EMPOWR 3D Knee™
NATURAL MOTION TECHNOLOGY

Abstracts
A Dual-Pivot Pattern Simulating Native Knee Kinematics Optimizes Functional Outcomes After Total Knee Arthroplasty

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Source
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Abstract
Few studies on kinematics correlate patterns to functional outcomes after total knee arthroplasty (TKA). The purpose of this study was to determine if lateral pivot motion in early flexion and medial pivot in high flexion, simulating native knee kinematics, produces superior clinical outcomes. One hundred twenty consecutive TKAs were performed using sensor trials to record intraoperative knee kinematics. Lateral and medial pivot pattern designations were based on the center of rotation within 3 flexion zones: 0°-45° (early), 45°-90° (mid), and 90° to full flexion (late). Knee Society Scores, pain scores, and patient satisfaction were analyzed in relation to kinematic patterns. The results showed that Knee Society function scores were higher in TKAs with early lateral pivot/late medial pivot intraoperative kinematics compared to all other kinematic patterns (P = .018), and there was a greater decrease in the proportion of patients who reported that their knee never felt normal (P = .011). Early lateral/late medial pivot patterns had greater function scores at 1-year (P < .001) and greater improvement from preoperative baseline (P = .008) compared to those with the least ideal pattern. All patients with the most ideal pattern (early lateral, late medial) compared to none of the least ideal pattern reported they were very satisfied (P = .003). Patients with an intraoperative early lateral pivot pattern followed by medial pivot motion in later flexion, reported higher functional outcome scores along with higher overall patient satisfaction. Replicating the dual-pivot kinematic pattern observed in native knees may improve function and satisfaction after TKA.

Summary
- The purpose of this study was to determine if lateral pivot motion in early flexion and medial pivot in high flexion, simulating native knee kinematics, produces superior clinical outcomes.
- The results showed that Knee Society function scores were higher in TKAs with early lateral pivot/late medial pivot intraoperative kinematics compared to all other kinematic patterns, there was a greater decrease in the proportion of patients who reported that their knee never felt normal, as well as higher overall patient satisfaction.
- Replicating the dual-pivot kinematic pattern observed in native knees may improve function and satisfaction after TKA.
Tibiofemoral kinematics and condylar motion during the stance phase of gait.

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Source
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Abstract
Accurate knowledge of the dynamic knee motion in-vivo is instrumental for understanding normal and pathological function of the knee joint. However, interpreting motion of the knee joint during gait in other than the sagittal plane remains controversial. In this study, we utilized the dual fluoroscopic imaging technique to investigate the six-degree-of-freedom kinematics and condylar motion of the knee during the stance phase of treadmill gait in eight healthy volunteers at a speed of 0.67 m/s. We hypothesized that the 6DOF knee kinematics measured during gait will be different from those reported for non-weight-bearing activities, especially with regards to the phenomenon of femoral rollback. In addition, we hypothesized that motion of the medial femoral condyle in the transverse plane is greater than that of the lateral femoral condyle during walking.

Furthermore, we noted that motion of the medial femoral condyle in the transverse plane was greater than that of the lateral femoral condyle during the stance phase of gait. The rotational motion and the anterior-posterior translation of the femur with respect to the tibia showed a clear relationship with the flexion-extension path of the knee during the stance phase. Additionally, we observed that the phenomenon of femoral rollback was reversed, with the femur noted to move posteriorly with extension and anteriorly with flexion.

Summary
• The data in this study failed to support the hypothesis that the knee pivots medially but rather the results proved that the knee pivots laterally during walking.
• This study reported lateral pivot knee motion through the measurement of increased anteroposterior translation of the medial femoral condyle relative to the lateral femoral condyle during walking.
• These findings demonstrate that knee kinematics are activity dependant and motion patterns of one activity (non-weight-bearing flexion or lunge) cannot be generalized to other activities such as walking.

Internal tibial rotation during in vivo, dynamic activity induces greater sliding of tibio-femoral joint contact on the medial compartment.

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Source
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Abstract
Although extensive research has been conducted on rotational kinematics, the internal/external rotation of the tibio-femoral joint is perhaps less important for protecting joint health than its effect on joint contact mechanics. The purpose of this study was to evaluate tibiofemoral joint contact paths during a functional activity (running) and investigate the relationship between these arthrokinematic measures and traditional kinematics (internal/external rotation). Tibio-femoral motion was assessed for the contralateral (uninjured) knees of 29 ACL-reconstructed individuals during downhill running, using dynamic stereo X-ray combined with three-dimensional CT bone models to produce knee kinematics and dynamic joint contact paths. The joint contact sliding length was estimated by comparing femoral and tibial contact paths. The difference in sliding length between compartments was compared to knee rotation.

