Electronic prostheses: A new hope to improve the quality of life for people

Prótesis electrónicas: Una nueva esperanza para mejorar la calidad de vida de las personas

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Summary

The aim of this article is to show how the prosthesis of lower and upper limbs became a possibility to improve the quality of life of the population with different capacities, providing products with great technological advances and taking into account the extraction of patterns for the creation of each prosthesis with the characteristics that define a person. Taking into account the above, to improve this quality of life, we will talk about: how prostheses should be seen in their bodies so that they feel incorporated into society and active in their daily functions. Finally, the author shows how they perform experimentation in sciences such as bioengineering, mechanics, electronics, robotics and electromechanics with new designs and creations of electronic prostheses that little by little perfect based on alternate research, scientific criteria and the observations of each one of the people who will use them daily.

Keywords: Prosthesis; lower limb prosthesis; upper limb prosthesis, prosthesis, biomechanics.

Introduction

Giving a look to the future with the aim of improving the quality of life of people with a certain type of amputation, a contribution is made for the rehabilitation of this population (Meier, 1999), focused mainly on giving new hope from the point of view of the electronic engineering, bioengineering, nanotechnology, biomechanics, robotics and other sciences that help the creation of tools or devices guided by different concepts, laws and theories that entail the solution of a problem that is evident at present. (Vera, Arias, Espejo, & Martín, 2007, Ascencio, Gómez, Espejo, & Martín, 2007, Torres, 2005).

Therefore, in order to provide new hope to the entire population or to most of these people, a study of the different types of amputations was developed to determine possible changes in the design of the prosthesis, based on mechanical prostheses but taking them to an electronic prosthesis with better functions and a facility to modify their respective characteristics such as size, color, texture, center of gravity, alignment, leg prosthesis walking, finger handling in arm prostheses with criteria physiatrist physicians, physiotherapists, theorists, technicians, electronics and practitioners (Salazar, 2012, Grosso & Tibaduiza, 2009, Ascencio, Gómez, Espejo, & Martín, 2007).

The census conducted by the DANE in 2005 shows that of 41,242,948 people in Colombia, there are 770,128 people with limitations to walk, and there are 387,598 people with limitations to use their arms and hands. (Dane, 2005), resulting in a large population that can improve their quality of life by adapting a prosthetic element in their body.

On the other hand, it is important to note that in Colombia, as well as in the world, amputations of some limb have increased due to traffic accidents, anti-personnel mines, chronic degenerative diseases or wars (Maya, Guerrero, Ramírez, 2007) for this reason the World Health Organization (WHO) carried out studies that show information about the number of people who undergo amputations for reasons of diseases such as diabetes. (Martínez, 2013).

Colombia is the fourth country with the highest number of victims of anti-personnel mines, given that rural and urban territories have been affected by the presence of mines and unexploded ordnance, as shown in Figure 1 (UNICEF, 2004).

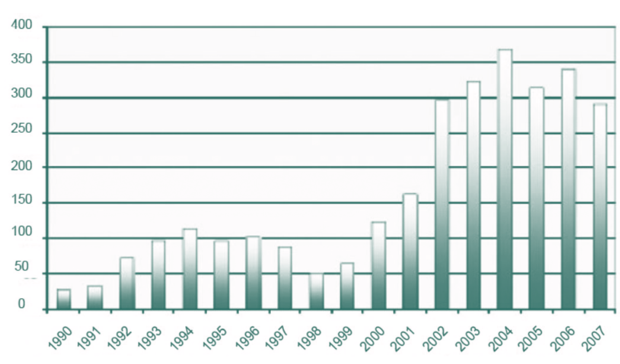

Figure 1. Annual frequency of municipalities affected by antipersonnel mines (APM) and unexploded ordnance Source: Republic of Colombia, 2008.

