Knee Kinematics during Over-Ground Gait for Medial Congruent and Cruciate Retaining Implants in Patients Post-Total Knee Arthroplasty

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Summary

Gait analysis provides an objective approach to evaluating functional knee status post-surgery. Three-dimensional kinematic data captured via markerless motion capture using Theia3D was used to investigate patients with medial congruent and cruciate-retaining implant designs during overground walking. Differences were observed in the transverse plane, with cruciate-retaining implants showing, on average, greater internal rotation throughout gait, while no discernible differences were seen in the sagittal plane.

Introduction

Normal joint mechanics are often not achieved post-total knee arthroplasty and are a proposed contributor to patient dissatisfaction after surgery [1]. Medial congruent knee implants are designed to provide medial stability and enhance lateral translation due to the asymmetric shape of the tibial component, intended to restore typical knee kinematics. Cruciate retaining implants preserve the posterior cruciate ligament and aim to increase kinematic rollback, allowing for greater knee flexion. The objective of this study was to investigate if three-dimensional knee kinematics during gait differed post-surgery in patients receiving a medial congruent (MC) or cruciate retaining (CR) design.

Methods

Patients who received the Persona MC (Zimmer Biomet) or NexGen CR Flex (Zimmer Biomet) implants and were at least one-year post-surgery were recruited. Markerless motion capture using Theia3D (v. 2023.01.0.361 p7, Theia Markerless Inc. Kingston, ON) was used to determine whole body kinematics. Patients were instructed to walk at a self-selected speed across a 12-metre distance for one minute in front of eight Sony RX0II video cameras (Sony, Minato, Japan) in their own clothing and footwear. Visual3D (HAS-Motion, Kingston, ON) was used for gait event detection and knee joint angles were calculated in accordance with ISB recommendations. Principal component analysis (PCA) was performed in R (v.2023.06.0, Posit Software, Boston, MA) to analyze gait waveforms in the sagittal and transverse plane. PC scores were compared between implant types using independent t-tests (alpha = 0.05).

Results and Discussion

Eighty-five patients were included in the study. Forty-two patients received the NexGen CR Flex (male = 11, female = 31; mean age = 72 years (SD = 8)), and 43 patients received the Persona MC (male = 22, female = 21; mean age = 69 years (SD = 7)). Forty-two percent of patients had both knees replaced at the time of assessment. Only one replaced knee was included per patient and chosen at random for bilateral patients. There was no difference in gait speed between groups (p = 0.88).

PC1 (capturing overall waveform magnitudes) was statistically significantly different between implant types in the transverse plane (p = 0.03), but not the sagittal plane (p = 0.48). PC2 for knee flexion (capturing differences between peaks) was not statistically significantly different between implant types in either the sagittal (p = 0.39) or transverse plane (p = 0.15). Figure 1 (left) shows similar trends in flexion/extension, while separation is evident in knee rotation throughout gait in Figure 1 (right) between implants. The CR group had on average greater internal rotation throughout the gait cycle, similar to findings of Gray et al. using marker-based motion capture [2].

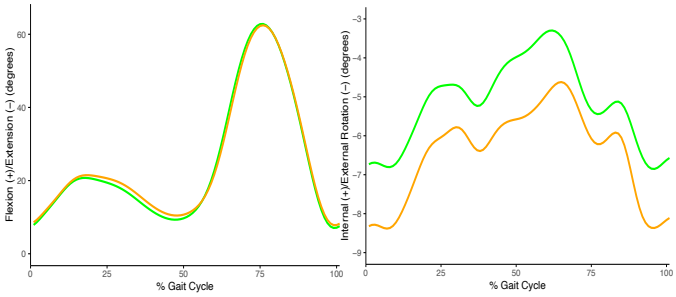

Figure 1: Mean waveforms in the sagittal (left) and transverse plane (right) throughout gait in patients who received the Persona MC (orange) and NexGen CR Flex implant (green).

Conclusions

Knee kinematics in the transverse plane during over-ground walking were different between the Persona MC and NexGen CR Flex implants in patients at least one-year post-surgery. Markerless motion capture is a biomechanical tool that allows easier clinical integration to quantitatively assess a replaced knee joint throughout ambulation. These findings highlight markerless motion capture as a potential tool to capture functional implant design outcomes that are not evident from traditional arthroplasty metrics such as patient-reported outcome measures.

References

[1] C. S. Leichtenberg et al. (2018). *J. Orthop. Res.,* **36**: 2671–2678.

[2] H. A. Gray et al. (2020). *J. Orthop. Res.,* **38:** 1753-1768.