LOW COST PROSTHETIC DEVICE FOR TOE PART

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ABSTRACT :

This paper describes the various prosthetic devices which required for foot. Society is affected by many problems and diseases. Also few of people loss there foot in accident or in war. In such condition they are not ready to stand on their legs, even in society. For that purpose any artificial arrangement is necessary. In this paper we study the different prosthetic foot with low cost and better design. Now a day's research is focused on the material and cost of foot. Researchers are investigates the different prosthetic foots with different design and material according to the requirement. Some prosthetic device is made for knee and some are for toe.

INTRODUCTION

Natural disasters are occurring everyday across the globe, these claim the lives and livelihood of many individuals and families, especially in poorer regions of the world where if there is access to necessary medical care it is difficult to afford. Because of this there are many who have suffered a lower limb amputation and thus have had their ability to provide for themselves and their families greatly reduced or taken away. Our projects goal was to meet this critical need by building on the work of previous senior design teams at the University of Arkansas, in the testing, analysis, and design of a low-cost prosthetic foot that would allow lower limb amputees who are unable to afford a high level prosthesis to regain a significant portion of their lost mobility. The final design of the prosthesis underwent static and fatigue testing as described in the ISO standard 10328 (Prosthetics-Structural testing of lower limb prostheses-Requirements and test methods). The project was then submitted to the universities institutional review board (IRB) for the approval of an actual human test. After receiving approval the test was successfully performed at Snell Prosthetic & Orthotic Laboratory with the assistance of a local prosthetics Randy Ludolph and a local volunteer who had a previously existing lower limb amputation. Although further testing still needs to be completed to ensure safe long-term use of the prosthesis the preliminary static and fatigue testing, and most importantly, the successful human trial show significant promise for our prosthesis to be successfully used to aid lower limb amputees in living more enjoyable and productive lives.

This project is the continuation of previous design projects at the University of Arkansas, devoted to developing low cost, easily producible prosthetic devices. Over the last four years four senior design teams have been involved in the design and development of a low-cost prosthetic foot, with each year building on the work of the previous ones. Our teams task was to take the prototype from the previous year and perform the necessary testing on it, in accordance with ISO standard 10328 (Prosthetics-Structural testing of lower limb prostheses-Requirements and test methods) to prepare it for human trials. This device could offer an affordable, locally producible prosthesis for uses in countries that have low access to affordable healthcare. At the present there are some affordable prosthetic feet but they are not the dynamic type that offer the flexibility needed for highly mobile amputees. The type of foot that this project will continue to develop is a dynamic-response type of prosthesis made from steel. It allows for a "push-off" sensation when the user walks. This is achieved through spring metal on the heel and toe contact points. As of right now, the many different prosthetic feet that are available are made from plastic, metal alloys and carbon steel. Some of the types allow little to no cushion, while others allow the ankle joint to hinge front-to-back as well as side-to-side. In addition, the dynamic response type allows for a well-replicated walking movement as compared to the natural foot.

This project is needed to provide an option for the many lower limb amputees around the world who cannot afford the dynamic prostheses on the market, or who do not have access to such devices, that can be affordable and most importantly be manufactured in the country with local labour. The idea of a low cost dynamic-response foot is currently in development and being tested in Thailand, but this design does not seem to be a design that could be produced by in-country craftsman.

A REVIEW ON DESIGNS OF PROSTHETIC FOOT

Muhsin J. Jweeg et al study the Design and Analysis of New Prosthetic Foot and entire characteristics test, design fatigue foot tester according to ISO 10328 and design new foot. They conclude that the new foot was easily the most suitable foot for the patient conditions chosen both in energy storing potential and energy return efficiency. By comparing the characteristics exhibited by prosthetic foot to these of a human foot , a selection of these prostheses was undertaken based on their favorability to the characteristics of a human foot , the new foot is a good characteristics.

Samuel K. Au, Jeff Weber, and Hugh Herr investigate Biomechanical Design of a Powered Ankle-Foot Prosthesis In this paper, we present a novel, powered ankle-foot prosthesis that overcomes these design challenges. The prosthesis comprises a unidirectional spring, configured in parallel with a force controllable actuator with series elasticity. With this architecture, the ankle-foot prosthesis matches the size and weight of the human ankle, and is shown to be satisfying the restrictive design specifications dictated by normal human ankle walking biomechanics.