In order to help the population that is known with different disabilities, the article focused on making known what prostheses are, what types of prostheses exist and their specific uses in people. Therefore, it must first be known that the word prosthesis comes from the Greek prothesis (προθεσις) formed from pro (προ) which means before and thesis (θεσις) from tithemi which means I put, in the sense of position (Puglisi & Moreno, 2006) , that is to say, that the prostheses were created and developed as an artificial extension that totally or partially replaces part or parts of the body that have been lost, and which provides versatility when carrying out their daily tasks, based on prostheses already created today. , as are those of Ilimb and Michelangelo of the companies Touchbionics and Otto Bock, respectively. (Flores & Dorador, 2009).

Orthosis and Prosthesis Regulations

To improve the quality of life of people with some amputation and for the creation, development, construction, research and adaptation of mechanical and electronic prostheses, the existing regulations in the world must be applied, since it is an addition to the human body that must have requirements, the foregoing with the aim of guaranteeing that at no time they affect people, For this reason, ISO standards "The International Organization for Standardization" on orthoses and prostheses are taken into account to cover aspects such as performance, safety, environmental factors, interchangeability, procedures, auxiliary equipment, relevant thermal effects on prostheses and amputations (ISO / TC 168, 1989; ISO 8549-1, 1987; ISO 8549-2, 1989; ISO 8549-4; 2014).

Therefore, for the creation, adaptation, manipulation and commercialization of external medical devices (Giménez, Bresó, Guirao, Fayos, Atienza, & Solera, 2013), as are the prostheses of a lower or upper limb, compliance with the requirements established in standards, laws and resolutions for this purpose, that is, all the regulations that establish the technical and sanitary conditions that each of the companies dedicated to the manufacture, preparation and adaptation of prostheses must have for the potential clients such as those who have suffered an amputation, therefore, these procedures are carried out for safety and health reasons (Ministry of Social Protection, 2010).

Electronic prostheses

When taking a tour of the history of prosthetics from the past to the present, it is observed that in the year 1500 a.C. the computerized leg was created and it continued to evolve over the years (Gómez, 2006). After the year 424 a.C. to the year 1 a.C. an artificial leg of iron and bronze with wooden core was unearthed for a person with amputation below the knee, following the High Middle Ages, where the Greeks were present who were pioneers with their wooden legs and hooks for the arms giving later a new creation with a toe prosthesis.

Towards the XXVII and XIX centuries, in the year 1696 the first prosthesis below the knee was created by Mr. Pieter Verduyn, then in the year 1800 a wooden leg prosthesis with lace, knee joint in steel and foot was created articulated by Mr. James Potts (Norton, 2007).

Advancing in time in the Renaissance age and the prosthetics began to be created with copper, steel, iron and wood; in 1929 modern amputation procedures were introduced by Mr. French Ambroise Paré and in 1936 he developed prostheses for people with upper or lower limb amputation (Pedroza, S.F.).

Lower limb amputations

The amputation is derived from the Latin, amputare, where its meaning is to cut and separate a limb or portion of the body (DRAE, 2014). Therefore, amputations are a surgical act to which a person is subjected, taking into account factors such as the level of amputation according to the classification provided by the American Academy of Orthopedic Surgeons (Espinoza & Garcia, 2014).

Transfemoral amputations, through the thigh, above the knee, known as AK according to its acronym in English, are a type of amputation with which it is intended to have an ischial point, as seen in Figure 2 of the bone outline of the pelvis, taking into account the length of the stump, since that length depends on the result that the person has in the fast march, races, or in the practice of some sport (Sáenz, 2014; Araujo, 2012).

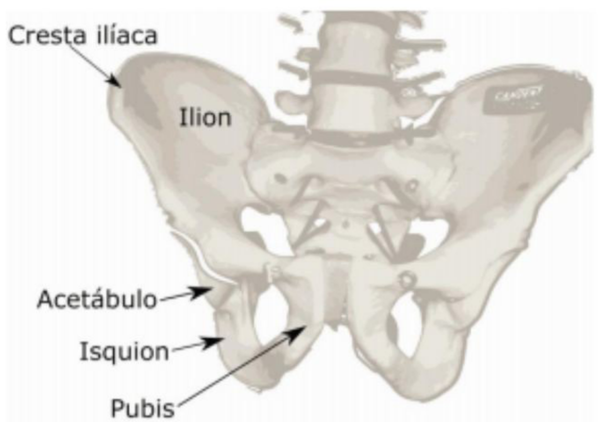

Figure 2. Outline of the pelvis of a human being (Sáenz, 2014).

