

1) Protocol Information

Title: Microprocessor knee vs. mechanical knee: Impact on functional outcomes in dysvascular transfemoral amputees.

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Study Information

Type of Research: Biomedical Research

2) Background/ Key Questions:

In older adults, poor circulation in the lower extremities or dysvascular disease can lead to serious health complications. In addition, these individuals also suffer from serious co-morbidities like diabetes and coronary or cerebrovascular disease. Circulatory dysfunction or dysvascular disease is the major cause for amputations in the United States (www.amputee-coalition.org/fact_sheet/amp_stats_cause.html). Increasing sedentary lifestyles have lead to increased rates of diabetes which has significantly contributed to an increased number of amputations in recent years. The risk of amputation in a diabetic individual is 25 times higher than in the non-diabetic population (Witsø & Rønningen 2001).

The level of amputation that is appropriate for an individual depends on the extent of damage to his/her tissues. Common amputations of the lower extremities in the dysvascular population include the transtibial and transfemoral amputations. The individual having a transtibial or below knee amputation, will be fitted with a prosthetic foot to assist with functional ambulation, while a person with a transfemoral amputation will require both a prosthetic foot and knee for ambulatory purposes. Currently dysvascular amputees are given prostheses based on the goal of returning them to a basic level of function focused primarily on stability. They are considered lower functioning walkers and are expected to use a slow and constant walking speed to ambulate around their homes and are not considered traditional community ambulators. Therefore, they are traditionally given standard mechanical knees which are considered safe, as they provide the ability for only simple single speed house-hold tasks. While this criterion does return the patient to function for basic Activities of Daily Living (ADLs) and walking at a single cadence, it does not empower the patient to counteract the previously existing co-morbidities. Dysvascular amputees tend to be less active predisposing them to a more sedentary lifestyle and exacerbating their risk factors. Their prostheses make them energy inefficient and use more energy for ADLs and functional walking. This causes early onset of fatigue, induces anxiety and fear of falling. Further, they are often depressed, lose

motivation and curtail their community interaction. This raises the question if dysvascular amputees are further functionally limited by the prostheses traditionally given to them.

More recently, technology has been used to assist with return to function in the amputee population. Microprocessor (MP) controlled knees are among the technological innovations applied to prostheses to not only return amputees to a basic function, but also with a view to return them to their highest possible function. Over the years, clinical use has shown that traditional knees provide the ability to complete ADLs and basic functions like sit – stand. However, activities like negotiating stairs/steps, walking on uneven ground and self-correction during tripping; functions which reintegrate amputees into unlimited community ambulation and social reintegration require prosthetics which advanced functionality. The Otto Bock C-leg is a MP knee that allows the patient a greater level of control in swing and stance phases of gait. This enables the TF amputee to adjust the requirements of gait during dynamic walking like changing the speed of walking, going up and down stairs and inclines, walking on grass and uneven surfaces and crossing an obstacle. The C-leg has been traditionally given to patients who begin post-amputation rehabilitation at a higher level, but are more expensive than traditionally mechanical knees. In the contrary however, a European study that defined health outcomes in terms of quality-adjusted life year (QALY), indicated that the C-leg showed a QALY gain of €3218 per patient (Brodtkorb et al 2008), makes it still financial viable keeping it mind its price tag.. The purpose of this study is to compare the traditional mechanical knee to the microprocessor knee (C-leg) in the dysvascular population. The study will specifically evaluate the potential of microprocessor knees to improve the quality of life in dysvascular transfemoral amputees. This includes identifying if the C-leg can increase the activity level to be classified at a higher level by the Medicare classification from K2 (lower level ambulators) to K3 (more proficient ambulators), along with increasing their social interaction in the community.

