Gait and Knee Flexion In-Vivo Kinematics of Asymmetric Tibial Polyethylene Geometry Cruciate Retaining Total Knee Arthroplasty

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Summary: The study findings demonstrate that native knee kinematics was not fully restored in patients with unilateral asymmetric tibial polyethylene bearing geometry CR TKA during functional activities.

Introduction:
The preservation of the posterior cruciate ligament in cruciate retaining (CR) total knee arthroplasty (TKA) designs has the potential to restore healthy knee biomechanics, however, concerns related to kinematic asymmetries during functional activities still exist in unilateral TKA patients. As there is a limited data available regarding the ability of the contemporary CR TKA design with concave medial and convex lateral tibial polyethylene bearing components to restore healthy knee biomechanics, this study aimed to investigate in vivo three-dimensional (3D) knee kinematics in CR TKA patients during strenuous knee flexion activities and gait.

Methods:
Using a combined computer tomography and dual fluoroscopic imaging system approach, in-vivo kinematics of fifteen unilateral CR TKA patients were evaluated during sit-to-stand, step-ups, single-leg deep lunge and level walking (Figure 1).

Results:
Significantly smaller internal knee rotation angles were observed for the contemporary CR TKA design during step-ups (2.6±5.8° vs 6.3±6.6°, p<0.05) and gait (0.6±4.6° vs 6.3±6.8°, p<0.05; Figure 1). Significantly larger proximal and anterior femoral translations were measured during sit-to-stand (34.7±4.5 mm vs 29.9±3.1 mm, p<0.05; -2.5±2.9 mm vs -8.1±4.4 mm, p<0.05) and step-ups (34.1±4.5 mm vs 30.8±2.9 mm, p<0.05; 2.2±3.2 mm vs -3.5±4.5 mm, p<0.05; Figure 2, 3). Significantly smaller ranges of varus/valgus and internal/external rotation range of motion were observed for CR TKA, when compared to the non-operated nee, during strenuous activities and gait.

Discussion:
The preservation of the posterior cruciate ligament in the contemporary asymmetric bearing geometry CR TKA design with concave medial and convex lateral tibial polyethylene bearing components has the potential to restore healthy knee biomechanics, however, the study findings demonstrate that native knee kinematics was not fully restored in patients with unilateral asymmetric tibial polyethylene bearing geometry CR TKA during functional activities.

