Increased Anterior-Posterior Translation Differences During Level Walking in Medial Stabilized Total Knee Arthroplasty as Compared to Other Implant Designs

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Disclosures: Gross (N), Gale (N), Almoukamal (N), Copp (N), Urish (5: Smith Nephew, Peptilogics, Onkos, Osteal), Anderst (5: Smith & Nephew)

INTRODUCTION: Roughly 700,000 patients receive total knee arthroplasty (TKA) in the United States each year to treat end-stage osteoarthritis [1]. TKA has excellent outcomes and is effective in reducing joint pain and improving range of motion (ROM). However, despite implant design advancements and surgical innovations, 20% of patients remain unsatisfied following TKA [2]. Medial congruent (MC) (also commonly known as medial stabilized) implant designs were introduced to provide increased stability and kinematics that better resemble the native medial knee in comparison to traditional posterior-stabilized (PS) and cruciate-retaining (CR) designs [3]. The objective of this study was to compare kinematics and patient-reported outcomes (PROs) after MC TKA to those after PS and CR TKA. We hypothesized that MC TKA restores native knee kinematics better than PS or CR TKA and that MC TKA PROs will be better following TKA.

METHODS: Patients undergoing primary MC, PS, or CR TKA provided written informed consent to participate in this IRB approved study. TKA was performed using a robotic system to increase precision and consistency following a restricted kinematic alignment philosophy. An approximate 1mm laxity completed by manual tension was the target for all knees. The implant design was selected by the surgeon. Patients performed level walking at a self-selected pace on an instrumented treadmill (Bertec) while synchronized biplane radiographs were collected at a rate of 100 frames per second with 1 ms exposure per image 1-year post-surgery. Late swing to midstance was imaged for three trials for each knee, and midstance through push off was imaged for three trials for each knee. Subject-specific three-dimensional bone models of the distal femur and proximal tibia were constructed from computed tomography (CT) scans (resolution: 0.433x0.432x0.625 mm) using Mimics 26. Bone models were matched to radiographs using a previously validated volumetric model-based tracking technique with 0.9° and 0.7 mm accuracy [4]. CAD models of the femur and tibia prostheses were obtained from the manufacturer and co-registered to static biplane radiographs to create a single bone-plus-implant model that was registered to the TKA knee. An automated process was used to create anatomic coordinate systems on each knee, with the femur origin centered between the condyles and the tibia origin centered between the medial and lateral edges of the tibia [5]. Six degrees of freedom tibiofemoral kinematics during gait were calculated during the stance phase of gait following standard methods [6]. Comparisons between the continuous kinematics waveforms of MC, PS, and CR TKA knees to their contralateral side were assessed using paired Statistical Parametric Mapping (SPM) t-tests. TKA groups were compared using SPM ANOVA. Knee Injury Osteoarthritis Outcome Score (KOOS) [7] at 1-year post surgery was compared among TKA groups using ANOVA. A Bonferroni post-hoc analysis was performed following significant ANOVA results.

RESULTS: A total of 9 patients received MC TKA, 14 patients received PS TKA, and 7 patients received CR TKA. A total of 360 trials were included in this analysis. Across all implant groups, the TKA knee was less varus (approximately 4°) and the tibia was less lateral (approximately 7mm) following TKA compared to the contralateral side. The femur to tibia origin distance was approximately 6 mm greater than contralateral knees following both PS and MC TKA. Following CR TKA, the tibia was 3-5° less externally rotated during the second half of stance compared to the contralateral side. Finally, when comparing implant types, the tibia was more anteriorly translated following MC TKA than after CR or PS TKA with the difference (approximately 7mm) significant compared to PS TKA. CR TKA patients reported significantly higher KOOS-ADL (CR 88.7±9.7 vs. MC 71.6±15.6; p=0.02) and KOOS-QDL (CR 73.2±14.8 vs. MC 48.6±19.5; p=0.01) scores compared to MC TKA.

DISCUSSION: The main kinematics difference between MC and other knee implant types during gait is that MC knees have greater anterior tibial translation. Varus and medial-lateral translation were near neutral for all implant types. These kinematics and outcomes are limited to the stance phase of gait at 1-year post surgery. These differences may also be a function that different tension laxity is required for different knee implants.

SIGNIFICANCE: Differences in anterior-posterior translation may contribute to differences in patient-reported outcomes after MC TKA.

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ACKNOWLDGEMENTS: This work was funded by Smith and Nephew.

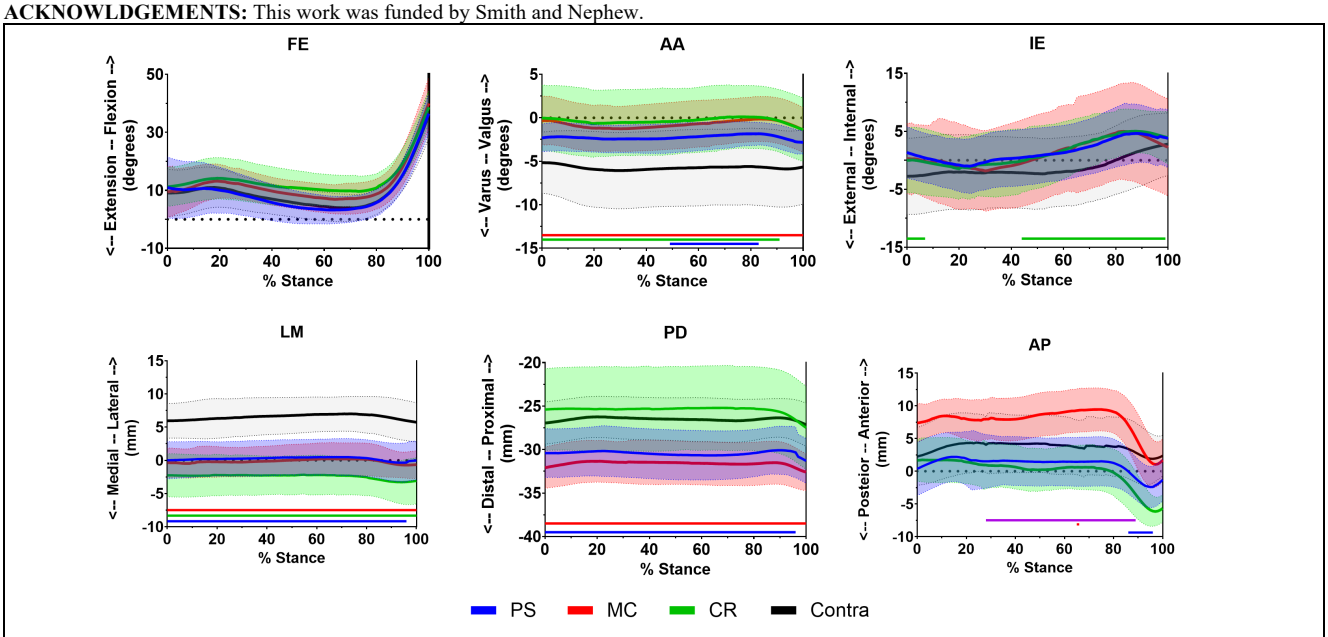

Figure 1: The average and standard deviation of continuous kinematics waveforms for posterior-stabilized (blue), medial congruent (red), and cruciate-retaining (green) TKA knees and contralateral knees (black) during the stance phase of gait. Solid straight lines on the bottom of each kinematic waveform indicate times during the gait cycle where significant differences exist between the corresponding colored TKA group and the contralateral knee. The purple significance line in AP translation indicates a difference between the medial congruent (red) and posterior-stabilized (blue) waveforms.