3) Hypotheses & Research Objectives and Purpose:

Central Hypothesis: We hypothesize that giving microprocessor knees (C-leg®), will significantly increase everyday function, social interaction, and quality of life in K2 Dysvascular subjects with transfemoral amputation in comparison to a standard mechanical knee (both FDA Class II exempt devices). The study will primarily aim to study the impact of the C-leg on ADLs and community interaction ADLs and function:

Hypothesis 1: We hypothesize that the C-leg will significantly increase every day physical activity measured using GPS tracked activity in K2 Dysvascular subjects in comparison to a mechanical knee.

Hypothesis 2: We hypothesize that the C-leg will significantly increase functional mobility in K2 Dysvascular subjects compared to a mechanical knee: increased stepping measured using Step Activity Monitor (SAM), increased gait speed and distance measured by Six Minute Walk Test (6MWT), increased mobility measured by the Amputee Mobility Predictor (AMP).

Hypothesis 3: We hypothesize that the C-leg will significantly increase community mobility measured using GPS technology in K2 Dysvascular subjects in comparison to a mechanical knee.

Sub -hypothesis

3a: That C-leg will improve ambulation distance vs. mechanical knee

3b: That C-leg will improve time out of home vs. mechanical knee

3c: That C-leg will improve ability to use public transport vs. mechanical knee

3d: That C-leg will decrease gait aid vs. mechanical knee

Hypothesis 4: We hypothesize that the C-leg will significantly improve social integration as measured by CPI (Community Participation Indicators) in K2 Dysvascular subjects in comparison to mechanical knee.

Hypothesis 5: We hypothesize that the C-leg will significantly improve both static and dynamic balance as measured by Single Leg Stance (SLS), Timed Up and Go (TUG), BERG Balance Scale (BBS), Four Square Step test (FSST) and Dual task TUG tests in K2 Dysvascular subjects compared to a mechanical knee.

Hypothesis 6: We hypothesize that the C-leg will significantly improve self-reported measures in K2 Dysvascular subjects in comparison to mechanical knee. reduced falls measured by The Falls Efficacy Scale (FES), improved prosthesis use measured by The Prosthesis Evaluation Questionnaire (PEQ)

This study will be conducted at the Rehabilitation Institute of Chicago, 345 E. Superior St, Chicago, IL 60611.

4) Research Methods:

Study Design:

The study will have a randomized, repeated measures design. Due to the high rate of attrition we will randomize a total of 40 subjects, 20 into each of the groups below.

Group I

Mech Knee+Old Foot	C-leg + New Foot	C-Leg + New Foot	Mech knee + New Foot	Mech knee + New Foot
>6 months post TF prosthetic fitting	Acclimation	Assessment	Acclimation	Assessment
Duration	3 months	3 months	3 months	3 months
Data Collection	Monthly	Monthly	Monthly	Monthly

Group II

Mech Knee+Old Foot	Mech Knee + New Foot	Mech Knee +New Foot	C-Leg+ New Foot	C-Leg+ New Foot
>6 months post TF prosthetic fitting	Acclimation	Assessment	Acclimation	Assessment
Duration	3 months	3 months	3 months	3 months
Data Collection	Monthly	Monthly	Monthly	Monthly

All measures will be administered and data collected under the supervision of a licensed physical therapist.

I. Assess and compare mobility in TF amputees:

- To quantify community ambulation including time spent out of the home, use of public transport, GPS technology will be used. Subjects will be required to wear a GPS monitor on their belts during the day. This will track their activities in their homes and in the community.
- To assess functional mobility the Amputee Mobility Predictor will be used. A standardized sequence of mobility tests with the prosthesis will be administered on the first pre-acclimation session. The patient will be scored out of 39.
- To quantify fall risk and functional mobility the Timed Up and Go (TUG) test will be used. TUG is the time taken for the subject to get up from chair, walk 3 meters and sits down; measured in seconds.
- To objectify the amount of steps in ADLs and functional mobility the Step Activity Monitor will be used. The subject will be given a monitor that he/she will have to wear around his/her ankle. This will record the number of steps.
- To determine community and social participation, the Community Participation Indicators questionnaire will be used. It is a valid, new generation of self-report outcome measure for community participation. It will take 15-30 minutes to complete and will be administered in room 1771.

