Kinematic Differences between Males and Females: A Comprehensive Comparison Study

Richard D. Komistek1, Diana A. Glaser1, Mohamed R. Mahfouz1, Robert Booth2, Giles R. Scuderi3, Jean-Noel Argenson4, Sumesh Zingde1, Methew Anderle1

1Mechanical, Aerospace and Biomedical Engineering Department, University of Tennessee, Knoxville, TN; 2University of Pennsylvania, Philadelphia, PA; 3Insall Scott Kelly Institut, New York, NY; 4The Aix-Marseille University, Marseille, France
dglaser@utk.edu

Introduction: Sexual dimorphism, better known as gender difference, is a well recognized phenomenon. The gender differences between the human species are found not only in size, but are obviously present in shape and behavior. Nevertheless, a debate has recently begun about the importance and the supposed advantages of gender specific total knee arthroplasty. Therefore, the purpose of the current study was to evaluate in-vivo kinematics for male vs. female knees regarding any significant differences in the data, to investigate if the variance is significant for movement and articulation of the knee, and to determine if the differences justify gender-specific knee implants.

Materials and Methods: An overall randomized sample of 321 subjects implanted with a TKA was selected for the present study. The breakdown for the implanted knees was 35% male and 65% female, similar to the reported percentages of males vs. females receiving TKA in the USA. Ten different TKA designs were included in this study and none of the implants were reported to be gender specific at the time of analysis. Twenty normal knees were also included in the study. All subjects were analyzed using video fluoroscopy while performing deep knee bend activity. Both the femoro-tibial and patello-femoral joints were analyzed. A previously published 3D-to-2D registration technique [1,2] was used to determine 3D rotational and translational kinematics. The main parameters included for comparison were range of motion, medial and lateral anterior/posterior (A/P) translations, axial rotation and lift off. For the statistical analysis a regression model was used whenever the assumptions combined with it were fulfilled. This analysis enables to control for influential parameters and is capable of testing complex hypotheses.

Results: Non-implanted females achieved greater weight-bearing range-of-motion (p<0.01), a more posterior lateral condyle contact position (p<0.05; 0 to 60deg), and greater internal tibial rotation (p<0.05; 0-60deg) than the males. (Figure 1, Figure 2)

After TKA, the males achieved greater weight-bearing range-of-motion (p<0.01) and the females achieved similar femoral contact positions and axial rotation patterns, losing their pre-TKA differences. Implanted females lost on average 7.5 degrees of flexion, 1.8mm lateral condylar position and 4 degrees of axial rotation more than the implanted males. Furthermore, the implanted females experienced a significantly higher intra-group variance, which suggests more incoherent results. There was a significant difference between implanted and normal females in LAP and MAP, but almost no significance was found for the difference between the implanted and normal males. Implanted females achieved up to 67% less axial rotation than the normal females. The difference in the axial rotation between the implanted and normal females for all flexion angles, except full extension, was found to be highly significant. The males, on the other hand, showed significant difference only at full extension and 90 degrees of flexion.

Discussion: This is the first study to perform a sexual comparison of normal and implanted subjects with respect to in vivo kinematic motion during a deep knee bend. A decrease in sexual differences following TKA was observed and may be interpreted as equalization of the gender motion and performance. Equivalent implant designs led to equal motion for the implanted females and males, though before surgery, differences were present and significant. In addition, as more evident differences between implanted and normal females were observed when compared to male groups, it could be concluded that the kinematic changes after TKA among the females were greater, and that females conformed to male kinematics

Average lateral (LAP) and medial translation (MAP) for implanted and normal subjects

Percentile differences in axial rotation, lateral and medial translation between implanted and normal subjects (comparison of male and female changes after TKA) (Figure 3). These results will likely lead to stronger negative changes in female performance when compared to the males' following TKA. Since differences between females and males are relevant in healthy conditions, they should also be preserved with the implanted knee. It is unclear at this time if a Gender Specific TKA would allow females to recover their normal kinematic patterns, but further research is now being conducted to bring more insight. Requirements for this new implant include higher flexion angle, more natural movement, better patello-femoral performance, kinematic similarity to normal females, and lower incidence and magnitude of lift-off.