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# Variability in static alignment and kinematics for kinematically aligned TKA

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ABSTRACT

Background: Total knee arthroplasty (TKA) significantly improves pain and restores a considerable degree of function. However, improvements are needed to increase patient satisfaction and restore kinematics to allow more physically demanding activities that active patients consider important. The aim of our study was to compare the alignment and motion of kinematically and mechanically aligned TKAs.

Methods: A patient specific musculoskeletal computer simulation was used to compare the tibio-femoral and patello-femoral kinematics between mechanically aligned and kinematically aligned TKA in 20 patients.

Results: When kinematically aligned, femoral components on average resulted in more valgus alignment to the mechanical axis and internally rotated to surgical transepicondylar axis whereas tibia component on average resulted in more varus alignment to the mechanical axis and internally rotated to tibial AP rotational axis. With kinematic alignment, tibio-femoral motion displayed greater tibial external rotation and lateral femoral flexion facet centre (FFC) translation with knee flexion than mechanical aligned TKA. At the patellofemoral joint, patella lateral shift of kinematically aligned TKA plateaued after 20 to 30° flexion while in mechanically aligned TKA it decreased continuously through the whole range of motion.

Conclusions: Kinematic alignment resulted in greater variation than mechanical alignment for all tibio-femoral and patello-femoral motion. Kinematic alignment places TKA components patient specific alignment which depends on the preoperative state of the knee resulting in greater variation in kinematics. The use of computational models has the potential to predict which alignment based on native alignment, kinematic or mechanical, could improve knee function for patient's undergoing TKA.



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## 1. Introduction

Total knee arthroplasty (TKA) is an established procedure for improving pain and restoring a significant degree of function, especially for low-demand activities of daily living. However, an understanding of optimal alignment and patient specific kinematics is needed to restore knee motion closer to normal, allowing performance of physically demanding activities that more active patients consider important [1–3].

The philosophy of mechanical alignment of the implant after TKA has traditionally been done to preserve longevity of the implant and enhance post-operative knee function [4–6]. However, studies have shown that although a mechanically aligned TKA improves the patient's function, 20% to 25% of patients remain dissatisfied [7,8]. In addition, recent data has challenged the importance of post-operative mechanical alignment in TKA. Paratte et al. [9], in a study reviewing 398 TKAs, demonstrated no improvement in the 15 year implant survival rate in patients within and outside of a post-operative mechanical alignment $0° \pm 3°$ (standard deviation).

Recently, kinematic alignment has been proposed by Howell et al. [10–14] as an alternative to restore normal knee motion and function. Kinematic alignment references the femoral transcylindrical axis, believed to be the flexion extension axis of the knee. The aim is to align the angle and level of the distal joint line of the femoral component, posterior joint line of the femoral component, and joint line of the tibial component to those of the normal knee [11].

Kinematically aligned TKA has been performed since 2006 however unanswered issues continue regarding patient outcomes, survivorship, surgical technique and use of specialised surgical guides [15–18]. A randomized controlled study demonstrated kinematically aligned TKA resulted in better pain relief, post-operative function and range of motion than mechanically aligned TKA in 88 patients (88 knees) [16]. Other studies emphasized higher function as assessed using the Oxford Knee Score and WOMAC™ score on 198 patients (214 knees) [17]; on 101 patients (101 knees) with kinematic alignment [18]. However, one small series emphasized the potential for malalignment using the OtisKnee system, which places implants at higher risk of early failure [15].

The optimal targets for alignment in TKA remain unclear, and indeed a single philosophy may not be applicable to an optimal outcome in all patients. Computer simulations are powerful tools that can provide insight into how different alignments influence post-operative outcomes for TKA patients. It allows control of component alignment for the same subject in ways not possible with in-vivo studies. With imaging data, computer simulations are also able to include patient variations into the analysis [19–22]. Previous studies with computational models have shown comparable kinematic and forces to those measured experimentally or with in-vivo fluoroscopy [23–26].

Ishikawa et al. [27] were able to analyse kinematic alignment for TKA using a computational knee simulation. Their study suggests that kinematically aligned TKA produces near-normal knee kinematics and may provide better clinical results than mechanically aligned TKA. However, only a single model was used in the study and the kinematic alignment for that single model was defined with the clinical average and therefore its conclusions were limited.

The aim of our study was to compare the alignment and motion of kinematically and mechanically aligned TKAs with a computational knee simulation using pre-operative Computer tomography (CT) scans from a series of 20 patients undergoing TKA. Computer simulation of both kinematic and mechanical alignments was performed for each subject. Measures of tibio-femoral translation, tibio-femoral rotation, patellar tilt and patellar shift were taken and compared between kinematic and mechanically aligned knees.

## 2. Materials and methods

### 2.1. Simulation set-up

A validated musculoskeletal computational simulation was used to evaluate the kinematic behaviour of kinematically and mechanically aligned TKA in a series of 20 subjects selected from 'The Joint Dynamics Registry' which includes

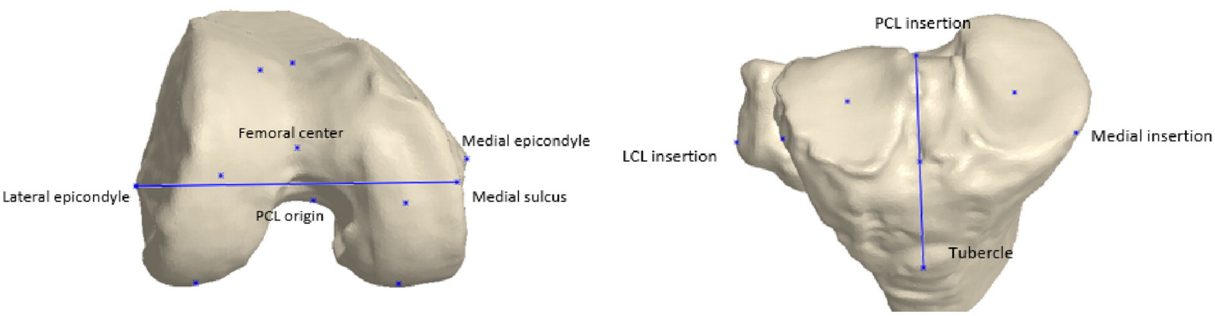


**Figure 1.** Schematic of landmarks and attachment points. Line connecting lateral epicondyle and medial sulcus defines the surgical transepicondylar (TEA) axis of the femur. Line connecting PCL insertion and tubercle defines the tibia anterior–posterior (AP) axis which then projected onto a plane perpendicular to the mechanical axis to be used as AP rotational axis as defined by Insall [29].

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