In Vivo Contact Kinematic Comparisons of Asymmetrical Bearing Geometry Cruciate Retaining Total Knee Arthroplasty and the Native Knee During Gait

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INTRODUCTION: Total knee arthroplasty (TKA) is the surgical treatment of choice for patients with knee osteoarthritis whom want to regain normal function in their day-to-day lives. A recently introduced Asymmetrical Bearing Geometry cruciate retaining (CR) TKA attempts to mimic *in vivo* native knee kinematics of femoral rollback and lateral femoral rotation through the design of medial concave and lateral convex tibial components and a posterior medial lip. Native PCL retention has been proposed to help mimic native knee kinematics and aid patients in maintaining proprioception. A knee replacement design that mimics native knee kinematics during gait may help patients return to active lifestyles following TKA procedure. This study compares the *in vivo* femoral-tibial contact kinematics between the contemporary CR TKA design and the contralateral knee using a validated dual fluoroscopy imaging system.

METHODS: Fifteen well-functioning Asymmetrical Bearing Geometry CR TKA patients (9 females and 6 males) with no post-operative complications were included in this study, in accordance with the Institutional Review Board's policies. The average age of the enrolled patients (± SD) was 68.4 years (± 5.9; range: 60.5-80.6) and the patients had an average BMI of 31.2 kg/m^2 (± 9.9; range: 19.6-60.6). All fifteen patients underwent a computed tomography scan to generate 3D subject-specific, anatomic models of both knees. The coordinate systems for the tibial and femoral knee components were determined using anatomic landmarks with a previously described protocol. All 15 patients had two trials of their gait analyzed under dual fluoroscopy to generate 2D projections of each knee that were imported into a virtual DFIS environment. In the DFIS environment, the 3D anatomic models were projected onto the 2D projections in order to determine *in vivo* kinematics of each knee over the gait cycle. From the kinematic profile of each knee and the 3D anatomic models, we determined the medial and lateral contact position between the femoral and tibial components at each point in the gait cycle. Using the contact positions of the medial and lateral condyles, we determined the angle between the medial and lateral condyle contact positions, about the long axis of tibia (axial angle), to compare how native and CR TKA knees rotate through the gait cycle. The kinematic differences between the CR TKA and the native knee were assessed using a two-sided Wilcoxon rank sum test, with the significance level set at $\alpha = 0.05$.

RESULTS: Asymmetrical Bearing Geometry CR TKAs demonstrated differing contact positions relative to the native knee throughout the gait cycle (Fig 1). Lateral-medial and anterior-posterior contact position of the medial condyle differed significantly between CR TKA and native knee throughout the entire gait cycle, by an average of 3.1 ± 0.5 mm and 6.2 ± 1.3 mm, respectively. Lateral-medial position of the lateral condyle differed only intermittently between the CR TKA and native knee during the gait cycle, but anterior-posterior contact positions of the lateral condyle differed throughout the gait cycle by an average of 7.8 ± 2.0 mm. As can be seen in Figure 1, the distal-proximal contact positions of both lateral and medial condyles were greater for the CR TKA throughout the gait cycle by an average of 4.4 ± 0.5 mm for the medial condyle and 6.1 ± 0.5 mm for the lateral condyle. There were no statistical differences between the CR TKA and the native knee for net translations during the stance phase in either the anterior-posterior the lateral-medial axes, for either condyle. The CR TKA and the native knee exhibited no significant differences in axial angles throughout the stance phase (Fig 2).

DISCUSSION: A recently introduced Asymmetrical Bearing Geometry cruciate retaining (CR) TKA attempts to mimic *in vivo* native knee kinematics of femoral rollback and lateral femoral rotation through the design of medial concave and lateral convex tibial components and a posterior medial lip. Analysis of the *in vivo* contact kinematics between a CR TKA and the contralateral native knee revealed asymmetric 3-dimensional positioning, throughout the gait cycle. Despite asymmetric contact positions, the CR TKA displayed comparable contact kinematics patterns to the contralateral native knee in translation and rotation during the gait cycle. The similarity in anterior-posterior and lateral-medial translation suggests that the CR TKA is able to mimic *in vivo* kinematics of the native knee during the small angles of knee flexion observed during gait.

SIGNIFICANCE/CLINICAL RELEVANCE: Analysis of the *in vivo* 3D contact kinematics revealed asymmetry in contact point positioning between the Asymmetrical Bearing Geometry CR TKA and contralateral native knee; however, similar contact kinematic patterns in translation and rotation were observed, suggesting that the contemporary CR TKA design may have the potential to replicate the native knee contact kinematics during gait.

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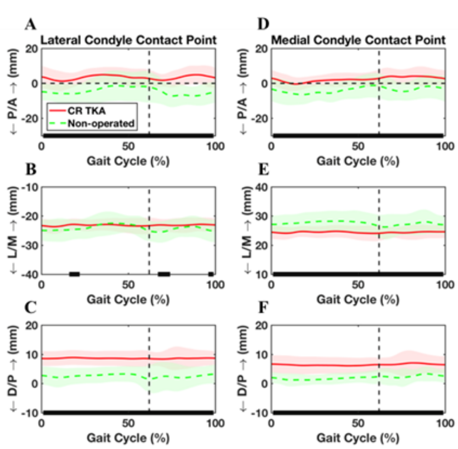

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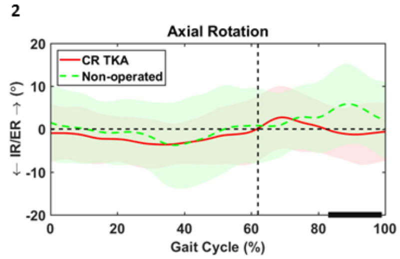

Figure 1: Average and standard deviation (shaded) of contact position along multiple axes during gait cycle for both lateral and medial condyle. Black bar denotes points of significant difference. (ABC) Lateral Condyle (A) Anterior-Posterior (B) Medial-Lateral (C) Proximal-Distal (DEF) Medial Condyle (D) Anterior-Posterior (E) Medial-Lateral (F) Proximal-Distal.

Figure 2: Average and standard deviation (shaded) of axial angle between medial and lateral components during gait cycle. Black bar denotes points of significant difference.