Sliding length was significantly larger on the medial side (10.2 ± 3.8 mm) than the lateral side (2.3 ± 4.0 mm). The difference in sliding length between compartments (mean 7.8 ± 3.0 mm) was significantly correlated with internal tibial rotation (P<0.01, R2 = 0.74). The relationship between rotational knee kinematics and joint contact paths was specifically revealed as greater tibial internal rotation was associated with larger magnitude of sliding motion in the medial compartment. This could suggest that lateral pivot movement occurs during running. Rotational kinematics abnormality should be treated for restoring normal balance of joint sliding between medial and lateral compartments and preventing future osteoarthritis.

Summary
• The data in this study failed to support the hypothesis that the knee pivots medially but rather the results proved that the knee pivots laterally during running.
• Other studies that report medial pivot motion are limited by the study of cadavers instead of humans with excessively low muscle loads which fail to replicate functional activities.
• Traditional total knee arthroplasty implants that are designed to solely duplicate medial pivot movement, may fail restore natural motion during demanding activities.
The knee joint center of rotation is predominantly on the lateral side during normal walking.

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Source
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Abstract
The purpose of this study was to test the hypothesis of whether the center of rotation (COR) in the transverse plane of the knee is in the medial side during normal walking in a manner similar to that previously described during non-ambulatory activities. The kinematics for normal knees was obtained from 46 knees during normal walking using the point cluster technique. The COR of the medial–lateral axis of the femur relative to the tibia was determined during the stance phase of walking. The hypothesis that the COR is in the medial side during stance was not supported by this study. The average COR during the stance phase of walking was in the lateral compartment for all 46 knees. In addition, the instantaneous COR occurred on the medial side on average <25% of the time during the stance phase. Thus, while the COR is predominantly on the lateral side of the knee during walking, the normal function of the knee during walking is associated with both lateral and medial pivoting. These results also demonstrate the importance of describing knee kinematics in the context of a specific activity or the constraints of the test conditions.

Summary
• The study objective was to determine whether the center of rotation (COR) of the knee lies more frequently on the medial side or the lateral side of the knee during walking.
• The results of this study demonstrated that the instantaneous COR of the knee was predominantly lateral to the center of the tibia during the stance phase of walking.
• The author concludes that TKR implant designs should permit lateral pivoting motions during normal walking (the most frequent activity of daily living) while permitting the capacity for medial pivoting motions during non-ambulatory activities such as squatting.

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In vivo deep-flexion kinematics in patients with posterior-cruciate retaining and anterior-cruciate substituting total knee arthroplasty.

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Source
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Abstract
Posterior-cruciate ligament retaining total knee arthroplasty designs have long been used with excellent clinical success, but often have shown kinematics and flexion performance that are significantly different from the natural knee. The purpose of this study was to compare deep-flexion knee kinematics in patients with two types of posterior-cruciate ligament retaining total knee arthroplasty. One group received a traditional curved symmetric articular configuration, and one group received a design incorporating a lateral compartment which constrains the lateral condyle to the antero-posterior center of the tibial plateau in extension, but allows translation in flexion—roughly approximating the role of the anterior cruciate ligament. In vivo kinematics were analyzed using three-dimensional model registration and plain radiographs of kneeling and squatting activities in 20 knees in 18 patients. Knees with the anterior cruciate ligament substituting design exhibited greater flexion, femoral antero-posterior translation and tibial internal rotation. Geometric features intended to improve knee flexion, including greater antero-posterior stability, a more posterior tibial sulcus, and reshaped femoral condyles, do provide measurable and significant differences in deep-flexion knee kinematics.

Summary
• Studies have shown that knee implant designs which restore more natural knee motion will manifest in superior clinical and functional results (Dennis, 1998; Banks 2003) and that ACL retaining knee replacements are preferred by patients (Pritchett, 2004).
• DJO Surgical’s 3DKnee™ recreates the function of the ACL through a laterally conforming tibial insert design. This conformity provides anteroposterior stability in extension yet allows posterior rollback in flexion.
• This study investigated the performance of the 3DKnee™ versus a traditional, symmetric cruciate retaining implant and demonstrated that the 3DKnee resulted in 10 degrees of increased flexion, increased lateral femoral rollback and increased tibial internal rotation, all of which support normal knee motion.
Additional References


15. Data on file with DJO Surgical


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