In this paper, a novel, powered ankle-foot prosthesis is proposed. The prosthesis comprises a unidirectional spring in parallel with a high performance, force-controllable actuator with series elasticity. By exploiting parallel and series elasticity, the design is shown to be capable of satisfying the restrictive design specifications dictated by normal human ankle walking biomechanics.

Michael P. Dillon et al describe Effect of prosthetic design on centre of pressure excursion in partial foot prostheses. They suggest that the effective foot length can be restored when the prosthesis incorporates a relatively stiff forefoot, restricts dorsiflexion, and includes a mechanism whereby forces caused by loading the toe lever can be comfortably distributed to the leg (e.g., an anterior tibial shell). They also demonstrated using three-dimensional motion analysis that the prosthesis must incorporate each of these design elements to restore the effective foot length.

This investigation systematically altered aspects of prosthesis design to understand which design elements were important to restoration of the effective foot length in persons with PFA. Our observations in two persons with PFA suggest that the prosthesis must incorporate each of the following design aspects to restore the effective foot length: a stiff forefoot, an anterior leg shell, and restrained dorsiflexion. When such a device was provided to the persons with TMT and Lisfranc amputations, we observed not only restoration of the effective foot length but also less exaggerated dorsiflexion, reduced loading on the sound limb during initial contact, and normalization of the ankle and knee moments during late stance as the device compensated for the limited contribution of the ankle plantar flexors.

Denial riths et al studies the prosthetic foot design. They design incorporate modified foot with an ankle section. this enable prosthesis to have better impact absorption at heel strike. the heel used in new design contain low density, polyurethane wedge.

Brian J. South et al investigate Manufacture of Energy Storage and Return Prosthetic Feet Using Selective Laser Sintering. The objective of this study was to develop a framework based on SLS manufacturing technology to rapidly design and fabricate prosthetic feet with custom stiffness levels for detailed studies designed to understand the relationships between foot stiffness and gait performance in transtibial amputee walking. In addition, the high load testing showed the SLS foot does not fail under high loads nor show any permanent deformation. The spatiotemporal, kinematic, and kinetic gait characteristics of the CF foot were nearly identical when the subject walked with the SLS foot. Some minor differences were noted between the SLS and CF feet in the residual leg ankle and knee moments during midstance.

Ranjan Das, M.D Burman, Sagar Mohapatra study Prosthetic Foot Design for Transtibial Prosthesis. The basic goal of prosthesis of any type is to improve or restore the function of a physically handicapped individual or amputee. The current prosthetic feet fail to accurately mimic, the characteristics exhibited by normal foot. Such dynamic Characteristics include eversion, dorsiflexion energy return impact, absorption and torsion about the ankle. The analysis prosthetic feet will be required to identity, the as well as further requirement for better ADL activities.

By comparing the characteristics exhibited by a prosthetic foot to those of a human foot, a selection of these prostheses was undertaken based on their favorability to the characteristics of a human foot.

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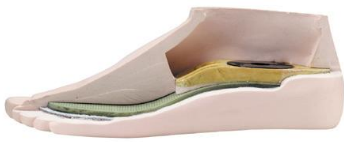
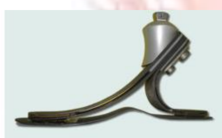
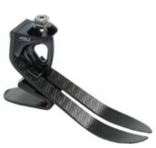
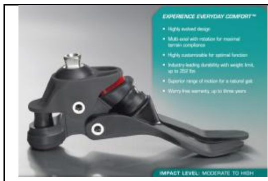
TYPES OF PROSTHETIC FOOT

