Proceedings of the Canadian Society for Mechanical Engineering International Congress 2021
CSME Congress 2021
June 27-30, 2021, Charlottetown, PE, Canada

Force Characterization of Soft Tissues in the Post-TKR Knee During Activities of Daily Living

Liam Montgomery[1*], Samira Vakili[1], Brent Lanting[1,3], Ryan Willing[1,2]
[1]Department of Biomedical Engineering, Western University, London, Canada
[2]Department of Mechanical and Materials Engineering, Western University, London, Canada
[3]London Health Science Center, London, Canada
*lmontgo7@uwo.ca

While total knee replacement (TKR) aims to provide patients with a pain-free joint, previous studies have reported that as few as 52% of patients are satisfied with their functional outcomes. A leading cause of dissatisfaction and revision of TKR is joint instability. The key to correcting TKR instability is better understanding of the loads crossing the knee. Therefore, the objective of this study is to characterize the force contributions of knee ligaments after TKR under loading conditions and motions representative of those present during activities of daily living (ADL) and compare them to published *in situ* TKR contact forces.

This study used data collected while testing six post-TKR cadaveric knees, on a VIVO 6 degrees of freedom joint motion simulator (AMTI, Watertown, MA). Following TKR surgery with cruciate retaining implants, each specimen was mounted onto the VIVO and subjected to loading simulating ADL, including gait, stair ascent, and stair descent while joint kinematics were recorded. The polyethylene bearing was removed, and joint reaction forces were measured while the knee underwent displacements according to the previously recorded kinematics. Force measurements were repeated after sequentially cutting the posterior cruciate ligament (PCL), medial-side ligaments, and lateral side-ligaments. Using the principle of superposition, the force contributions of each structure throughout ADL could be calculated. These ligament forces were compared with representative TKR joint contact forces measured with instrumented implants, obtained from the Orthoload database.

We determined the average ligament forces through each ADL motion cycle and noted that medial side ligaments were the main ligament force contributors for all motions. We also compared average total ligament force to the average total joint contact forces during all ADL motions, as reported by Orthoload. During the swing phase of all motions ligaments contributed to a large portion of the total joint contact force (e.g. 141.284+/-24.167 vs 300.645+/-64.346 during gait). We note that the absolute ligament contribution is highest during stance phase when the leg is fully extended, since this is when knee ligaments become most taut. However, ground reaction forces also peak during this phase, so the relative contribution of the ligaments is at its lowest.

Despite being relatively small compared to total joint contact force during weight-bearing phases of ADL, the ligament contribution to joint compression is not negligible. Thus, ligament forces should be considered in situations where joint contact forces are being predicted (e.g. when estimating joint contact forces using musculoskeletal modelling).