EFFECT OF FOOT PATH ALTERATIONS ON ADDUCTION MOMENT REDUCTIONS PRODUCED BY KNEE MEDIALIZATION DURING GAIT

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INTRODUCTION

Gait modification is a non-invasive strategy for reducing the external knee adduction moment in patients with medial compartment knee osteoarthritis (OA). The first knee adduction moment peak during early stance phase has been shown to be a surrogate measure for medial compartment load [1], disease progression [2], and pain [3]. Thus, gait retraining to reduce this peak is a conservative treatment option with disease modifying potential.

Recently, a novel "medial thrust" gait pattern characterized by knee medialization during stance phase reduced both knee adduction moment peaks by 30 to 40% in a single patient with knee OA [4]. This gait pattern was designed for the patient using a patient-specific computational model. Changes in foot path (i.e., toe out angle and stance width) are also known to affect the adduction moment peaks, but it is not known whether foot path changes might provide significant additional adduction moment reductions for this particular patient. Thus study uses the same patient-specific computational model to investigate this issue.

CLINICAL SIGNIFICANCE

Gait retraining involving multiple movement modifications may be difficult for patients to achieve during exploratory experimental studies. Medial thrust gait is a new gait retraining approach that is just beginning to receive attention, and an optimal gait retraining protocol is yet to be developed. Since other gait modifications (e.g., altered foot path) may be synergistic with medial thrust gait, it would be valuable if such combined therapies could be explored quickly and easily without the difficulties involved in trying to train patients to achieve multiple goals simultaneously. A computational approach for assessing combinations of gait retraining strategies might therefore be valuable for identifying synergistic treatments.

METHODS

Gait data collected from a patient with medial compartment knee OA (male, age 37 years, height 170 cm, mass 69 kg, alignment 5º varus with Kellgren and Lawrence grade 2 medial OA in both knees based on radiographic assessment) were used for this study [4]. Data collection utilized a video-based motion analysis system with modified Cleveland Clinic marker set (Motion Analysis Corporation, Santa Rosa, CA) and two force plates (AMTI, Watertown, MA). The patient gave informed consent and performed gait and isolated joint motion experiments to permit calibration of joint and inertial parameters in a dynamic, 27 degree-of-freedom full-body gait model.

The calibrated gait model was used to perform patient-specific dynamic optimizations that predicted the simultaneous influence of knee medialization and foot path alteration on the patient's left knee adduction moment. The computational framework used for the optimizations was previously validated for the same patient by assessing its ability to predict knee adduction moment changes caused by knee medialization [4] or foot path alteration [5]. For the present study, the framework was modified to predict adduction moment changes produced by knee medialization and foot path alteration simultaneously. The specific foot path alterations investigated were all possible combinations of three toe out angles (nominal ± 15°) and three stance widths (nominal ± 50 mm).

RESULTS

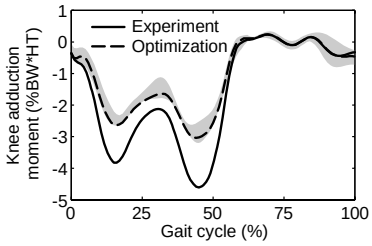

Fig. 1: Experimental and optimized adduction moment curves produced by medial thrust gait. Shading indicates range of predictions for all 9 foot path variations.

Overall, foot path alterations had only a limited influence on the 32 and 34% reduction in the first and second adduction moment peak, respectively, produced by medial thrust gait with the patient's normal foot path (Fig. 1). Changing the foot path decreased either peak by at most 9% and increased either one by at most 3% relative to the normal foot path. Decreased toe out angle had the most favorable influence on the first peak (4 to 8% additional reductions) but increased the second one (0 to 3%). In contrast, increased toe out angle had the most favorable influence on the second peak (5 to 9% additional reductions) while simultaneously decreasing the first one (0 to 4%). Increased stance width had a generally favorable influence on both peaks (0 to 9% additional reductions), while decreased stance width reduced the first peak only for toeing in (8%) and the second one only for toeing out (5%).

SUMMARY/CONCLUSIONS

This study used a validated patient-specific computational model to assess how foot path changes affect knee adduction moment reductions caused by knee medialization during gait. The results provide theoretical estimates for the adduction moment changes this particular patient is likely to achieve in clinical practice. Our results suggest that further gait retraining effort to alter the patient's foot path is not warranted, as the additional decrease in the critical first peak would be at most 4% assuming degradation in the second peak is unacceptable.

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ACKNOWLEDGEMENTS

This work was supported by NIH grant 1R21HD053490-01 and by NICTA.