POLYCENTRIC FOUR BAR HIP PROSTHESIS

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Introduction

Uniplanar-under-actuated polycentric mechanisms had been implemented on the design and building of a prototype of an external prosthetic hip for unilateral joint in the case of severe disarticulation in order to improve the movements generated by existing prosthesis, and to allow the user to walk with motions that are similar to that of a person in full physical ability.

Among the main causes of a limb amputation are nervous and circulatory complications related to diabetes, accidents and birth defects. In Mexico there is no official number of amputations performed annually, but it is estimated that diabetes alone causes 75,000 amputations per year [1]. The main reason leading to the usage of a hip prosthesis is the severe disarticulation surgery, a method used in cancer and severe infections. The aim in prosthetics is to design mechanisms whose movements are as close as possible to the human body and at the lowest cost. This design offers a choice of prosthesis for severe hip disarticulation, whose main characteristic is to provide damping by means of a pneumatic system.

Methodology

The first stage begun with the study, in appropriate literature, of human walking in normal conditions; with that knowledge in mind models of a possible design were generated. Thus, having the design and aided with CAD software, the prototype was tested via effort analysis method to ensure its resistance once loaded. After it fulfilled all these requirements, the prototype proceeded to construction.

Discussion

The most used prosthesis for hip disarticulation, so far, is the "Canadian" prosthesis introduced by McLaurimin in 1957. The relatively slow progress in this type of prosthesis could be explained due to the low number of users compared with other prosthesis. The design has been modified since then and modernized but has kept the basic idea. It is common to quote the modular prosthesis of Otto Bock, called Helix, since it has become the model of choice in cases of hip disarticulation. The cons of this prosthesis are the high price and the described movements, which are thought to be in 2 axes but which do not address natural gait movements. Adding new materials with lower density and control technologies based on microcontrollers, the Link polycentric system could become superior. Once the mechanism design was obtained, a stress and deformation analysis was performed on it. The analysis used a software based in Finite Element Analysis to ensure the mechanism bore the load of the subject using it and to recognize if the width of the links and elements were optimal.

Results

A design of a unilateral hip using polycentric mechanisms, which are based on the design of a four-links mechanism knee design, was generated in SolidWorks software. The movements correspond to the hip flexion-extension ones, which are observed from the sagittal axis. The design can be subjected to changes according to the physicians´ and patients´ needs. The movement was simulated and it was found that the mechanism´s instant centre of rotation can be located on the intersection of the central line of the anterior and posterior links at any bending position, indicating that the resulting design is a polycentric mechanism. The distal portion is 200mm from the coupling plate of the basket, which indicates that we have a space of 120mm to 200mm to adapt in patients of 1.50m to 1.90m heights. This feature makes the prosthesis have a wide range, as shown in the figure 1.

Figure1. Design of the hip prosthesis showing the four links mechanism at a -17° of flexion. The link in blue is the body having the particular shape to protect the pneumatic actuator and optimize weight.

Conclusions

If we want to build prosthesis that increasingly resembles normal human movement, it is necessary that each of its segments, starting from the hip, is able to respond to changes on the others. Therefore, it is recommended to have and develop automatic actuators, or ones controlled by intelligent systems, capable of making instant decisions. This work followed such premises and managed to develop a prototype of prosthesis.

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