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NEW DESIGN OF THE SOCKET OF HIP DISARTICULATION PROSTHESIS

Abstract: *The main goal of a lower limb prosthesis is to fulfill the functions of the missing limb such as structure and aesthetics. Among all the lower limb prostheses, the one of hip disarticulation represents a great challenge due to problems of making and accommodating the patient using it. After trying to make a classic hip disarticulation prosthesis, it is noticeable how difficult it is to use. This paper aims to create a new optimized and improved hip disarticulation prosthesis focusing on the socket but also on functionalities and on its design.*

Key words: *hip disarticulation prosthesis, new product, design*

1. INTRODUCTION

In the 18th century, hip disarticulation was introduced, being considered one of the most radical operations performed for trauma or diseases of the lower limb. Due to its high morbidity and mortality associated with it, this procedure is rarely used. Since the first successful hip disarticulation was described, a number of important advances have occurred trying to make the process more easier [1].

Hip disarticulation is the surgical removal of the entire lower limb at the hip level. A traditional hip disarticulation is made by separating the form from the socket of the hip joint, while a modified version retains a small portion of the proximal (upper) femur to improve the contours of the hip disarticulation for seating [2].

A hip disarticulation prosthesis is composed of: prosthetic socket, body adaptation system, hip joint, knee joint, prosthetic tube, ankle joint and prosthetic leg.

Although several types of hip disarticulation prostheses have been tried in the past years, as it concerns the prosthetic socket, the model made in the 1940s by Mc Laurin, named Canadian prosthesis, still remained on top [3].

Over the past few years, prosthetic components such as knee and hip joints have been updated with electronic components. An example to consider is the Helix 3D hip prosthesis. Despite this fact, there are components that have not yet developed sufficiently [4].

2. DIFFICULTIES

Thus, a hip disarticulation prosthesis was made in the Activ Ortopedic company (Figure 1). The prosthesis was made for a 76-year-old patient suffering from this type of amputation, and difficulties arose that led to the non-use of the prosthesis.

We have to take into account that amputation was made 10 years ago so the accommodation with this kind of prosthesis it's quite difficult. The main cause of amputation was peripheral arterial disease and other associated disease are: diabetes, permanent arterial fibrillation, arterial hypertension and obesity.

After the clinical examination, the type of components that will make up the prosthesis assembly are decided.

The prosthesis will be composed of: socket made of acrylic resin and fiberglass, fixed hip joint, self - locking knee joint, prosthetic tube, movable ankle joint that allows movement and prosthetic leg with a single axis.

The main reasons why the prosthesis was not used were the socket that was not comfortable, the difficulty of mounting the prosthesis to the body due to the adaptation system and the type of hip joint that did not allow joint movements.

Figure 1 Traditional Hip Disarticulation Prosthesis [5].

Therefore, it is desired to create a new prototype that will focus mainly on the design of the socket but also the modification of the other mentioned components.

Having the dimensions of the patient from the creation of the prosthesis, the prototype will be made according to them in order to be suitable (Figure 2).

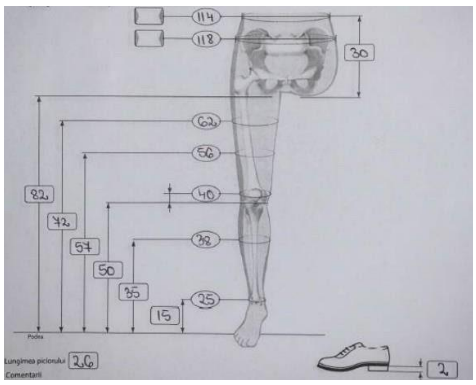

Figure 2 Dimensions of the hip disarticulation prosthesis.

3. NEW DESIGN

The new hip disarticulation prosthesis was designed in the Autodesk Fusion 360.

So, the main component of this type of prosthesis that raises problems being the prosthetic socket, most changes will be found at its level. A "bikini" socket will be created that will not encompass the entire basin and will give freedom to the area.

The new type of socket consists of: two wings, the body adaptation system and the area of the socket that will include the patient's abutment.

Initially, it starts with the wing that will be equipped with barriers against slipping, as it is a patient suffering from diabetes. In the case of people who suffer limb amputations, increased protection of the abutment is necessary due to the fact that the skin becomes much more sensitive and thin (Figure 3).

