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Spring Loaded Foot: A Low Cost Foot Design

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ABSTRACT

Background: A less-resourced setting has been defined as a geographic area with limited financial, human, and infrastructure resources. These conditions are common in low- and middle-income countries and can represent a substantial barrier to the delivery of appropriate services. A negative aspect of R&D is that the vast numbers of end users reside in developing nations and are not able to benefit from this new technology due to the cost, durability, maintenance and accessibility of these components. The Spring-Loaded foot is an artificial foot designed to perform varying functions depending on the desired walking.
Case description and Method: The spring-loaded foot is designed with a foot plate with a connection mechanism embedded with a coil spring, foam and micro cellular rubber elements.
Result: These embodiments provide great flexibility for economic prosthetic feet that provide an alternative to the complex and more expensive prosthetic feet currently in use.
Conclusion: This prosthetic foot is an economical and light weight design with proper biomechanical implications providing proper gait.

Key Words: prosthetic foot, transtibial amputee, push-off.

INTRODUCTION

The human body requires feet to provide stability and balance when standing or moving. The amputation of the foot significantly reduces the amputees' ability to perform normal activities such as walking [(1)].

The lower limb amputation was most seen as compared to the upper limb amputation. The former accounting for 94.8% of all amputation and the later for only 5.2%. Among all lower limb cases below knee amputation were the most common followed by above knee amputation [(2)].

The basic goal of the prosthesis is to improve or restore the function to physically handicapped individual. Current prosthetic feet fail to accurately mimic the characteristics exhibited by a normal human foot. Primarily the physical limitations of a prosthesis are its inability to replicate the dynamic of a sound foot. Such dynamic characteristics include eversion, dorsiflexion, energy return, impact absorption and torsion about the ankle. These are the major characteristics generated by a human foot during a normal walking gait cycle [(3)].

There are variety models of prosthetic foot available today. Some are designed for special tasks such as walking, dancing, cycling, golfing, swimming, snow skiing or running. Many are water proof and lightweight materials such as plastics, metal alloys and carbon fibre composites.

Prosthetic feet can be basically articulated or dynamic response. Today's prosthetic feet may have toe and heel springs to allow more ankle movement and adjustable heel heights, and to absorb shock. Prosthetist should choose a prosthetic foot base on your amputation level, age, weight,

foot size, activity level and job requirement of the user [4].

Current prosthetic feet design makes it difficult to replicate the exact characteristics of a normal foot. Major advances in research and development of a prosthetic foot have increased the function and quality of life for many individuals with lower limb amputation residing in industrialized nation in the last two decades. A negative aspect of this new R&D is that the vast numbers of end users reside in developing nations and are not able to benefit from this new technology due to the cost, durability, maintenance and accessibility of these components. Research is needed in this area for design and development of a worthwhile prosthetic foot that meets economic, environmental, and physical standards which can handle adverse climates and working conditions. Information on this subject is limited and through more research and feedback from this population a more functional design may be developed. The current review attempts to synthesize available data on commonly used prosthetic in developing countries to include, demographics, engineering, material design and current issues to help guide the future of minimal cost prosthetic foot development. Of all prosthetic feet reviewed only two of (>25). Low cost prosthetic feet have passed international standard organization testing (ISO). Based on available research the current prosthetic feet feasibly available to individuals with lower limb amputations in developing nation fall short in providing durable cost effective and or biomechanically appropriate options [5].

The Spring-Loaded foot is an artificial foot designed to perform varying functions depending on the desired application. The foot is designed to function under the stress of ambulation. The function of heel within a prosthesis is to provide the impact absorption at heel strike and provide the kinetic energy return required for a smooth transition between the initial contact and Preswing. This spring-Loaded foot is mainly designed for the use of low-income users.

The project is aimed to design a cost-effective foot for transtibial amputee to restore lever arm for the normal push-off in terminal stance.

