The Relationship Between Alignment, Function And Loading In Total Knee Replacement: In-Vivo Analysis Of A Unique Patient Population

David E. Williams, BEng1,2, Andrew Metcalfe, MRCS1,2, June Madete, BEng PhD1,2, Gemma Whatling, BEng PhD1,2, Paul Biggs, BEng1,2, Alexis Roux, BEng1,2, Peter J. Kempshall, MBChB MRCS3, Kathleen Lyons, MB BCh BAO FRCR3, Mark Forster, FRCS (Orth)3, Catherine A. Holt, BEng PhD1,2.
1Cardiff University, Cardiff, United Kingdom, 2Arthritis Research UK Biomechanics and Bioengineering Centre, Cardiff, United Kingdom, 3Cardiff and Vale University Health Board, University Hospital of Wales, Cardiff, United Kingdom.


Introduction: One of the main surgical goals when performing a total knee replacement (TKR) is to ensure the implants are properly aligned and correctly sized; however the effect of alignment on the biomechanics of the knee during functional activities is not well understood. Cardiff University has a unique access to a group of patients within the local region who have a relatively high frequency of poor alignment, and early failure [1]. Despite the obvious disappointment, it provides a rare insight into how mal-alignment of TKR’s can affect patients from a clinical and biomechanical point of view to determine how to best align a TKR. The aim of this study was to perform an in-vivo analysis investigating the relationship between alignment and biomechanical function to assist surgeons by determining the optimum alignment for patients.

Methods: Twenty-eight patients with 33 Kinemax (Stryker) TKR’s were recruited. Ethical approval was obtained. Patients undertook gait analysis of level walking using 8 Qualysis Pro-Reflex cameras with 2 Bertec force plates built into the floor using a modified Helen Hayes marker set. Visual3D (C-motion, Inc.) was used to compute lower limb kinetics and kinematics. Single plane video fluoroscopy of the knee was taken for a step-up and step-down task to determine TKR kinematics. Joint Track image registration software (University of Florida, USA) was used to match CAD models of the implant to the x-ray images. This technique is known to have high accuracy in measuring TKR kinematics [2]. Further processing using JointView software (University of Florida, USA) calculated 3D joint kinematics and the tibio-femoral contact points. Bespoke code developed within MATLAB (The Mathworks Inc, USA) was utilised to calculate the centre of rotation (CoR) using the contact point data. Long-leg radiographs and CT scans were used to define component alignment and rotation. Hip-Knee-Ankle (HKA) angle was measured from the radiographs to determine long leg alignment in the frontal plane with lateral distal-femoral angle (LDFA) and medial proximal tibial angle (MPTA) calculated as secondary measures. The CT scans were used to calculate each components rotational alignment and inter-component rotation.

Results: The mean age of the patients was 74 (range 60-89), a mean oxford score of 35 (13-47) and mean KOOS score of 72 (15-98). Average HKA measurement was 1.1° varus (10° to 9.5° valgus) and mean femoral and tibial rotation was 1° internal and 4° external respectively. Preliminary CoR calculations (n=25) for step up and step down showed 72% of patients have a laterally positioned CoR.
A weak correlation was found between medial-lateral location of CoR and internal/external rotation range of motion (ROM) (Spearman’s rank $r=0.351$) as well as LDFA ($r=0.337$). CoR was not related to inter-component rotation or individual component rotation.

**Discussion:** Results from the gait analysis showed that varus alignment increases the knee adduction moment, valgus alignment results in poor gait function and neutral alignment remains the best compromise at present. Preliminary fluoroscopy results show that the majority of patients have a laterised CoR during a step up and step down activity.

CoR in this pilot correlates to ROM of internal/external rotation and LDFA and yet did not correlate to HKA or the rotational alignment of the components.

This method will be used in a future study of these patients to investigate TKR kinematics and COR for the full cohort during step up and step down activities separately.

**Significance:** Understanding the relationships between alignment and biomechanical function in patients with malaligned knee replacement implant components can inform surgeons and aid surgical planning decisions. Determining the factors that influence optimal alignment for individual patients will result in improved function post-surgery and increase patient satisfaction.

*ORS 2015 Annual Meeting*

*Poster No: 1790*