II. Assess and compare gait distance and speed:

- To determine maximum gait distance while using the prosthesis, distance and perception ratings will be recorded during the 6 minute walk test. Subjects will walk for 6 minutes with prosthesis with researcher walking alongside with walking wheel to determine distance walked in 6 minutes while recording their Rating of Perceived Exertion on the Borg Scale.

III. Compare the static and dynamic stability:

- a. To assess balance during functional activities the BERG balance scale will be used. This is a performance based tool, scored 0-56.
- b. To assess static balance, the single leg stance will be used. This will time in seconds, how long the subject can stand on one leg.
- c. To assess stepping and change of direction, the four square step test will be used. The subject will be required to walk in a sequence across canes arranged in four squares, timed in seconds.
- d. To assess dynamic falls risk and multitasking ability, the Dual task TUG will be performed. The patient will be given a second motor task while performing the TUG (e.g. carrying a glass of water)

IV. Assess and compare patient perception and preference:

- a. To determine falls and near falls, subjects will fill out a self-reported Falls Efficacy scale (FES)
- b. To determine if cognition is a limitation the Mini-Mental State Exam (MMSE) will be administered.
- c. To determine prosthesis use and preference, the Prosthesis Evaluation Questionnaire (PEQ) will be given to the subject to fill out.
- d. These questionnaires will take between 5-20 minutes each to fill out.

Data Collection and Analysis

Subjects will be screened and medical history and information relevant to why and when they received an amputation will be accessed from their medical records. Subjects will be explained the study design, procedures, tests, questionnaires and physical therapy visits asked to sign an informed consent prior to participating in the study. After subjects are randomized into two groups, they will be provided with a GPS device and a step activity monitor which will track their walking/mobility patterns at home and in the community for 4 weeks. When they return, over 1-2 visits, they will be assessed for a full battery of baseline outcome measures: six minute walk test (6 mwt), Amputee Mobility Predictor (AMP), Timed Up and GO (TUG), BERG balance test,. They will also be required to fill in self-report questionnaires for falls and the PEQ. They will then be fitted with the randomized prosthesis and new foot by a certified prosthetist. There will a period of acclimation for 3 months during which patients will be provided physical therapy with either the C-leg with a new foot or a mechanical leg with a new foot. Subjects will come for an average of two times a week for physical therapy training. The pre-training visits will include 1 for informed consent and GPS, 1-2 for evaluation and an additional 1-2 for prosthetic fit. The training sessions will be a maximum of 14. There will also be 1-2 re-assessment visits. This will be repeated for the other prosthesis. There will be a maximum total of up to 45 visits. Subjects will be compensated \$40 per session for evaluation and assessments, prosthetic fittings and training sessions. This is the usual amount in similar studies and other studies at the Rehabilitation Institute of Chicago. The total compensation will be determined by the number of sessions that the subject completes while enrolled in the study. There will be 2 sessions allowed for a subject to be paid, even if they arrive but are unable to complete a session due to unscheduled issues (such as illness). However, if patients miss 3 or more consecutive visits, or experience a medical illness that may/may not require hospitalization, patients may have to be withdrawn from

the study. Patients will be offered the additional service of adjustments for prosthesis/refining home exercise program in phone or in person, but they will not be compensated for these patient initiated services.

The training will focus on providing both groups 1) strength training for upper limbs, core and lower limbs, 2) functional training, e.g. sit – stand, gait training on level surfaces, community ambulation and 3) cardiovascular and endurance training. The following 3 months there will be an assessment period for that particular knee and foot combination. In the course of the assessment period, patients will come in at regular intervals for data collection for the AMP and the 6 mwt. During the last 2 weeks of the assessment, patients will be given GPS devices for tracking their mobility data. At the end of 6 months there will be a crossover where patients with the mechanical leg will receive a new C leg + new foot and patients with the C leg will receive a mechanical leg + new foot. Once again, this will be followed by baseline testing, a period of 3 months acclimation with physical therapy sessions and a 3 month period of assessment where patients will come in for data collection. In the last 2 weeks, GPS data will be collected. The data collected will be analyzed for differences in outcome measures caused by the different prosthetic devices.