METHODOLOGY

Case Report

A 30-year-man, who had a right transtibial amputee in 2017 secondary to RTA reported to P & O department. Following the amputation, he was undergone rehabilitation procedure.

A prosthetic foot was designed in simple fabrication method with available materials which reduces the cost of the foot. This uncomplicated design principle helped workers in time saving and effortless job. This foot benefited for the low-income patient who were not affordable for buying a prosthetic foot.

Objective

The study was aimed to design a cost-effective foot for transtibial amputee to provide necessary external support to the foot and to restore lever arm for the normal push-off in terminal stance.

Design concept

Embodiment of the spring-loaded foot included a resilient foot plate with a connection mechanism embedded with a coil spring, foam and micro cellular rubber elements.

The first element was footplate, approximately shaped and configured to provide load bearing support and prosthetic foot characteristic permitting smooth ambulation. Another plate is cut and shaped to fit on the proximal of the foot. The connection mechanism includes an intermediate portion between the plates which is engaged by the spring. The material used to construct the foot plate is the mild steel plate. In the posterior middle portion of the foot plate and centre of the proximal steel plate had a recessed portion to accommodate the attachment bolt.

The second element was long helical coil spring that was cut into four pieces to same level which is bonded into the foot plate distally and proximal steel plate.

The third element was foam such as the ethaflex and EVA were cut and strongly embedded alternatively. The alternatively embedded foam matrix was bonded to the foot plate anteriorly. The foam was shaped to provide cosmetically pleasing appearance for the prosthetic foot. The foam element having a higher stiffness.

The fourth element was the MCR were used that was cut and bonded to the foot plate distally which is shaped to the resilient foot plate. At the distal surface of the MCR, fore foot rocker was constructed that helped in forward progression of the gait at terminal stance. This provide improved initial contact, cushioning and maintaining the stability.

The MCR bumper elements were used which is placed anteriorly between the plates in front of the coil spring engaged portion. This placement was to avoid forward bending of the proximal steel plate.

At last the ethaflex foam were provided at the posterior portion to cover the spring engaged portion. This covering was done for the finishing of the foot that results in good cosmetic appearance.

Fig 1: Basic Structure of the foot

This embodiment provided low cost prosthetic foot that performs all the necessary functions of a prosthetic foot and was easy to manufacture. As previously discussed, stiffer bonded heel spring provides good stability during mid stance, and terminal stance, while still providing amputee cushioning and energy storing during the initial contact.

Fig 2: Posterior view of prosthetic foot

Fig 3: Front view of the foot

RESULT

These embodiments provide great flexibility for economic prosthetic feet that provide an alternative to the complex and more expensive prosthetic feet currently in use.

It is understood that the size of the prosthetic foot and the components there of can be adjusted during the manufacturing, so that many different users having different sized feet may benefit from the present

design of prosthetic foot. Specifically, the width, thickness and length of the foot plate may be varied to accommodate different foot sized user. Accordingly, the size of the foam elements may respectively vary.

DISCUSSION

A low resource setting is usually a low- or middle-income geographic area that is at a stage of economic and social development in which resources are insufficient to meet the need of a population. There are many strategies that can be used to help meet the need of individuals who could benefit from prosthetic services in a low resource setting.

The prosthetic feet provide great flexibility for transtibial amputee, alternative to the complex and more expensive prosthetic feet currently in use. This prosthetic foot is an economical and light weight design with proper biomechanical implications.

CONCLUSION

This case report shows that the low-cost foot design can be an effective treatment option in transtibial amputation. Because of low cost, light weight and flexibility with all kid of shoes, it will be preferred mainly by lower economic group patients in developing countries.

This foot has the disadvantage of cosmetic appearance which is less cosmoses than other prosthetic feet. This disadvantage can be accommodated by wearing this foot inside the shoe.

Further development of this foot can be done by the skilled artisan will recognize the interchangeability of various features from different embodiment. This invention has been disclosed in the context of certain exemplary embodiment, it therefore understood by those skilled in the art that can be modified by alternatives embodiments.

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