Transtibial amputations are performed through the leg, below the knee, also known as BK, according to its acronym in English; When practicing surgery, one must take into account the bones that belong to an anatomical physiology such as the tibia and also the internal part such as the muscular compartments, since these will determine the degree of comfort that the person will have for the future use of a prosthetic element. (Smith, 2003; Araujo, 2012).

The knee and ankle disarticulation amputations are performed through the knee and ankle joints, respectively. When the knee joint is lost, there are no muscle joints. Resulting in alterations in normal locomotion, that is, decreases efficiency and increases energy expenditure in the person. (Ocampo, Henao, Vásquez & 2010; Araujo, 2012).

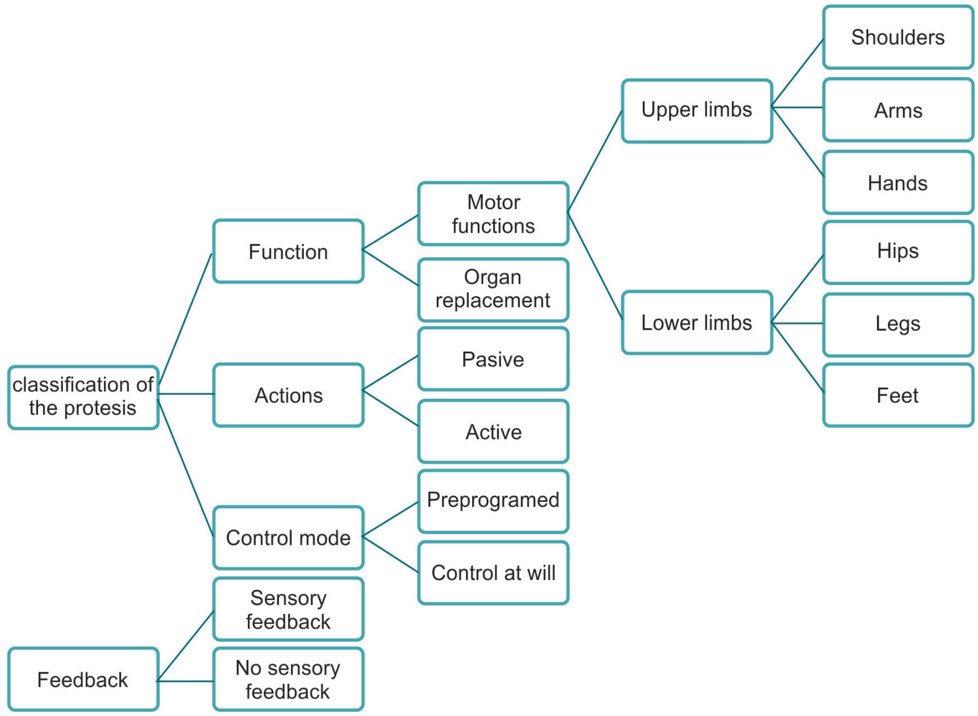

Figure 3. Classification of prostheses. Taken and adapted from Ramírez, 2012.

Lower limb prosthesis

The prostheses have a classification according to their function, action, control mode, and feedback as we see in Figure 3. (Ramírez, 2012; Araujo, 2012).

Intelligent lower limb prostheses are created from the study in anatomical planes where they obtain 8 degrees of freedom, of which the hip has 3, the knee has 2, and the ankle has 3. Therefore, an analysis of the biomechanics of the gait is made, recognizing each cycle in the executed movements and in this way it will be known which are the respective movements that must be made by means of the prosthesis, where 60% belongs to the support phase and 40% to the oscillation phase as seen in Figure 4 (Martínez, 2013; Rodríguez & Torres , 2005).

