

# In-Vivo Patellar Kinematics Analysis of Bi-cruciate Retaining Total Knee Arthroplasty During Functionally Strenuous Activities

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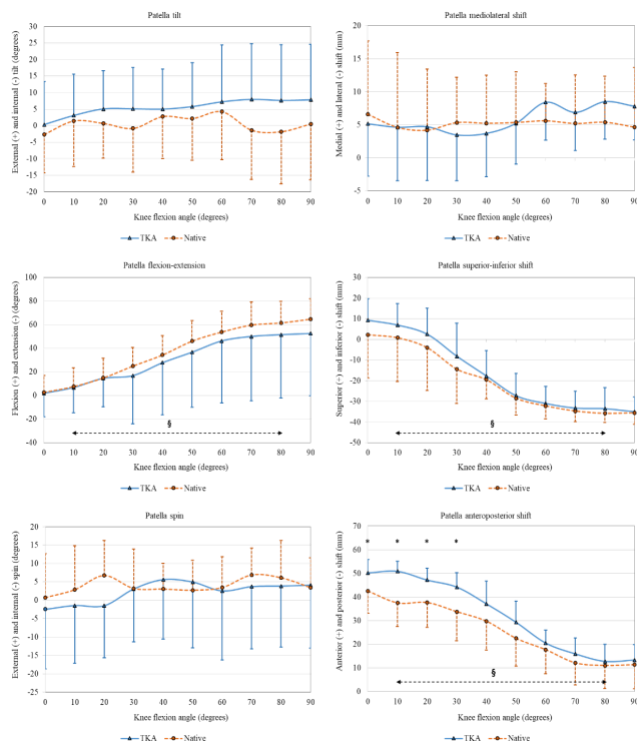
**INTRODUCTION:** Abnormal patellofemoral kinematics is one of the most common causes of anterior knee pain after total knee arthroplasty (TKA), which can result in reduced patient satisfaction and quality of life. Bi-cruciate (BCR) TKA retains both the anterior and posterior cruciate ligaments, which have the potential to optimize in vivo kinematics. Several studies have demonstrated improved patient satisfaction compared to conventional TKAs. However, few studies have evaluated the BCR TKA design in terms of its ability to restore in vivo patellofemoral kinematics. The aim of this study was to compare in-vivo patellar kinematics between the operated and contralateral native knee in patients who have undergone BCR TKA during strenuous functional activities.

**METHODS:** Eleven patients who received unilateral BCR TKA were evaluated during single-leg lunges and sit-to-stand using a validated computerized tomography and dual-fluoroscopy imaging system. A 3D-to-2D image mapping procedure was performed to calculate the patella kinematics at six degrees of freedom. A mixed-model ANOVA with repeated measures was applied to compare the kinematics between the BCR TKA and native contralateral knee.

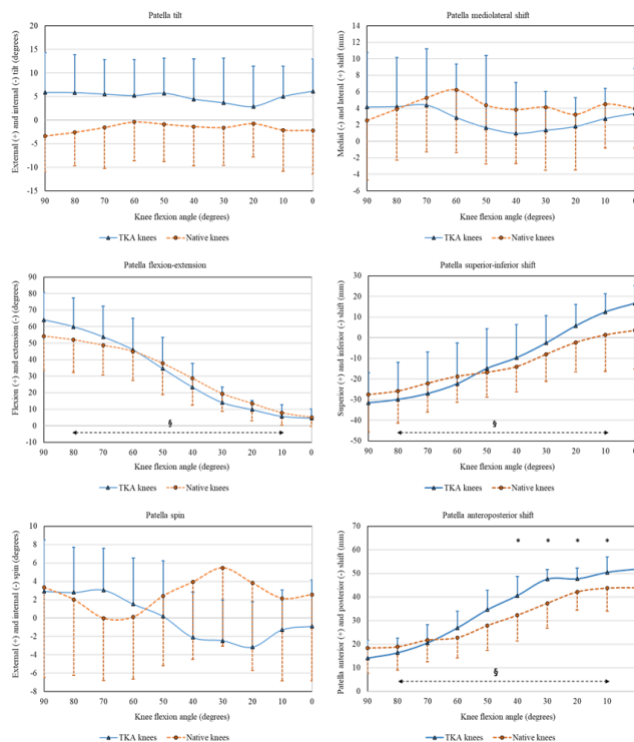
**RESULTS:** The composite patella thickness in BCR TKA was similar to that of the native patella ( $21.62 \pm 3.41$  mm vs.  $20.07 \pm 4.12$  mm,  $p = 0.347$ ). BCR TKA demonstrated a significantly greater anteroposterior shift of the patella compared to native knees within 30 degrees of knee flexion in both single-leg lunges and sit-to-stand maneuvers ( $F = 118.01-445.98$ ,  $p < 0.040$ ; Figure 1 and 2). No significant differences in other kinematic parameters were noted between the two groups during the two activities.

**DISCUSSION:** Our results showed that BCR TKA did not fully restore patella kinematics during strenuous activities. Preserving both crucial ligaments in TKA has the potential to minimize paradoxical anteroposterior movement of the knee joint, which prevents delayed engagement of the patella to the trochlear groove and mitigates the anterior shift of the patella during deep knee flexion. However, at early knee flexion, the increased anterior shift of the patella in BCR TKA demonstrated in this study may be attributed to the discrepancy between the implant and the native shape of the anterior femur, resulting in a lengthened arc of the extensor mechanism and modified load distribution across the patellofemoral joint.

**SIGNIFICANCE/CLINICAL RELEVANCE:** The findings of this study highlight that bi-cruciate retaining TKA does not fully restore in vivo patella kinematics during strenuous activities.



**Figure 1.** Six degrees of freedom patellar motion as a function of knee flexion in implanted knees (solid line) and native knees (dashed line) during single-leg lunges. \* denotes a significant difference between TKA knees and native knees ( $p < 0.05$ ). § and the arrowed dashed line indicates that the knee flexion angle had a main effect on the specific patella movement ( $p < 0.05$ ).



**Figure 2.** Six degrees of freedom patellar motion as a function of knee flexion in implanted knees (solid line) and native knees (dashed line) during sit-to-stand. \* denotes a significant difference between TKA knees and native knees ( $p < 0.05$ ). § and the arrowed dashed line indicates that the knee flexion angle had a main effect on the specific patella movement ( $p < 0.05$ ).