Prosthesis	Conclusions
Impulse Foot  http://www.owwco.com/pdf/catalog/C/OWW% 20catalog%20sec%20C_00020.pdf	• Composite foot plate attached to a Kevlar® /nylon keel • Good flexibility/ toe response • Features recessed keel, aids in energy return, storage, and provides stability on different types of terrains • 350 lb weight limit
Flex-Foot Axia by Ossur 	• Replicates the action of the anatomical foot • Guided Roll-Over feature increases lateral stability, allowing more balanced motion during stance • Increased comfort • Moderate energy response and low build height • Small split toe
Trias Foot   (Otto Bock, 2009).	• Designed based on anatomy of tendons / ligaments in the foot • Lightweight, carbon fiber • Heel contains two linked spring elements that absorb shock on initial impact • No split toe
Elite2 Foot by Endolite (Endolite, 2008) 	• Shock absorbing heel • The curvature /asymmetrical designed toepromotes smooth transition during rollover phase of gait cycle. • Split toe • Composite lightweight carbon material • Simple design, minimal maintenance, 3-5 year lifetime (Zahedi et al., 2008)
TruStep Foot by College Park Industries (College Park Industries,2009)	• Moving parts • Customization • The shock heel bumper reduces the shock of the initial impact. • Split toe • One flaw in the design is that the rubber bumpers tend to wear out quickly, requiring them to be replaced approximately every

	6-8 months (Crandall et al., 1999) • High maintenance

VARIOUS TESTING ON PROSTHETIC LEGS

STATIC TESTING

There are two levels of static testing required by ISO standard 10328 (Prosthetics-Structural testing of lower limb prostheses-Requirements and test methods) to ready the prosthesis for human use, the static proof test, and the static strength test. Do to time constraints only the static proof test was able to be performed on the prosthesis. This test requires that a 2240 N (503.6 lbf) load be applied to both the fore foot and the heel at an incline of 20 degrees and 15 degrees respectively. These tests were performed with the use of an instron machine that allowed us to control both the rate and the magnitude of the load applied. Two jigs were constructed, one to test the forefoot and one to test the heel of the prosthesis, that could be bolted onto the testing surface of the instron and hold the prosthesis at the desired angles. To pass this test the desired load needed to be reached and held by both portions of the prosthesis without the prosthesis cracking or fracturing, and without any plastic deformation exceeding 5mm. The heel passed the test completely, while the fore foot deformed slightly, however this test showed that the prosthesis should be able to handle the load of an average sized person standing on it.

FATIGUE TESTING

In order to have a realistic assurance of the prosthesis' durability and long-term performance, cyclic loading tests must be performed on the foot. A previous senior design team built an experimental fatigue tester. The machine consists of a frame, two pneumatic pistons, and a control box that commands solenoid valves to allow air pressure into the cylinders, thus exerting a theoretical steady 1330 ft-lb_f (at 95 psi) repeatedly on the toe and heel to be compatible with ISO standards. In order to pass ISO standards regarding lower limb prosthetics, it must undergo 2,000,000 cycles at a rate of 1 Hz. If the foot fractures in any area or cannot reach this load it will have failed the ISO standard for cyclic testing. While it was not possible to complete the 2,000,000 cycles do to time constraints more than 11,000 cycles were completed successfully.

DISCUSSION AND CONCLUSION

In conclusion, with the success of the first human trial of the prosthetic foot has met most of the goals outlined for it at the beginning of the project, specifically.

1. Potential to be an option for a dynamic low cost prosthetic foot

2. Use materials and tools that would be readily available in most countries
3. Easily made with a manufacturing process that does not require any high tech

Equipment

1. Allow for walking motion similar to that provided by a natural foot

It is still necessary to continue static and fatigue testing to achieve full compliance with ISO standards and ensure safety for prolonged use. There are also several modifications that should be made based on feedback from the volunteer during the human trial.

1. Increasing the density and thickness of the crepe rubber used in the heel and toe of the prosthesis to provide more rigidity
2. Tapper the toe and heel to reduce width (allow prosthesis to more easily fit into a shoe)
3. Use an angle grinder to buff any sharp or rough edges of the prosthesis
4. Use four holed pyramid adapter instead of single hole. (reduce strain on bolt and keep sections of prosthesis from sliding when under dynamic load)

Thus while there is still work to be done to finish testing, and some minor design modifications, to be made the prosthesis is looking to be a viable option for a low cost dynamic response prosthesis that can be affordably produced and obtained worldwide.

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