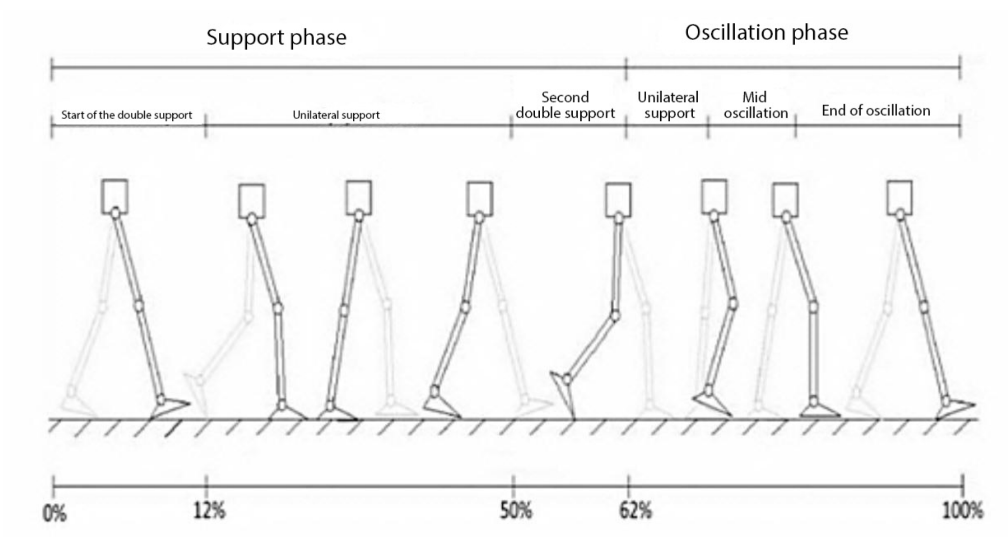

Figure 4. A cycle of human gait. Taken from Martínez, 2013

Based on research on the progress of the human being, intelligent lower limb prostheses are created, achieved from artificial cloning using mechatronic stem cells obtained from the analysis in sciences such as bioengineering, electronics, mechanics, nanotechnology, robotics and other useful tools for its continuous development. There are functions and potential elements such as movement patterns, intelligent controllers and articulations that have the ability to perform data acquisition to obtain effective cloning when creating the prosthesis. (See Figure 5).

That is to say, that the determined data set delivered by the cloning process is processed by a system and there Defuzzification of a part of the chromosome is one of the most important stages to obtain a range of values of discourse and not belonging to blurred sets (Muñoz, Díaz & Gómez, 2012; Batista, Abreu & Fernández, 2012))

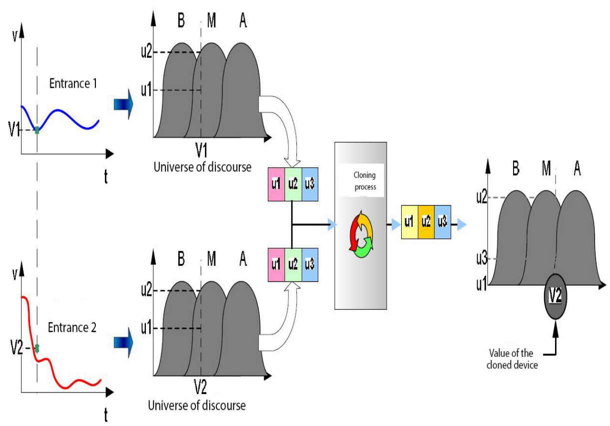

Figure 5. Cloning procedure. Taken from Muñoz, Díaz, and Gómez, J., 2012.

In order to obtain experimental results of some of the electronic and mechanical prostheses that are designed, it is part of a pilot test carried out in the *Integral Center of Rehabilitation of Colombia - CIREC*, which is a laboratory in charge of evaluating the part of the advanced technology, orienting it in advanced study models about the movement and its effects during the march process (Contreras & Roa, 2005).

