

# Bicruciate Stabilized Total Knee Arthroplasty Restores Native Knee Kinematics Better Than Cruciate Retaining Total Knee Arthroplasty

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**INTRODUCTION:** Knee arthroplasty is an effective procedure for end-stage osteoarthritis that is performed in over 700,000 patients each year in the United States, yet 20% of patients report limited function, persistent disability, and reduced quality of life<sup>1-4</sup>. Total knee arthroplasty (TKA) is the most common knee arthroplasty procedure, but the type of TKA prosthesis is often determined by surgeon preference rather than which prosthesis most closely restores native knee kinematics. Previous studies using single-plane fluoroscopic imaging during squatting demonstrated that cruciate-retaining (CR) TKA had greater external rotation and anterior motion of the medial femoral condyle during deep flexion than bicruciate-stabilizing (BCS) TKA. However, it remains unclear which TKA more closely restores kinematics to that of the native knee<sup>5</sup>. Rising from a chair and climbing stairs are common activities of daily living that require deep flexion and are highly correlated with patient satisfaction after knee arthroplasty<sup>6</sup>. The purpose of this study was to determine how well CR and BCS TKA restore native tibiofemoral kinematics during chair rise and stair ascent. Our hypothesis was that due to retention of more native anatomical structure, the CR would resemble the native knee kinematics more closely than BCS.

**METHODS:** Patients undergoing unilateral total knee arthroplasty provided informed written consent to participate in this IRB-approved study. The NAVIO robotic system was used by the surgeon to guide implant placement with the goal of achieving mechanical alignment. All participants had KL scores > 2 on the operated knee and KL scores < 2 on the contralateral knee. Synchronized biplane radiographs were collected at 100 images/second for each knee during three trials each of a chair rise and a stair ascent motion (80 kV, 125 mA, 1 ms exposure per image). Motion of the affected and contralateral femur and tibia were tracked by matching digitally reconstructed radiographs obtained from subject-specific CT scans to the biplane radiographs using a validated registration system (accuracy: 0.7 mm, 0.9°)<sup>8</sup>. Coordinate systems were constructed on the contralateral side using anatomical landmarks of the distal femur and proximal tibia, as well as the hip joint center and ankle joint center, and were mirrored onto the operated side after co-registering corresponding bones<sup>9</sup>. Tibiofemoral kinematics were calculated for pre- and post-operative test sessions for both knees<sup>9,10</sup>. Results from three trials were averaged for each activity for each knee. Side-to-side differences (SSDs) of the kinematics waveforms (post-operative surgical knee minus contralateral knee) at corresponding knee flexion angles were calculated for each participant. Group differences were identified using an unpaired t-test and statistical parametric mapping (SPM) to compare SSD waveforms between groups<sup>11</sup> with significance set at  $p < 0.05$ .

**RESULTS:** This is an interim analysis of an ongoing study. Thus far, 16 patients (6F, 10M, average age  $65.5 \pm 5.8$  years), seven that received CR (Journey II CR, Smith & Nephew) and nine that received BCS (Journey II BCS, Smith & Nephew), completed post-operative ( $14.3 \pm 1.59$  months) testing. A total of 192 trials were included in this analysis. Relative to the contralateral knee, the femur was more posterior to the tibia for the CR group compared to the BCS group from  $46^\circ$  to  $89^\circ$  of flexion during chair rise ( $p < 0.001$ ) (Figure 1). During stair ascent, CR knees were more abducted ( $p = 0.050$ ), internally rotated ( $p = 0.050$ ) and medially translated ( $p = 0.032$ ) relative to the contralateral knee than in BCS knees from  $26^\circ$  to  $41^\circ$ ,  $63^\circ$  to  $65^\circ$  and  $26^\circ$  to  $65^\circ$  of knee flexion, respectively (Figure 2). Average SSD was larger in the CR knees for all kinematics components, except for Int/Ext rotation (Table 1).

**DISCUSSION:** The most important finding of this study was that BCS TKA appears to restore tibiofemoral kinematics more closely to that of the contralateral knee than CR. This study is unique in that post-surgical bilateral knee kinematics were measured over multiple trial repetitions and continuous knee kinematics were compared. These results are limited to the specific knee replacements and activities tested, and it was assumed that contralateral knee kinematics match healthy knee kinematics of the operated side.

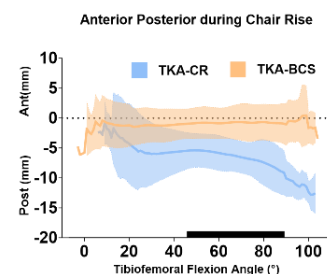
**SIGNIFICANCE:** This study provides quantitative data to suggest that sparing the posterior cruciate ligament in a CR leads to tibiofemoral kinematics that differ significantly from the contralateral knee in comparison to BCS. Evidence on how different prosthesis affect kinematics may aid in clinical decision making and improve patient satisfaction with knee arthroplasty by restoring native kinematics symmetry.

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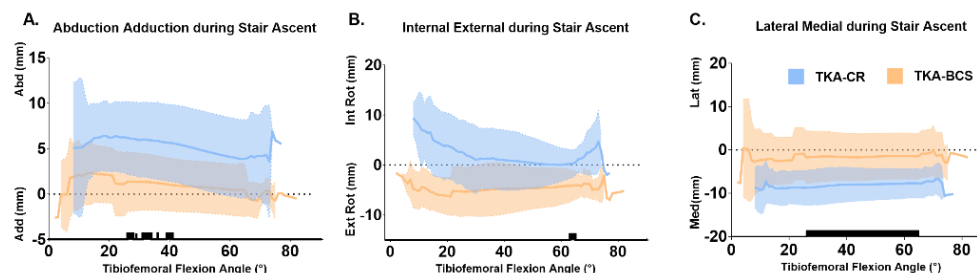
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**Table 1.** Average side-to-side differences in knee kinematics at corresponding flexion/extension angles during chair rise and stair ascent.

		Abd/Add (°)	Int/Ext Rot (°)	Lat-Med (mm)	Prox-Dist (mm)	Ant-Post (mm)
Chair Rise	CR	4.38	-3.68	-7.29	-2.04	-6.40
	BCS	0.84	-5.75	-2.35	-3.90	-0.97
Stair Ascent	CR	5.25	1.73	-8.14	-2.56	-4.19
	BCS	0.93	-4.75	-1.59	-3.57	-0.94



**Figure 1.** Group average side-to-side difference between post-operative knee kinematics of operated and contralateral knee in CR and BCS TKA during chair rise. Shaded area represents one standard deviation. The solid black bar on the X-axis identifies the period of significant differences between groups ( $p < 0.05$ ).



**Figure 2.** Group average side-to-side difference between post-operative knee kinematics of operated and contralateral knee in CR and BCS TKA during stair ascent. (A) Ab/adduction, (B) internal/external rotation and (C) medial-lateral translation. Solid lines indicate group means, while the shaded area represents one standard deviation. The solid black bar on the X-axis identifies the period of significant differences between groups ( $p < 0.05$ ).