Author
LeCursi, Nicholas (Troy US) | CO
Becker Orthopedic - Research and Development

Title
A clinical algorithm for sagittal plane kinematic optimization of articulated ankle foot orthoses

Coauthors
Janka, BJ

Summary
An algorithm was developed for the optimization of sagittal plane kinematics by combining the clinical outcomes of a variety of patients whose gait was optimized using articulated AFOs with a multifunction ankle joint. Case studies will be presented to illustrate the approach.

Introduction
Algorithms have been published for determining the optimal ankle angle in a non-articulated ankle-foot orthosis (AFO) and for optimizing shank and thigh kinematics using tuned shoe sole rocker modifications. However, in many cases, there may be functional benefits to using articulated AFOs with tuned alignment and where the motion of the ankle is permitted but controlled. Due to a patient's unique biomechanical deficits, the ability to alter AFO ankle alignment and stiffness after fabrication may also be advantageous. A clinical tuning algorithm for optimization of sagittal plane gait kinematics using articulated AFOs has been developed using a multifunction ankle joint. Research has shown that gait kinematics and kinetics can be systematically influenced by independently adjusting the alignment and resistance of an AFO. Case studies will be presented to illustrate the approach and clinical outcomes using the proposed algorithm.

Methods
Subjects: Patients with pathologies including CVA, CP, MMC, MS, PPS and SCI presenting with lower extremity biomechanical deficits, were included in the development of the tuning algorithm.
Apparatus: Custom multifunctional ankle joint ankle-foot orthoses were fabricated for each patient.

Procedure: Each patient's clinical presentation was fully qualified. A custom orthosis was designed and fit for each patient and then statically aligned and dynamically adjusted using slow-motion video and observational gait analysis. Specific gait events were identified for the purpose of kinematic optimization of gait through the tuning process.
Data Analysis: Sagittal plane gait videos were used to compare lower extremity kinematics before and after adjustments. Observational gait analysis, patient feedback, and/or outcome measures including TUG and Tinetti Balance were used to determine the effectiveness of the optimized orthoses.

Results

An initial treatment flow chart based upon customary orthotic practice was created as a starting point for the development of the algorithm. Multiple clinical trials were conducted with patients presenting with a variety of biomechanical deficits to help identify advantageous approaches to optimization. It was found to be advantageous to divide the gait cycle into three phases during the dynamic adjustment part of the algorithm: swing, early stance phase, and late stance phase. It was also found to be advantageous to proceed from static alignment to swing phase adjustment before the dynamic adjustment of the stance phase. The literature was consulted to identify specific, observable and predictable gait events that were responsive to adjustments of the sagittal plane mechanical characteristics of the AFO. These gait events were selected and included in the development of the algorithm. The independent adjustments of AFO mechanical characteristics facilitated by the multifunction ankle joint and found to systematically influence gait kinematics were associated with phases of the gait cycle. Suggested starting values for bench adjustment of the sagittal plane characteristics of the AFO were derived from relating each patient's final orthosis characteristics to the patient's deficits. Through iterative optimization of the flow of the algorithm and after repeated trials with various clinical presentations a simplified tuning algorithm was created.

Conclusion

An algorithm was developed for the optimization of sagittal plane gait kinematics using articulated AFOs by combining the orthotic treatment approach from a variety of patients with lower extremity gait deficits. The algorithm was based on prior clinically oriented approaches to orthotic optimization, biomechanics research into the systematic influence of a multi-function ankle joint on gait kinematics and kinetics and multiple clinical trials using the approach to optimize gait for patients with a variety of biomechanical deficits. Overall, the clinical algorithm provided a systematic means to optimize sagittal plane AFO characteristics to enhance patients' clinical outcomes as measured using slow-motion video with observational gait analysis and common outcome measures. The algorithm was found to be an advantageous starting point for orthotic optimization for patients with a variety of clinical presentations.

References

1. Owen E. Gait Posture; 22S, S38-S39, 2005.
2. Kobayashi, T. J. Biomechanics; 83, 57-64 2019.
3. Kobayashi, T. Clin Biomech; 59, 47-55, 2018.
4. Janka B, et al. AOPA National Assembly, Boston, MA, USA, 2016.