During the data collection process and the training sessions, a licensed physical therapist will be present to provide supervision and monitoring of the patient's vitals, signs and symptoms. During the sessions, subjects may be photographed or videotaped performing assessments, functional tasks, or exercising, with their consent. The photos and video recordings will not include the subjects face and if used for presentations or publications, will not identify the subject. The data collection and the training sessions will be terminated if the subjects expresses that he/she is unable/does not wish to participate. Subjects will be compensated \$40 per session. Payment will be in cash or by ClinCard per session, at the end of each session. RIC is moving away from using petty cash. During this transition period the subject may be paid in cash or by ClinCard. If a ClinCard is available when you come for the the study, you will be paid by card. If a ClinCard is not available, then you will receive cash payments.

If the subject is issued a ClinCard, which is a specially designed debit card for clinical research, the funds will be loaded as appropriate. When a visit is completed, funds will be approved and loaded onto the card. The funds will be available within 1 day after being loaded and can be used at the subject's discretion. The subject will be issued one card for the duration of your participation. If your card is lost or stolen, please call (866) 952-3795 or ask a coordinator for a replacement ClinCard.

Fees are incurred if used at an ATM (fees vary by location). However, if the card is used for in-store or online purchases via credit or debit, or presented to a bank teller, there are no associated fees and no expiration date.

If subjects wish to join RIC's gym to exercise to increasing endurance and fitness, we will provide them membership (with an RIC physician signing membership form) to RIC's Fitness Center and Sports Program (a \$35 cost that the study will pay to the Fitness Center for the subject). Subjects may be required to participate in a maximum of 45 sessions, although the maximum may not be needed for all subjects. The maximum

compensation is \$1800, although the total compensation will be determined by the number of sessions that the subject completes while enrolled in the study.

The data collected will be analyzed offline. All data and medical information of potential subjects will be locked in a file cabinet in the office of the PI. All study personnel listed will have access to the data and medical information. Subjects will be assigned a code when they are enrolled in the study. All GPS data will be analyzed by a researcher who is blinded to the subjects' identity. All data will be kept on computer hard-drives with accounts and passwords for security. Data will be stored in a locked file cabinet and on a secured-access computer. Data will not be destroyed. Only authorized individuals working directly in the study will have access to the computers.

Selection and Withdrawal of Subjects

Lower limb transfemoral amputees will be recruited from inpatient and outpatient amputee clinics at The Rehabilitation Institute of Chicago and Northwestern Memorial Hospital. Criteria will be:

Inclusion criteria

- Males or females with dysvascular transfemoral amputations
- 6 months or more post prosthetic fitting
- Homebound or limited community ambulators post amputation
- Ability to walk >50m in a 2 min walk test

Exclusion criteria

- Traumatic, cancer or genetic amputation
- Co-morbidity that completely prevents physical activity
- Significant skin lesions/ulcers on stump that prevent fitting of prosthesis
- Cognitive deficits or visual impairments that would impair their ability to give informed consent or to follow simple instructions during experiment

Withdrawal criteria

- 3 or more consecutive or 5 total per leg missed sessions
- Hospitalizations
- At PI's discretion for unforeseen/unplanned medical events that may alter inclusion or exclusion criteria

Subject Recruitment and Screening

Lower limb amputees will be recruited from amputee clinics at RIC and Northwestern. Clinicians at these locations will be informed that the Center for Bionic Medicine is looking for lower limb amputees who, in their judgment will fill the above criteria. Potential research subjects will be referred to Gayatri Mathur, PT, Megan Hermann, PT, Kelly Nance PT and Susan Dluhy, PT,. They will be provided with a contact card with contact details for the physical therapists. Potential subjects will be informed of the time commitment required and questioned regarding the inclusion/exclusion criteria.

