruency between the natural patella and the femoral component affect knee tracking and contact mechanics, and may alter contact stresses on the articular surface of the patellar cartilage [3], potentially leading to early degeneration.

A femoral component with perfectly anatomic geometry may aid in restoring natural kinematics to the joint, but contact mechanics are affected not just by geometry, but also by the material properties of the contacting surfaces. The purpose of this study was to compare mechanics of the natural patella articulating against four femoral representations; natural femoral cartilage, two current femoral component designs (anatomic and dome-compatible), and an idealized natural component, in order to assess the role of geometry and material properties in driving patellofemoral (PF) mechanics.

METHODS
A population of 15 subject-specific explicit finite-element models of the PF joint were developed from MR scans of normal knees. Hexahedral meshes of the femoral and patellar cartilage were created using an automated custom-scripted algorithm and morphing approach and represented as deformable (E = 12 MPa, ν = 0.45). The analysis was performed using ABAQUS/Explicit (Simulia, Providence, RI) four times for each subject with the patella articulating against: deformable femoral cartilage, a dome-compatible femoral component, an anatomic femoral component, and a ‘natural’ component. The natural component was modeled as femoral cartilage geometry with femoral component material properties (Figure 1). Due to the greater stiffness of CoCr relative to the natural knee, each femoral component was modeled as a rigid body for computational efficiency. The extensor mechanism and retinacula of the knee were represented by 2D fiber-reinforced membranes with a 1000 N ramped load distributed among the quadriceps (vasti and rectus femoris) as the knee was flexed from full extension to 120° [4]. Six-degree-of-freedom kinematics and contact mechanics were evaluated.

RESULTS
Predicted PF kinematics and contact mechanics illustrated differences between the femoral representations. Kinematics for the natural cartilage and the natural component were identical, while the anterior and posterior geometry may improve contact mechanics in later flexion; however, material property differences limit how closely femoral component designs can come to reproducing natural PF mechanics.

DISCUSSION
Using a (small) population of subject-specific models, unresurfaced joint mechanics were impacted by congruency of the femoral representation. In early flexion, conformity between the anatomic component and the patella resulted in lower contact pressure compared to the less conforming dome-compatible design. In deeper flexion, contact area was similar for both components as the intercondylar notch was wider than in the natural knee, resulting in less contact area for conformity. The natural component maintained a larger contact area and lower pressure with the patella in deeper flexion.

Despite kinematic agreement, there were substantial and consistent differences in contact mechanics between the natural femur and natural component, attributable to material property differences between metal and cartilage surfaces. Component designs with a more anatomic distal and posterior geometry may improve contact mechanics in later flexion; however, material property differences limit how closely femoral component designs can come to reproducing natural PF mechanics.

REFERENCES

ACKNOWLEDGEMENTS
This work was supported in part by DePuy, a Johnson & Johnson company.

Figure 1: Unresurfaced patella articulated against natural femoral cartilage, natural, anatomic and dome components (left to right).

Figure 2: PF kinematics (mean and ± 1 standard deviation) of the unresurfaced patella and four femoral representations.

Figure 3: PF contact mechanics (mean and ± 1 standard deviation) of the unresurfaced patella and four femoral representations.

Figure 4: Representative PF contact distributions for one subject at 40° and 110° flexion.

REFERENCES

ACKNOWLEDGEMENTS
This work was supported in part by DePuy, a Johnson & Johnson company.

Poster No. 2188 • 56th Annual Meeting of the Orthopaedic Research Society