Improvements in Gait Pre to Post Knee Arthroplasty are Associated with Specific Intraoperative Gap Balancing Variables

Stephanie Civiero[1,2], Michael Dunbar[1,2], C. Glen Richardson[1,2], David Wilson[1,2], Jennifer Leighton[1,2], Janie Astephen Wilson[1,2]
[1]Dalhousie University, Halifax NS, Canada; [2]Nova Scotia Health, Halifax NS, Canada
Email: s.civiero@dal.ca

Summary

Understanding the relationship between biomechanics, surgical decisions, and post-operative outcomes is critical person-specific TKA approaches. This study investigated associations of intra-operative passive laxity and tibiofemoral gap measurements with changes in gait kinematics pre- to post-TKA in 10 patients. Intra-operative medial-lateral (ML) laxity and tibiofemoral flexion-extension gaps were significantly associated with post-operative improvements in knee gait kinematics.

Introduction

Total knee arthroplasty (TKA) outcomes are heavily influenced by the patient's pre-operative gait biomechanics and anatomy [1-3]. While traditional surgical approaches have relied on standardized methods, person-specific TKA will aim to incorporate detailed analysis of individual biomechanics before, during, and after surgery. Understanding the relationship between pre-operative patient biomechanics and intra-operative decisions on post-operative function is critical, yet our knowledge of these connections remains limited. This study was an initial investigation into the relationships between intra-operative passive laxity and tibiofemoral gap measurements with changes in gait kinematics pre- to post- TKA.

Methods

Patients (6F/4M, BMI: 35.8 +/- 5.9 kg/m^2, Age: 63.7 +/- 12.0 years) with end-stage knee OA awaiting robotic-assisted (MAKO, Stryker) TKA completed a pre- and post-operative gait assessment (within 3 months of surgery and at 3-months post-surgery). Lower extremity walking kinematics were captured using a 10-camera optical system (Sony RX0II) with markerless motion capture software (Theia). Outcomes included discrete and principal component sagittal and frontal plane knee angles relevant to TKA [2,4]. Intra-operative frontal plane laxity and tibiofemoral gap data were recorded using the robotic system. Native ML laxities at 10- and 90-degrees flexion were normalized to the intraoperative passive frontal plane alignment. Differences between the final implanted versus native ML gap ratio in extension and flexion were calculated. Associations between pre to post changes in gait outcomes and the intra-operative variables were investigated using Pearson's correlations ($p < 0.05$).

Results and Discussion

1. Intraoperative Extension Gap Balancing (10°):

Reducing the lateral-to-medial gap (i.e. more symmetrically balanced joint in full extension) was significantly associated with an increase in the flexion/extension range of motion (PC2) during walking (r =-0.75). Increasing the lateral gap was associated with more change in abd-to-adduction motion in early to midstance (PC3) and increased flexion/extension ROM in stance (r=0.73; r=0.75) Increasing the medial gap was associated with more flexion/extension ROM during walking and also more change in abd-to-adduction motion in early-mid stance (PC3) (r = 0.79; r = 0.81).

2. Intraoperative Flexion Gap (90°) and Laxities:

Increasing the medial gap in flexion was associated with more change in the abd-to-adduction motion in early-mid stance (PC3) during walking (r=0.69), and increased flexion/extension ROM (r=0.72). Lower ML passive range of motion at 10° intraoperatively was associated with increased flexion/extension range of motion during walking (r = -0.65). Less absolute valgus motion with valgus stress at 10-degrees intraoperatively was associated with increased knee flexion/extension range of motion (r = 0.68), increased abd-to-adduction motion in early-mid stance (PC3) during walking (r = 0.69). These preliminary results suggest a potential sagittal plane gait benefit (improved range of motion) of having larger medial compartment gaps, while maintaining a more symmetric lateral-to-medial gap ratio. The associations found between gap balancing and increased early stance range of ab/adduction angles during gait along with these improvements in sagittal plane range of motion suggest a gait pattern characterized by less midstance 'bracing'. Robotic-assisted surgery now allows for personalization of surgical planning in three-dimensions. Given that sagittal plane gait deficits are common for the majority of patients after TKA [1,4], this finding has important clinical significance for the feasibility of identifying surgical approaches to specifically target sagittal plane gait deficits.

Conclusions

Associations between change in intraoperative surgical gap balancing variables with changes in improvements in knee joint kinematics during walking from pre- to post-surgery highlight the feasibility of using perioperative gait analysis to inform personalized approaches to knee arthroplasty surgery.

References

[1] Astephen et al., 2019. *J. Orthop. Res.* 37(8):1754-9. [2] Young-Shand et al., 2020. *JBJS*, 5(2):e0038. [3] Young-Shand et al., 2023. *J. Orthop. Res.* 41(2):335-44. [4] Outerleys et al. 2020 *J Appl Biomech*.