Figure 1: Dual fluoroscopic imaging system (DFIS) aprroach used for registration of 3D models on fluoroscopic silhouettes.
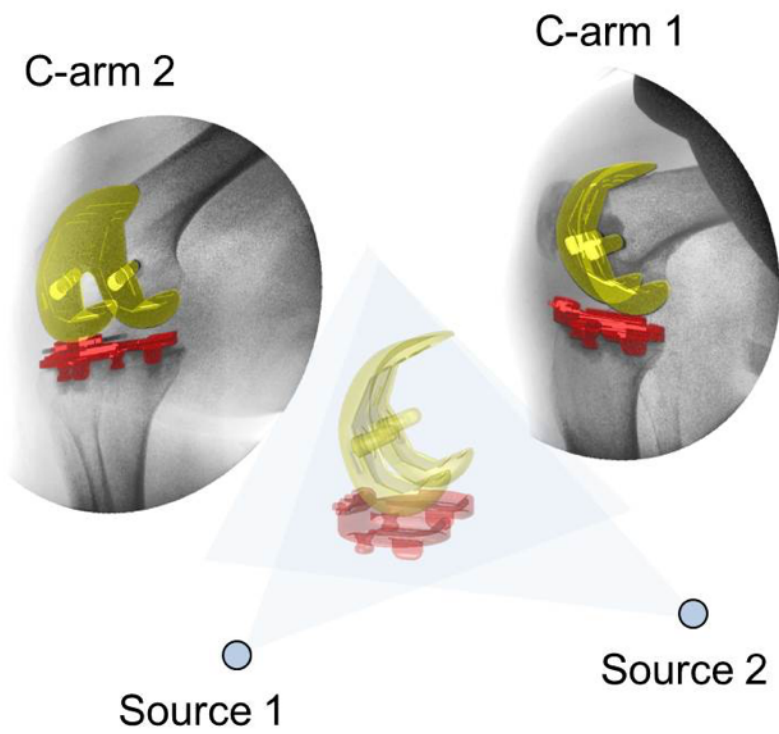
Figure 2: Average and standard deviation of knee extension/flexion (a), knee valgus/varus (b), knee external/internal rotation (c), medial/lateral femoral translations (d), distal/proximal femoral translations (e), and posterior/anterior femoral translations (f) for the operated and non-operated knees in unilateral CR TKA patients during sit-to-stand. Black bars on the horizontal axis (Sit-to-stand cycle %) indicate statistical significant differences between limbs.
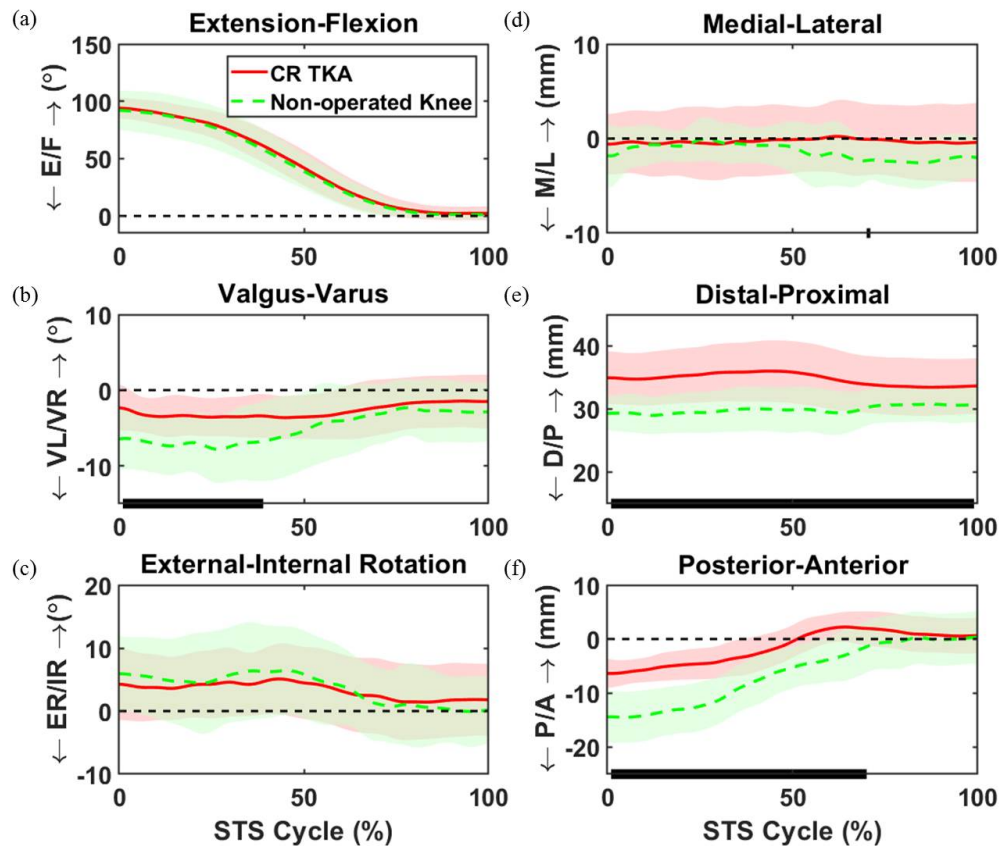
Figure 3: Average and standard deviation of knee extension/flexion (a), knee valgus/varus (b), knee external/internal rotation (c), medial/lateral femoral translations (d), distal/proximal femoral translations (e), and posterior/anterior femoral translations (f) for the operated and non-operated knees in unilateral CR TKA patients during step-ups. Black bars on the horizontal axis (Step-up cycle %) indicate statistical significant differences between limbs.
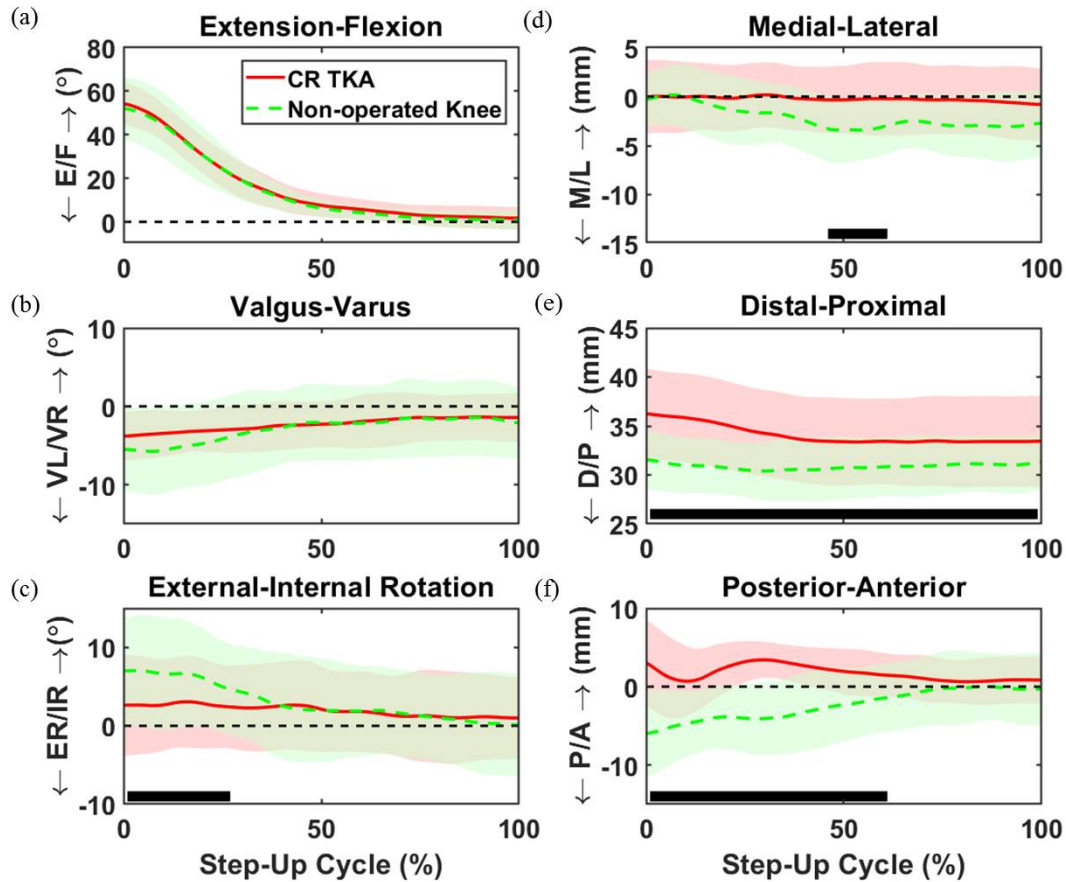
Figure 4: Average and standard deviation of knee extension/flexion (a), knee valgus/varus (b), knee external/internal rotation (c), medial/lateral femoral translations (d), distal/proximal femoral translations (e), and posterior/anterior femoral translations (f) for the operated and non-operated knees in unilateral CR TKA patients during gait. Black bars on the horizontal axis (gait cycle %) indicate statistical significant differences between limbs.