ARE KNEE KINEMATICS BASED ON SENSOR-GUIDED TECHNOLOGY CORRELATED WITH PATIENT OUTCOMES?

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INTRODUCTION: Recently there has been strong interest in postoperative knee kinematics after total knee arthroplasty (TKA). Intuitively, the purpose of performing TKA is to reproduce and restore normal knee kinematics and functioning to diseased knees. According to a study conducted by Dennis et al., 80% of patients with normal knees presented with a medial pivot location during a deep knee bend compared to only 60% during normal gait [1]. Nishio et al. compared patient reported outcomes in 40 knees using the Knee Society Score (KSS) between those having a medial pivot knee and a non-midal pivot knee, and found that medial pivot knees had significantly better subjective outcomes and knee flexion angles [2]. The purpose of the present study was to determine whether real time, intraoperative kinematic data is correlated with four month and one year clinical outcomes following primary TKA.

METHODS: With institutional review board approval, we retrospectively reviewed data on 171 consecutive primary TKAs in which sensor-embedded tibial trials were used to evaluate kinematic patterns in the medial and lateral compartments of the knee following traditional ligament balancing based on manual and tactile surgeon judgment. The sensing device combines a single-use, smart technology tibial trial with a graphic user interface to identify loading contact points and measure peak loading pressures (in lbs.) in the medial and lateral compartments of the tibiofemoral interface. Procedures were performed between April 2013 and April 2014 by two board-certified arthroplasty surgeons at a teaching and a tertiary care hospital. The same Stryker Triathlon Knee System and surgical approach was used for all knees.

Contact locations on both the medial and lateral condyles were recorded for each patient at full extension, 45° and 90° of flexion, and hyperflexion. Medial and lateral contact locations were plotted together for visual representation of kinematic patterns on the tibial surface. Vector equations were created by contact locations on the medial and lateral sides and the vector intersections determined the center of rotation between measurement positions. Centres of rotation were calculated based on vector intersections of extension to 45° of flexion and from 45° to 90° of flexion. If the center of rotation was between 16mm and 1000mm of the contact location on the medial side it was considered a medial pivot, otherwise knees were considered non-medial pivots. Non-medial pivots were further classified into translating (greater than 200mm medially or laterally), lateral (between 16 and 200mm on lateral side), and other (less than 16mm on both medial and lateral sides). Patient outcomes were evaluated preoperatively and at four months and one year postoperatively. The new Knee Society Scoring System (KSSO objective knee score, KSSS knee satisfaction score, KSSF knee function score), the EQ-5D™ Health Status Index, and the University of California Los Angeles (UCLA) Activity Level Score were measured at each interval. Minitab 17 (State College, PA) was used for data analysis. Dixon’s r22 ratio was used to test for statistical outliers with significance levels set at ≤ 0.05. Anderson-Darling (AD) tests using alpha ≤ 0.05 revealed that, among all independent and dependent variables, only patient age was normally distributed. Pivot type saw no distinct differences based on sex or side and the covariates age, height, weight, and BMI were controlled for using the general linear model ANOVA comparison. Outcomes were analyzed based on pivot type.

RESULTS: Nine of the 171 study TKAs were removed from the analysis to eliminate potential bias due to device malfunction, atypical hardware, surgery at a non-study hospital, or early postoperative infection or fracture resulting in a final sample size of 162 patients. Seventy-five percent of the sample was female. Mean age, height, weight, and BMI were 63.1 years, 167.1 cm, 94.4 kg, and 34.0, respectively.

There was a large range for centers of rotations— -4991 to 77969 mm with negative signifying the lateral side. Medial pivot knees ranged from 17 to 843mm, and all other knees were classified as non-medial pivots and subsequently were sub-classified. Sixty of the total sample size were medial pivot (37.0%). Surgeon and implant type were related to pivot classification (p<0.024 and p=0.019, respectively). Posterior stabilized (PS/PS) had significantly fewer medial pivots compared to cruciate sacrificing implants in the analysis for 45° and 90° of flexion intersection points. These groups were addressed appropriately in the statistical analysis. Other potential confounds including gender and implant side were unrelated to pivot classification (p=0.129 to p=0.917).

Absolute KSSO, KSSS, and KSSF scores; UCLA activity level, and the EQ-5D™ health state index at one year—and the amount of improvement from preoperative baseline—were unrelated to total movement of contact locations (p=0.069 to 0.975). There was no difference between groups when classified as translating, medial, lateral, or other pivots. As a continuous variable, center of rotation was modestly correlated with KSS walking pain (r=0.219, p=0.009) and EQSD pain (r=0.246, p=0.024) at one year, indicating that a medial pivot knee tends toward better pain scores than a translating knee. This result did not manifest itself in any of the other pain specific questions. Compared to non-medial pivoting knees, medial pivots displayed a lower subjective outcome score in patient reported outcomes across the aforementioned categories, but none of these comparisons reached significance (p=0.072 to 0.977).

DISCUSSION: We observed that pivot location measured by vector intersection from extension to 45° and from 45° and 90° of flexion resulted in a wide range of centers of rotation. Medial and non-medial pivot knees were statistically similar in all of the reported outcome measures. Our results did not replicate those found by Nishio et al., and thus demonstrate that the pivot classification by intraoperative sensing may not be a substantial governor of clinical outcome success; however, it remains unknown if medial pivot kinematic patterns result in superior functional outcomes and decreased pain in TKA patients.

SIGNIFICANCE: Restoring kinematic alignment is crucial for a well-attached functioning implant, and therefore a significant goal for an outcome of the procedure. It could be beneficial to continue research in this area in order to shed light on relationships between kinematics before and after surgery as well as their relationship to outcomes. As the numbers of TKAs rise, finding a scientific reason related to outcomes becomes necessary.

REFERENCES: