Relationship between Midflexion Knee Laxity, Isokinetic Strength, and Patient-Reported Outcome Measures at 3-Months After Cruciate-Retaining Total Knee Arthroplasty

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INTRODUCTION: Patient perceptions of knee instability are a leading cause of dissatisfaction and revision surgery following total knee arthroplasty (TKA) [1]. Joint instability after TKA is a multi-factorial problem that can arise from excessive ligamentous laxity in one or multiple planes and/or muscle strength deficiency [2-4]. However, whether laxity and strength relate to patient reported outcome measures (PROMs) after TKA remains poorly understood. To answer this question, we are conducting a prospective study to quantify knee laxity, measure extension and flexion strength, and administer clinical PROMs to patients 3-months and 1-year after cruciate-retaining (CR) TKA. In this interim analysis of data from the 3-month timepoint, we asked whether greater midflexion laxity and lower extension strength correlate with worse PROMs.

METHODS: With IRB approval and informed consent, 109 subjects (out of a target enrollment of 150) were prospectively enrolled and underwent robotic-assisted TKA with a single design of PCL-retaining implant. 72 subjects (66%) returned for follow-up three months after surgery and completed laxity and strength assessments (32 females/40 males; mean age: 64±6 years; mean BMI: 29±3; mean time after surgery: 96 days (range: 61-132 days)). The knee's load-displacement response in the varus-valgus (VV), anterior-posterior (AP), and internal-external rotation (IER) directions were measured using a custom-designed multiplanar arthrometer [5]. During testing, the subject sat reclined with their leg at 30° of flexion in the arthrometer, and both the thigh and shank were secured with controlled compressive forces. Each test consisted of manually applying four cycles each of AP forces (30 N posterior to 50 N anterior), IER moments (±3 Nm), and VV moments (±6 Nm), in series, to the lower leg. Laxity was defined as translation or rotation from the position at no applied load to the load target in each direction. Peak isokinetic extension and flexion torques (Nm) were measured using a dynamometer (Biodex System 4) at a velocity of 60°/second over five cycles. Peak torque was normalized to body weight (Nm/kg). The PROMs collected were the Forgotten Joint Score (FJS); Knee injury and Osteoarthritis Outcome Score (KOOS), Quality of Life (QoL) domain; and KOOS, Joint Replacement (KOOS JR). Spearman rank correlations were calculated for univariate relationships between laxity and strength measures (i.e., the explanatory variables) and all three PROMs (α=0.05). P-values and correlation coefficients (r) are reported; a correction for multiple comparisons was not performed for this interim analysis. If multiple variables were found to correlate with a single PROM, a multiple linear regression was performed to control for each variable (α=0.05). P-value and coefficient estimate (β) are reported for each statistically significant variable in the multiple regression.

RESULTS: Varus ($p = 0.02$, $r = -0.28$) and valgus laxity ($p = 0.04$, $r = -0.25$) were negatively correlated with KOOS QoL (Figure 1). No other relationships between laxity measures and PROMs were detected. Extension torque normalized to body weight was positively correlated with all three PROMS ($p \leq 0.02$, $r \geq 0.30$) (Figure 2). A multiple linear regression for KOOS QoL consisting of varus laxity, valgus laxity, and normalized extension torque revealed that extension torque was related to KOOS QoL when controlling for laxity ($p = 0.03$, $\beta = 17.6$), but laxity was not when controlling for strength ($p > 0.3$).

DISCUSSION: Three months after CR-TKA, varus and valgus laxity and extension torque were all individually correlated with KOOS QoL. Previous studies showed a relationship between intra-operative medial and lateral gaps and patient outcomes, but whether post-operative laxity in multiple anatomical planes is related to PROMS has not been assessed [6,7]. Strength remained the statistically significant factor related to KOOS QoL in a multiple linear regression. This suggests that the domains queried by the KOOS QoL are more sensitive to strength than laxity at the early recovery timepoint. Reduced quadriceps strength three months after TKA compared to the pre-operative affected knee or the unoperated knee is associated with altered knee loading and gait [8-10]. Therefore, as activity levels increase at later postoperative timepoints, continued weakness could become more strongly related to worse PROMS than at 3-months. PROMs scores are multi-factorial and are unlikely to be fully reflected in a single measurement, such as coronal plane laxity or extension strength. Our findings at the early recovery timepoint serve as a baseline for data that will be collected 1-year after TKA.

SIGNIFICANCE/CLINICAL RELEVANCE: Our interim findings support that both intraoperative ligament balancing using a robotic assisted technique to reduce varus and valgus laxity and postoperative quadriceps strengthening may be important for improving patients' perceptions of knee function early after TKA.

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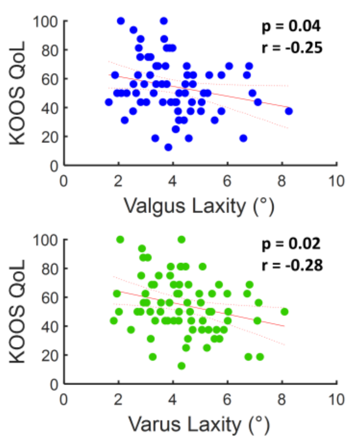

Figure 1. Scatterplot of KOOS Quality of Life domain versus valgus laxity (top) and varus laxity (bottom) 3 months after CR-TKA.

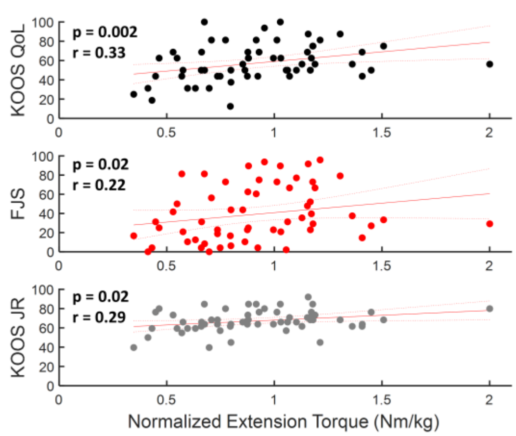

Figure 2. Scatterplots of KOOS Quality of Life (top), Forgotten Joint Score (center), and KOOS Joint Replacement (bottom) versus peak extension torque normalized to body weight 3 months after CR-TKA.