Measuring the Sensitivity of Total Knee Replacement Kinematics and Laxity to Soft Tissue Imbalances

Ryan Willing, Peter S. Walker

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ORIGINAL ARTICLE:

Measuring the Sensitivity of Total Knee Replacement Kinematics and Laxity to Soft Tissue Imbalances

Ryan Willing[1*], Peter S. Walker[2]

[1]University of Western Ontario, [2]NYU Langone Orthopaedic Hospital.

[*]Corresponding Author
Ryan Willing, Ph.D.
Assistant Professor
Dept. of Mechanical & Materials Engineering
The University of Western Ontario
1151 Richmond Street N. London,
Ontario N6A 5B9
Email: rwilling@uwo.ca
Mobile: (519) 661-2111 x80295

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ABSTRACT: Ligament balancing during total knee replacement (TKR) is receiving increased attention due to its influence on resulting joint kinematics and laxity. We employed a novel in vitro technique to measure the kinematics and laxity of TKR implants during gait, and measured how these characteristics are influenced by implant shape and soft tissue balancing, simulated using virtual ligaments. Compared with virtual ligaments that were equally balanced in flexion and extension, the largest changes in stance-phase tibiofemoral AP and IE kinematics occurred when the virtual ligaments were simulated to be tighter in extension (tibia offset 1.0 ± 0.1 mm posterior and 3.6 ± 0.1° externally rotated). Virtual ligaments which were tight in flexion caused the largest swing-phase changes in AP kinematics (tibia offset 2.3 ± 0.2 mm), whereas ligaments which were tight in extension caused the largest swing-phase changes in IE kinematics (4.2 ± 0.1° externally rotated). When AP and IE loads were superimposed upon normal gait loads, incremental changes in AP and IE kinematics occurred (similar to laxity testing); and these incremental changes were smallest for joints with virtual ligaments that were tight in extension (in both the stance and swing phases). Two different implant designs (symmetric versus medially congruent) exhibited different kinematics and sensitivities to superimposed loads, but demonstrated similar responses to changes in ligament balancing. Our results demonstrate the potential for pre-clinical testing of implants using joint motion simulators with virtual soft tissues to better understand how ligament balancing affects implant motion.

Keywords: Stability; Laxity; Joint motion simulator; Virtual ligaments; Ligament balancing; Total knee replacement