# RELATIONSHIPS BETWEEN SHAPE, KINEMATICS AND QUALITY OF LIFE BEFORE AND AFTER TOTAL KNEE ARTHROPLASTY

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## INTRODUCTION

Important factors affecting quality of life (QOL) after total knee arthroplasty (TKA) include postoperative knee kinematics and geometry, influenced by implant design and placement (Matsuda 2001; Nishikawa 2013; Noble 2005). Although specific design factors and their effect on kinematics or QOL have been investigated previously, the inter-relationships between preop-postop changes in kinematics, geometry and the resulting QOL have not been studied to our knowledge. These are essential to understand the interplay between the different factors, and to determine which factors manufacturers and surgeons should focus on when designing and implanting knee prostheses. In addition, the majority of TKA studies focus on the tibiofemoral (TF) joint, although the patellofemoral (PF) joint is routinely the source of postop complications; the PF joint is difficult to study due to polyethylene radiotransparency and because the femoral component obscures the patella from most directions.

The purpose of this pilot study was to correlate changes in knee articular shape, over which the implant designers and surgeons have some control, to changes in kinematics and postop QOL, with a particular focus on the PF joint, to answer the following research questions for a sample population with a given implant design and surgeon: (1) Do changes in knee shape affect knee kinematics? In particular, is patellar tracking affected by groove location? (2) Do changes in knee kinematics affect QOL? (3) Do changes in knee shape (resulting from implant design and placement) affect QOL? (4) Do individuals with worse QOL differ from those with better QOL?

## MATERIALS AND METHODS

A group of 9 osteoarthritis subjects participated in this IRB-approved study (5 male, 4 female, ages 44 to 82), before and at least one year after TKA (Table 1). All subjects were implanted with a cemented, rotating-platform posterior-stabilized, multi-radius prosthesis (PFC® Sigma™ Mobile Bearing; DePuySynthes, Warsaw, IN) with a resurfaced patella, and were operated on by a single expert surgeon. The surgeon uses a femur-first, ligament-balancing technique. All subjects were satisfied with their TKA.

**Table 1: Demographic & hip-knee-ankle data for the nine preop-postop subjects (negative HKA = varus).**

| Subject # | #1 | #2 | #3 | #4 | #5 | #6 | #7 | #8 | #9 | AVG |
|---|---|---|---|---|---|---|---|---|---|---|
| **Age (years)** | 65 | 56 | 75 | 71 | 82 | 67 | 44 | 75 | 82 | **68.6** |
| **Gender** | Female | Male | Male | Female | Male | Male | Female | Male | Female | **4F,5M** |
| **BMI (kg/m$^2$)** | 38.1 | 22.7 | 30.5 | 27.2 | 23.6 | 31.5 | 38.3 | 31.6 | 20.4 | **29.3** |
| **Side** | Right | Left | Right | Right | Right | Right | Right | Right | Right | **8R,1L** |
| **Preop HKA (°)** | -6.3 | -7.7 | -8.7 | -5.3 | -4.9 | 6.6 | -3.0 | -6.4 | -2.5 | **-4.2** |
| **Postop HKA (°)** | 2.6 | -3.0 | -4.0 | -1.2 | -0.7 | 1.6 | -3.0 | -6.1 | -1.0 | **-1.7** |

Six degree-of-freedom (DOF) weightbearing PF & TF kinematics before and after TKA were determined using calibrated sequential-biplanar radiographic imaging at 8 flexion angles

(Sharma 2012). Articular geometry was compared by matching 3D implant models and the original preop bone to the generated bone-implant volume from computed-tomography imaging (Ho 2012). Kinematic parameters were changes in: PF mediolateral translation, patellar shift within the groove and patellar tilt (together representing patellar tracking), TF anteroposterior (AP) translation, and TF internal-external (IE) rotation. Shape parameters were changes in: PF distance, femoral component rotation relative to the bone, distal condylar dimensions, posterior condylar dimensions, and femoral groove orientation. Validated QOL questionnaires included: HSS Patella Score, Knee Society Score, WOMAC, and Oxford knee score. Values higher or lower than one standard deviation from the mean of this group were flagged.

Inter-relationships amongst the kinematics parameters, geometrical parameters and collected QOL scores were evaluated using Pearson correlation coefficients ($p<0.05$ considered significant). While we recognize the limitations of investigating numerous correlations with a small number of subjects, this pilot study provides the basis for future studies, using advanced imaging and analysis techniques to produce a quicker analysis of a larger dataset.

