Longitudinal Changes in Knee Joint Gait Kinematics in Individuals Awaiting Robotic Knee Arthroplasty

Stephanie Civiero[1], Annemarie Laudanski[1], Michael Dunbar[1,2], C. Glen Richardson[2], Jennifer Leighton[2], Janie Astephen Wilson[1,2]
[1]School of Biomedical Engineering, Dalhousie University, Halifax NS, Canada
[2]Department of Surgery, Dalhousie University and Nova Scotia Health
Email: s.civiero@dal.ca

Summary

This study examined association of gait worsening awaiting knee arthroplasty with baseline patient factors (gait kinematics, patient-reported measures, demographics). Worsening gait was observed in 11/29 patients. At time 1, patients in the gait worsening group displayed significant differences in gait kinematics and patient-reported measures. Gait worsening was associated with both baseline gait kinematics and patient-reported measures.

Introduction

End stage treatment of knee osteoarthritis (OA) with arthroplasty surgery is associated with improvements in gait biomechanics related to pre-operative function [1]; however, gait biomechanics outcomes are seldom restored to healthy adult levels [2,3]. Patients awaiting knee arthroplasty in public systems such as Canada can experience lengthy wait periods before they have access to treatment, which can have negative implications for their quality of life while waiting and for their surgical recovery. The purpose of this study was to examine if and how knee joint kinematics during walking change during the wait period for knee arthroplasty surgery, and to examine the associations of gait changes with baseline patient factors.

Methods

Patients with end-stage knee OA awaiting arthroplasty completed two pre-operative gait assessments (>2 months apart). The time 1 assessment included questionnaires for self-reported pain and function (NRPS [4], OKS-Pain Component Score (PCS), OKS-Function Component Score (FCS)), physical activity (UCLA), and health status (EQ-5D-5L). Lower extremity walking kinematics were captured using a 10-camera optical system (Sony RX0II) with markerless motion capture software (Theia Markerless Inc.). Analysis included 7 discrete measurements and 8 principal components of sagittal and frontal plane knee angles previously associated with end stage knee OA outcomes [1,4]. Gait changes between time points were assessed using paired t-tests, and correlations between gait changes and baseline characteristics (age, BMI, self-reported and gait outcomes) were examined using Pearson's correlations and Spearman's rank. Patients were classified as gait worsening or stable based on sagittal plane kinematic outcomes declining beyond minimal identifiable differences [5], with between-group baseline differences analyzed using t-tests (α=0.05).

Results and Discussion

Twenty-nine patients (16F/13M; age: 67±8.3 years; BMI: 33.8±7.5 kg/m^2) completed gait assessments an average of 221±153.3 days apart (63-585 days). While the results did not show significant population-level gait changes, there was considerable variance in change on an individual-level. Eleven patients (38%) demonstrated significant gait worsening from time 1 to 2 (Figure 1). At time 1, the gait worsening group had significantly lower knee flexion angle peaks and magnitudes (PC1), reported more severe pain and function scores (OKS-PCS, OKS-FCS) and worse quality of life (EQ-5D-5L) compared to those in the stable gait group (p < 0.05). Gait decline during the wait period was associated with baseline (p < 0.05) lower peak and range of knee flexion angles and later peak knee flexion in swing (PC3); lower baseline peak and overall (PC1) adduction angle magnitudes during stance, lower early stance range of ad/abduction angles (PC4; i.e. varus thrust); and lower self-report function and physical activity, and higher self-report pain.
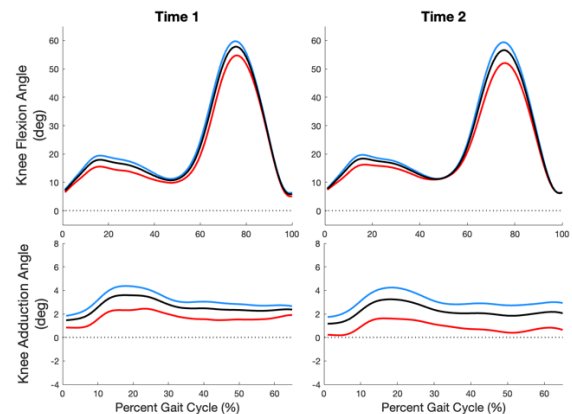

Figure 1: Mean sagittal- and frontal-plane knee angle waveforms at Time 1 and Time 2 for the worsening and stable subgroups.

Conclusions

One third of patients awaiting knee arthroplasty showed significant deterioration over a relatively short period of time, with distinct baseline differences in gait kinematics and patient-reported measures. The results support the role of gait biomechanics monitoring to predict decline risks while awaiting arthroplasty, informing surgical readiness and triage in low resource settings. Further investigation of these relationships in larger samples could guide wait list prioritization and identify patients who may benefit from additional pre-operative care.

References

[1] Young-Shand et al. (2020). *JBJS*, **5**(2): e0038. [2] Levinger et al. (2013). *J Arthro,* **28**(6): 994-5. [3] Hatfield et al. (2011). *J Arthro*, **26**(2): 309-18. [4] Astephen et al., 2008. *J. Orthop. Res.* 26(3):332-41. [5] Civiero, S. MASc thesis, Dalhousie University, 2024