In addition, research staff on the study will identify potential subjects from RIC's Cerner Information Systems. Once a dysvascular transfemoral amputee has been identified, study staff will contact the subject's clinician and get permission to pre-screen as a potential subject. If clinician agrees, clinician may contact potential subject or study staff will contact the potential subject on behalf of clinician, initially with a letter followed by a phone call to the potential subject.

A recruitment flyer will be distributed to prosthetists' offices (e.g. at Hanger, Scheck and Siress) for posting/handing out to potential clients who may be interested in learning more or participating in the study.

Study staff will also post information about the study by e-mailing members of the Midwest Chapter of the American Academy of Orthotists and Prosthetists, which is available only to prosthetic and orthotic professionals who are members and live within the boundaries of Wisconsin, Illinois and Indiana. Information about this organization may be found at: <http://www.oandp.org/membership/chapters/midwest/>. The same message will also be posted on OANDP-L (OANDP-L@LISTS.UFL.EDU) which is the listserver for the exchange of information for orthotics and prosthetics professionals..

Finally, Dr. Jayaraman will screen the potential subjects to ensure that they meet the inclusion/exclusion criteria.

Efficacy Assessment

Microprocessor knees have shown to be very effective to improve community mobility and quality of life in the K3&K4 amputee population. This protocol seeks to test the efficacy of the microprocessor knee (C-leg) in the K2 dysvascular population.

Safety Assessment

Risk and Injury

The primary risk in this study is the risk of falls, regardless of the prosthesis used. Fall prevention is a primary focus and the risk will be reduced by the use of harnesses, gait belts, assistive devices as needed and stand-by or contact guard assistance and supervision by researchers. All subjects will be initiated with testing and therapy sessions with simple activities, progressing on to more dynamic, complex activities when it is clear that they are safe and acclimated to the prosthesis being used. Other risks include muscle soreness from exercises during therapy sessions. To avoid this, subject will be provided with adequate rest periods and subjects will be monitored by questions regarding discomfort. Skin irritation from adjusting to a new socket fit can also be a risk. This risk will be minimized by regular check ups by a certified prosthetist, who will check for skin lesions/breakdowns.

Benefits

The benefits from this study to the individual subjects will only be related to similar physical therapy sessions they would receive as part of their rehabilitation. Although the immediate benefits of the study to the individual are limited, the entire community of transfemoral amputees stands to benefit with a better understanding of functional gains and quality of life changes with different prosthetic components. Upon completion of the

study, the participant may choose to keep the prosthetic foot used in the study if continued use is approved by their clinical prosthetist.

Statistical Analysis

The data will be analyzed using Statview version 5.0.1 will be used for statistical analysis. Power, the probability of rejecting a false null hypothesis, is fixed at 0.90. Two-sided significance level is set at 0.05. The sample size required for an attrition rate of 30% is therefore 40 subjects to be randomized into 2 groups of 20 each. A two way-repeated measures ANOVA will be used with main factors of prosthetic used and repeated testing session.

5) Anticipated Results & Potential Pitfalls

We anticipate the dysvascular amputees when using the c-leg will significantly improve in their functional outcomes, increase their community mobility leading in significant health benefits. We do not foresee any potential pitfalls.

6) Discussion of Next Steps

This research will be critical in establishing the efficacy of using a microprocessor knee in the improving functional outcomes and community mobility K2 dysvascular population. While this line of research will have many options of further investigation, the particular path this laboratory would like to follow three-fold: 1) does providing prosthetic knees with greater functionality help amputees improve their quality of life and social re-integration, 2) does prosthetics with greater functionality relate to greater exercise leading to reduction in co-morbidities and reduced health costs, 3) does intense rehabilitation as part of the amputee rehab contribute to better prosthetic use.

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