## RESULTS

Significant correlations were found between numerous kinematics parameters, shape parameters and QOL (Fig. 1). QOL improved for all subjects. Three out of four of the shape parameter changes correlated with at least one of the kinematic parameter changes. Two of the shape parameter changes and three of the kinematic parameter changes correlated with postop QOL. All of the subjects had at least one and up to four kinematic high/low values and all subjects had at least one and up to five shape high/low values.

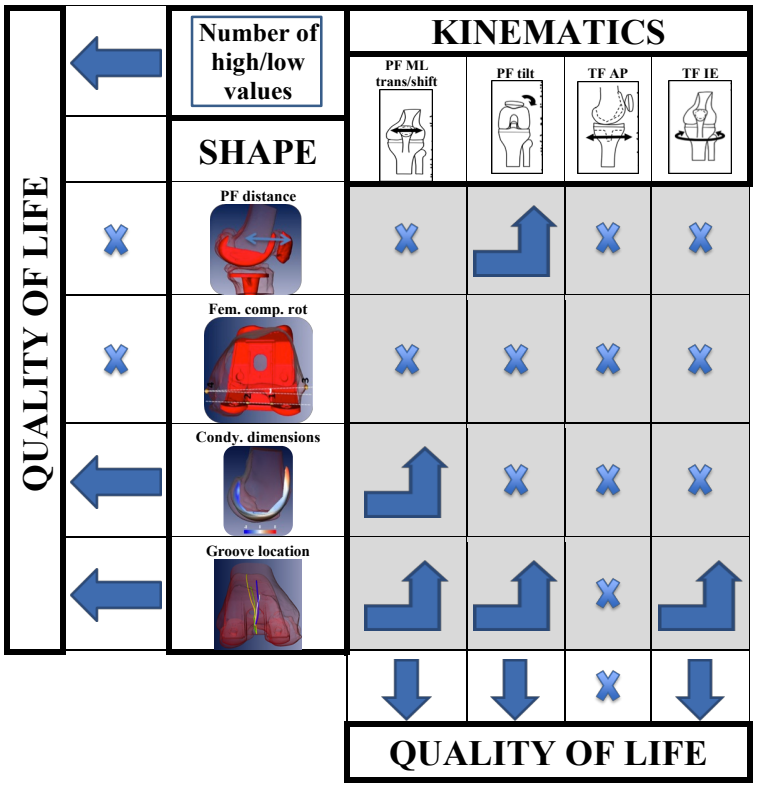


**Figure 1: Overview of correlations found between preop-postop changes in kinematics, shape, and QOL.**

Postoperative QOL in this cohort was better for a more lateralized proximal femoral groove, smaller changes in femoral condylar dimensions, more lateralized PF ML translation and

shift within the groove, less lateral patellar tilt, more internal TF IE rotation, and fewer individual shape and kinematic high/low values.

The postop patella in most cases tracked more closely to the postop femoral groove than to the original preop tracking, whereby the preop patellar tracking generally followed the preop femoral groove. In all cases, the proximal portion of the postop femoral groove was more lateral after TKA, and extended more proximally. In 8/9 cases, patellar tracking was more posterior postoperatively.

## DISCUSSION

This study investigated relationships between changes in knee shape, kinematics and QOL for nine TKA patients. Although all were functioning well postop, the variations in QOL favour a greater angle to the femoral component groove, more sizing options or customized implants, and more accurate component placement, potentially aided by surgical navigation. Since these analyses are unique to our knowledge, there are no studies for direct comparison, but the kinematic results were shown to be comparable to existing studies (Akbari-Shandiz 2015).

Subjects in this study with lower QOL (although not low QOL) generally had a higher number of high or low parameter values. The value of identifying patient-specific high/low values is that the source of pain or reduced function is different for each individual and may be a combination of factors. Preop and postop imaging should become routine for all patients, aided by new 2D/3D matching techniques (Dubousset 2007; Ehlke 2013).

In most cases, the postop patella seems to be guided more by the prosthesis groove than by the original preop tracking (recognizing that the numerous changes to the joint during TKA means that the patella would not necessarily be expected to follow the original path), suggesting that the femoral groove has more control over patellar tracking than the soft tissues.

This pilot study was limited by the small number of subjects with a single implant design and surgeon; results may be different for different implant designs and surgical techniques. A power analysis demonstrated that at least 48 subjects are required to detect significant correlations between all studied parameters. A larger study with multiple surgeons and implant designs, including patients with good and poor results, is recommended to identify implant and surgical factors that contribute to a good clinical outcome.

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## DISCLOSURES

CAD models were provided by Johnson and Johnson Medical Products (Study ID: IIS No. 2012-6-DEP). The authors have no conflicts of interest with this study.