Numerical sensitivity analysis of contact forces in several TKAs during squatting

INTRODUCTION:
Total Knee Arthroplasty (TKA) is a very successful surgical procedure, but patients with difficulties or pain during motion still persist. Patient outcomes in TKA surgery can be affected by implant design, alignment or patient-related anatomical factors. To evaluate the influence of some of these factors on contact forces, a numerical sensitivity analysis was performed on several TKAs during squatting.

METHODS:
A physiological leg model was obtained from a CT of a cadaver leg and the physiological soft tissue insertion points were taken from literature [1]. Four different TKA prostheses were implanted according to surgical guidelines:
1. A conventional fixed bearing, posterior stabilized (PS) designs: Genesis II PS (Smith&Nephew, Inc.);
2. A fixed bearing, high flex design: Journey BCS (Smith&Nephew, Inc.);
3. A mobile bearing design: EPP (Smith&Nephew, Inc.);
4. A hinge prosthesis design: RT-PLUS (Smith&Nephew, Inc.).

According to previous experiments [2], for each prosthesis a deep squat of 120° with a physiologic 45 pounds (~200N) constant hip load and the physiological soft tissue insertion points were taken from literature [1]. Four different TKA prostheses were implanted according to surgical guidelines:
1. A conventional fixed bearing, posterior stabilized (PS) designs: Genesis II PS (Smith&Nephew, Inc.);
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According to previous experiments [2], for each prosthesis a deep squat of 120° with a physiologic 45 pounds (~200N) constant hip load was simulated using LifeMOD/KneeSIM 2007.0.5 (LifeModeler, Inc., San Clemente, California), a validated, dynamic, musculoskeletal modeling system (fig. 1-2).

RESULTS:
For each TKA, the sensitivity of the contact forces to surgical alignment and to patient related anatomical factors was evaluated. The following configurations were analyzed:
1. the theoretical configuration corresponding to optimal surgical technique and physiological anatomy;
2. the change in location over ± 5mm of both proximal and distal insertion points of MCL, LCL and patellar tendon in medio-lateral (ML), antero-posterior (AP) and proximo-distal (PD) directions to simulate the effect of abnormal anatomy or ligament release;
3. the change in position of the tibial component in ML and AP direction over ± 3mm;
4. the change in orientation of the tibial component in flexion-extension (FE) and abduction-adduction (AA) over ± 3° and in internal-external (IE) orientation over ± 5°;
5. the change in position of the patella in height, simulating patella alta (BP index of 1.29) and patella baja (BP index of 0.59) [3-4];
6. the change in orientation of the patellar component in IE orientation over ± 10°.

For each configuration, the patellar component (TF), the patellofemoral (PF) and, for the two PS designs, the post-cam forces were extracted.

REFERENCES:
[1] Victor et al., The Knee 2009