Title: Ankle Foot Orthosis Comparative Effect (AFOCE)

NCT Number: NCT03901053

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Study Protocol:

Purpose and Procedures:

The purpose of this study is to investigate the effect of two commercially available carbon fiber custom dynamic orthoses (CDOs) on patient outcomes following traumatic lower limb injury to support evidence-based practice and optimal care. These data will provide evidence that can be used by clinicians to guide their clinical practice, including care for service members, veterans, and civilians who have experienced traumatic lower limb injuries.

Adult participants who have sustained a traumatic lower limb injury more than two years prior, who still experience deficits including weakness and/or immobility will be randomly assigned to one of two CDO testing sequences (AB or BA). Participants will be evaluated under 4 conditions: no device (NoCDO), standard of care (SOC), and each CDO (A and B). Study CDOs will include the Reaktiv from FabTech Systems and the PhatBrace from Bio-Mechanical Composites Inc.

Participants will be tested with no device and standard of care at baseline, after 3 months of accommodation to the first CDO, and after 3 months of accommodation to the second CDO. Physical performance measures will incorporate tests of agility, balance, speed and lower limb power. Questionnaires will be used to evaluate participant's perceived comfort and smoothness, pain, preference. Semi-structured interviews will be used to fully capture the perspective of the participant. Biomechanical gait analysis will be used to evaluate walking mechanics, allowing comparisons between conditions. Lower limb forces and body motion will be assessed using computerized motion capture and force plates in the floor. The investigators will also complete mechanical testing of the devices and collect demographic and descriptive data.

Objectives and Specific Aims:

Aim 1: Determine the comparative effect of custom dynamic orthosis type in individuals with limb impairment resulting from traumatic limb injury.

Aim 2: Determine if study-provided custom dynamic orthoses improve function relative to no device and standard clinical care conditions, in individuals with impairment resulting from traumatic limb injury.

Aim 3: Identify factors that are associated with device preference and function.

Background and Significance:

Traumatic lower limb injuries often result in poor outcomes for civilians and service members, including increased rates of depression, limited physical ability and decreased quality of life years after the injury. These deficits result, in part, from the inability to overcome the limitations resulting from extensive scar tissue, deformity and joint damage due to traumatic injury, using traditional rehabilitative techniques.

Ankle foot orthoses (AFOs) can be used to significantly improve limb function following lower extremity trauma. However, the type and quality of many commercially available AFO options are generally inferior to available prosthetic options, and evidence to guide orthotic care is limited, and even absent, for many areas of practice. CDOs are better able to compensate for decreased limb function than historic AFO alternatives and are being used more frequently. To date, CDOs have been provided to over a thousand patients within the DoD and VA. CDOs consist of a proximal cuff below the knee to support and transfer force to the limb, a posterior carbon fiber dynamic strut that can store and return energy, and a full-length rigid foot plate that supports the foot and acts as a lever to allow bending of the strut. Data demonstrate that orthosis type and design can have significant effects on resulting limb function. Little information is available regarding commercially available CDOs, their comparative effects, or factors that should be prioritized to provide the most appropriate CDO following traumatic lower limb injury.

Inclusion/Exclusion Criteria:

Inclusion Criteria:

- Ages: 18-65
- Sustained a function limiting, below the knee, traumatic lower leg injury that occurred greater than two years ago
- Weakness of ankle plantarflexors (<4/5 on MMT), limited pain free ankle motion (DF<10deg or PF<20deg), mechanical pain with loading onto hindfoot/midfoot/forefoot (>4/10 on verbal numeric pain

rating scale), ankle or hindfoot fusion or candidate for ankle or hindfoot fusion, AND/OR a candidate for amputation secondary to ankle/foot impairment

- Ability to walk 50 feet without using a cane or crutch
- Ability to walk at a slow to moderate pace
- Able to read and write in English and provide written informed consent

Exclusion Criteria:

- Pain > 8/10 while walking
- Ankle weakness as a result of spinal cord injury or central nervous system pathology
- Require a knee stabilizing device (i.e. Knee-Ankle Foot Orthosis or Knee Orthosis) to perform daily activities
- Surgery on study limb anticipated in the next 6 months
- Medical or psychological conditions that would preclude functional testing (ex. severe traumatic brain injury, heart condition, clotting disorder, lung condition, stroke, vestibular disorder)
- Nerve, muscle, bone, or other condition limiting function of the contralateral extremity
- BMI greater than 45
- Visual or hearing impairment that limit walking ability or limit the ability to comply with instructions given during testing
- Pregnancy

Design and Methods:

Personal/demographic (age, race, education, and self-efficacy, gender, ethnicity, date and mechanism of injury, surgical history, and current device, if any), injury characteristics (injury description and characteristics, fracture classification, and surgical history), and anthropometric information (height, weight, dominant leg, leg length, shoe length and width) will be used to characterize the cohort. Multiple outcomes measures will be used to characterize patient-centric outcomes and evaluate device function and participant outcomes.