These barriers will be made of silicone and will help to keep the prosthesis fixed but also for the comfort of the patient.

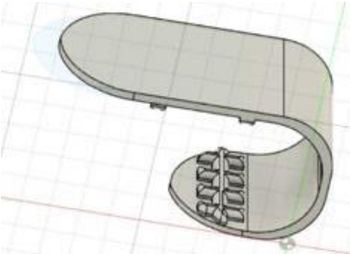

Figure 3 Design of the wing.

The arrangement of the two wings at an angle of 10 is chosen in order to be position optimally, taking into account the arrangement of a hip disarticulation prosthesis on the pelvis (Figure 4).

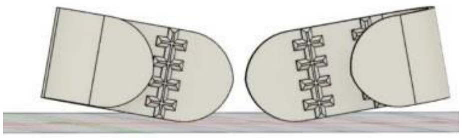

Figure 4 Position of the wings of new prosthesis.

Next comes the step in which the part of the socket that includes the patient's abutment will be made. Unlike the bulky size of the custom-made prosthesis socket, this type gives freedom to the patient. It can be seen from the way the abutment socket is arranged, being much smoother and thinner (Figure 5).

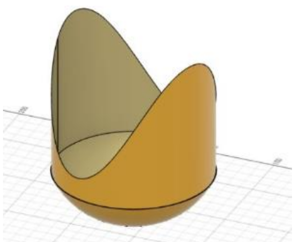

Figure 5 Design of the new abutment holder.

The new body adaptation system of the prosthesis will consist of 3 fastening belts and 3 buckles (Figure 6). The system will give the patient the freedom to choose how tight it should be on the body, hence the composition of 3belts.

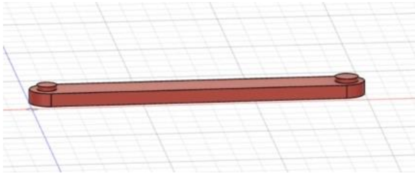

Figure 6 Design of the belt

The 3 buckles are joined with the fixing bars and thus will constitute the entire adaptation system. They will be made of a much finer metal, titanium (Figure 7).

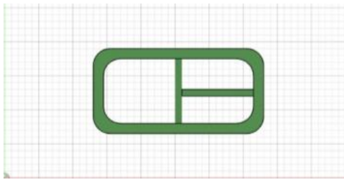

Figure 7 Design of the buckle.

The hip joint being a polycentric hydraulic type, the damping of the movements will be superior. In order to design the joint, the rod-cavity mechanism, present both in mechanics and in medicine, was taken as an example.

In addition to the trapezoidal cavity that will be attached to the prosthetic socket, you can also see the connector connecting the prosthetic tube (Figure 8). The prosthetic tube will be made of a metal alloy of titanium and carbon, being the easiest option that can be placed. The prosthetic tube is the connecting element between the hipjoint and the knee joint.

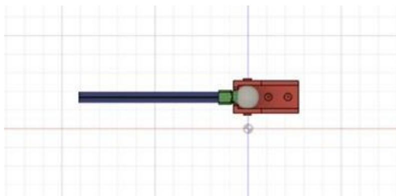

Figure 8 Design of the hip articulation mechanism.

It can be seen in Figure 9 as the hip joint is constructively limited in order not to lose balance and not make movements that may endanger the patient's stability.

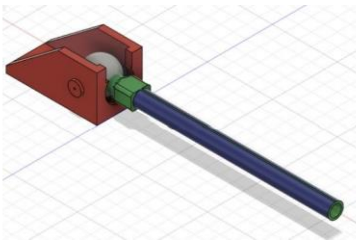

Figure 9 Limitations of hip joint.

Finally, the previously presented components are joined, obtaining the final assembly of the prosthesis (Figures 10-13).

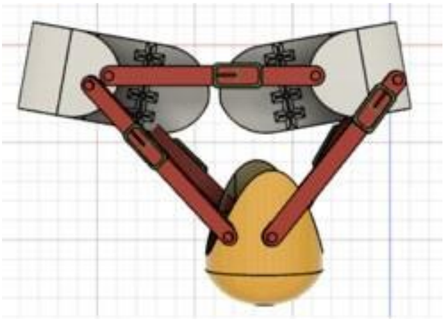

Figure 10 Front view of the assembled components.