The Four Square Step Test (4SST) uses a 1 inch pipe placed on the floor in the shape of a Maltese cross. Participants are instructed to begin in the back left quadrant and move 1) forward, 2) right, 3) backward, 4) left, then to move in the reverse direction back to the original square as fast as possible. During the *Sit to Stand 5 Times (STS5)* participants start sitting with their arms folded across their chest and their back against a chair. Participants are then instructed to stand up and sit down 5 times as fast as possible, avoiding touching their back to the chair during each repetition. During the *Self-Selected Walking Velocity (SSWV)* test participants are instructed to walk at their "normal comfortable" pace for a 10 m distance. Participants are timed as they walk in the middle 6m, the first and last 2m are not timed to account for participants speeding up and slowing down. During the *10 Meter Shuttle Run (SR)* participants are instructed to move as fast as possible for 10 meters, pick up a wooden block, return it to the ground behind the start line, and then turn around and repeat the procedure to pick up a second block. In the *Timed Stair Ascent (TSA)* participants are instructed to ascend a flight of 12 steps as quickly and safely as possible while contacting every step.

Patient-reported outcomes questionnaires will be used to evaluate participant health-related quality of life, comfort, satisfaction, and preference in addition to multiple other relevant outcomes. The *Patient Reported Outcomes Measurement Information System (PROMIS) physical function, pain interference, pain behavior, depression, participation in social roles and activities, and satisfaction with participation in social roles and activities* subscales will be used. The PROMIS questionnaires are a group of patient-centered tests, which can be used to characterize physical, mental, and social health and function. Pain will also be assessed using a standard 11-point *numerical pain rating scale (NPRS)*, in which 0 = no pain and 10 = worst pain imaginable. *The Activities-Specific Balance Confidence (ABC) Scale* is designed to assess fear of falling by evaluating confidence in performing various mobility-related tasks on a scale of no confidence (0%) to completely confident (100%). *The Orthotics Prosthetics Users' Survey (OPUS)* satisfaction with devices and satisfaction with services subscales will be used to evaluate device comfort, form, and fit. Comfort and smoothness will be assessed using a *Modified Version of the Socket Comfort Score*, where participants report the comfort and smoothness of the orthosis on a

scale of 0 = most uncomfortable to 10 = most comfortable, and from 0 = least smooth to 10 = most smooth. *Self-Efficacy* will be assessed using a 10-item measure that assesses how much people believe they can perform novel or difficult tasks, or cope with adversity in various domains of human functions. *Participant Preference* will be assessed by having participants rank-order three conditions: Device A, Device B, and SOC. *Semi-Structured Interviews* will be used to fully capture the patients' perspectives, experience and opinions associated with the device options they experienced as part of the study.

Impairment, biomechanical, and orthosis data will be used to compare between conditions and characterize limb and CDO function, to provide insight in a manner not commonly found in comparative studies. Impairment data will include *ankle range of motion and stiffness* which will be assessed using the Iowa Ankle Range of Motion device that utilizes a handheld force gauge and digital inclinometer. *Ankle strength* will be assessed using the Standing Heel-Rise Test where participants will perform as many standing heel-rises as they can. *Knee range of motion and strength* will be assessed using a goniometer aligned with the femur and tibia and Manual Muscle Testing as participants are seated with their legs dependent and their knees flexed about 90 degrees. Biomechanical data will include *ground reaction force and motion capture* data that will be used to evaluate the motion and loading of the lower limb as participants walk on an over ground walkway at self-selected speed and a controlled speed based on leg length.

Statistical Analysis Plan:

Analysis Methods:

Aim 1: We will use paired t-tests to compare continuous measures between use of the Reaktiv and PhatBrace. Data that are not normally distributed will be log-transformed and their distributions re-evaluated. If distributions are not normalized using this transformation, we will utilize the Wilcoxon Signed Rank Test in place of the paired t-test.

Aim 2: A series of paired t-tests will be used to test for significant differences in continuous measures between 1) each study orthotic device and the standard of care and 2) between each study orthotic device and no brace. We will utilize a Bonferroni-Holm correction to account for multiple comparisons. Data that are not normally distributed will be log-transformed. In cases where log transformation does not normalize distributions, analyses will be completed using the Wilcoxon Signed Rank Test.

Aim 3: We will use multinomial logistic regression to evaluate the relationship between the primary device preference and participant baseline characteristics such as age, height, weight, strength and motion, desired activity level, and physical ability as determined in the no device condition. If complete or quasi-complete separation occurs, due to low selection of a study orthotic device or standard of care, the categories will be collapsed to the two remaining options and logistic regression will be utilized.

Power Analysis:

Aim 1 requires a sample size of 59 participants to provide greater than 80% power (2-sided test) at an alpha level of 0.05 to detect a 10% difference between study orthotic devices (Aim 1) in 4SST and in SSWV. These values are based on published mean and standard deviation data (4SST=5.8±1.8 seconds, SSWV=1.50±1.8 seconds) for use of a dynamic orthotic device similar to the Reaktiv in individuals with similar injury characteristics, and assuming a correlation between measures within participants of 0.65.

Aim 2 will be adequately powered based on the results of previously published data. A total of 27 and 25 participants will be necessary for the 4SST and SSWV, respectively, to detect a significant difference with 80% power (2-sided test), an alpha level of 0.01, and 20% non-completion.

A formal sample size calculation for Aim 3 has not been performed because it is exploratory and requires prior knowledge of an expected odds ratio and proportion of participants who select each preference option. The rule of thumb is to have a minimum sample of 10 participants per independent variable in the model or a ratio of 10:1 for participants to variables. As such, we estimate we would have power to include up to 3 predictors.