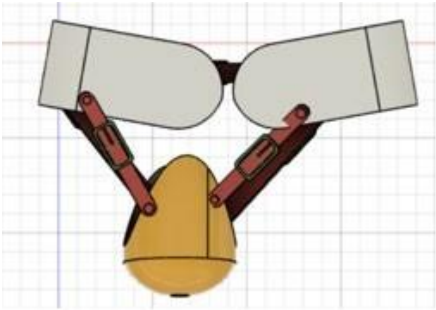

Figure 11 Back view of the assembled components.

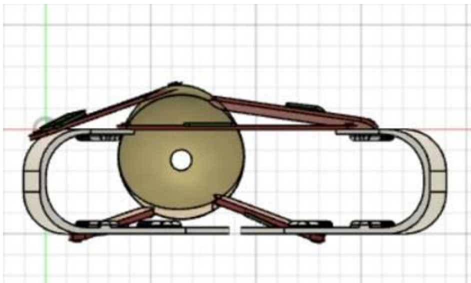

Figure 12 Top view of the assembled components.

It can be seen how the combination of all the previously listed components has been successfully achieved thus creating a unique design of the hip disarticulation prosthesis prototype.

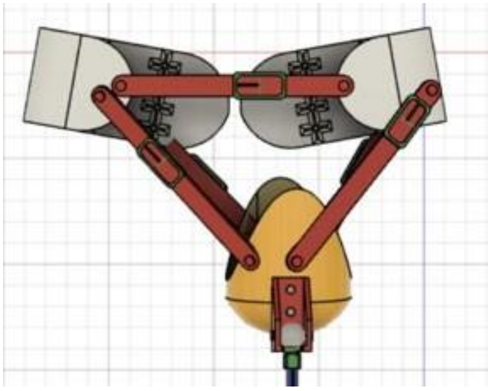

Figure 13 General view of the assembled components.

4. DIFFERENCES BETWEEN THE TWO SOCKETS

As can be seen in Figure 14 there are major differences between the actual prosthesis and the prototype that was tried to be developed.

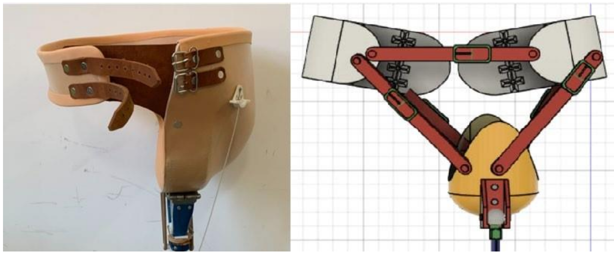

Figure 14 Comparison between the two prosthesis.

Making a bikini socket can mark the beginning of light, comfortable sockets instead of the old rigid and heavy sockets. Instead of encapsulating the entire pelvis, a socket is placed that gives freedom to the patient through its shape.

According to specialist studies, a socket of this type provides a superior biomechanical connection between the prosthesis and the user, resulting in a superior quality of life for the patient with such an amputation. The new prototype provides a much better grip on the anterior pubic bone, posterior sacrum, ischial tuberosity and iliac crest.

Also, the new body fit system consisting of 3 belts and 3 adjustable buckles has increased control regarding the capture of the abutment, so the user is free to set the level of freedom on each side.

Another advantage of the new prototype is the fact that the materials used to make it are incomparably light, taking into account of course the missing parts compared to the traditional prosthesis. Through these considerations, the level of energy consumed decreases, making it easier to use.

5. CONCLUSIONS

The main objectives of this article have been achieved as can be seen. Besides these, future considerations regarding the materials of the components are desired. The new socket is intended to be made by3D casting in layers and the material from which it willbe made will be carbon fiber.

The barriers that prevent sliding can be replaced with air cushions, which inflate and deflate for better ventilation of the tissue inside the prosthetic socket.

The new body adaptation system consists of 3 belts that will be made of a slightly elastic material and the fastening buckles will be made of titanium, this being a fine and light metal.

The hydraulic polycentric hip joint that allows joint movements to be damped in all phases of walking, approaching the imitation of a normal walk. In the case of the made prosthesis, the type of hip joint was locked and thus it was impossible to flex the leg. Also another impediment in the case of the locking hip joint is when sitting down when it is necessary to press a lever that allows flexion.

The knee joint, the ankle joint and the prosthetic leg did not raise functional level problems in the case of the prosthesis made and thus these components can remain the same.

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