Hand prosthesis

The human hand performs two basic functions, that of touch that is mainly focused on developing sensitivity capabilities, with which it can react and measure the amount of force or movements it performs, and pressure, which represents the manipulation that this can be developed in accordance with the activity that you want to execute. In the same way and as a majority percentage of the operation, the hand has the thumb, which represents 40% of the performance of the hand (Loaiza & Arzola, 2011).

All the factors that interact in the operation of a hand, offer the ability to give expression to words, as do people with hearing loss (deaf, deaf and dumb), which use them to communicate through the language of signs, or in the case of reading, with tact through the Braille language; or the sculptors, who shape their thoughts or imagination (Quinayas, Muñoz, Vivas & Gaviria, 2010).

For more than two thousand years, we have been working on the replacement of human members by elements or attachments that can give a type of function that is similar to the movements or activities performed by these extremities. In the twentieth century, innovations in hand prostheses that allowed amputees to return to work began, pioneering the French doctor Gripoulleau, who developed a series of elements that served as a replacement for the missing hand limb (Brito, Quinde, Cusco &, Street, 2013).

Through the study and innovations developed over the years, in different countries such as Germany, the United States, Japan, advances such as those obtained in 1912 by the American doctor Dorrance, who manufactured a hand prosthesis that can be opened and closed, were achieved. by movements of the shoulder girdle, with the help of attachments such as a rubber strap (Ávila, Gómez & Zapata, 2013). For the 60s, in Russia, a new technology of hand prosthesis called myo-electric prosthesis is born, which bases its principle of operation on the capture of small electrical potentials extracted from the muscular mass of the stump, to be subsequently conducted, filtered and amplified, getting energize and give movement to the prosthesis. (Escudero, Lejia, Álvarez, & Muñoz, s.f.).

With the advancement and development of different prosthetic elements, it has been possible to solve various types of amputation; throughout history a variety of actuators have been used that meet the requirements of each patient, and for which a classification by categories according to the actuator employed, organized by type, has been carried out, as shown in the Table 1 (Loaiza & Arzola, 2011).

Table 1. Types of hand prosthesis according to the actuator implemented

TYPE	CHARACTERISTICS
MECHANICS	Mechanical hand prostheses are devices that are used with the function of closing or opening at will, controlled by means of a harness that is attached around the shoulders, part of the chest and arm. They can only be used for the grip of relatively large and round objects due to the poor precision of the mechanism. (Dorador, 2004, Flores & Juárez 2004, Kutz, 2003, Vitali, 1996).
ELECTRIC	They use electric motors in terminal devices, wrist and elbow, with a battery rechargeable It is possible to control them in several ways: servo control, a push button or a switch with a harness. The acquisition price is high. There are also other inherent disadvantages such as more complex maintenance, low resistance to wet media and weight. (Díaz & Dorador, 2009).
PNEUMATICS	Powered by means of compressed carbonic acid, which provides a large amount of energy. Although, it has the inconvenience of the complications of its appliances and accessories, and the risk of using carbonic acid. Its development was interrupted due to the technical difficulties presented. (Díaz & Dorador, 2009).
HYBRID	They combine the movement of the body with the drive by electricity. This concept is widely used in transhumeral prostheses (amputation above the elbow), where the elbow is usually operated by the body and the terminal device (hook or hand) is electrically operated. Taken and adapted from Loaiza & Arzola, 2011. (Norton, 2007, Puglisi & Moreno, 2006)

The microelectronic system has been the one that offers the highest degree of rehabilitation, since it has a combination of aesthetic design, strength, freedom of movement, precision, and a range of combinations, thanks to its operation based on the capture of electrical pulses generated at the time of contraction of a muscle, making use of myoelectric signals (EMG), which will eventually be converted into the movements of the hand that the patient lacks (Silva, Muñoz, Garzón, Landinez & Silva, 2011).

With the evolution and development of hand prostheses, different mathematical and physical theories have been applied, in order to bring to a descriptive level the movement of the hand and the interpretation of myoelectric signals (Díaz & Dorador, 2010; León & Camacho, 2008). The Newtonian theory allows to describe in a detailed way the movement of the hand from the point of view of the geometry of the movement and the implementation of forces applied by muscles, tendons and bones. The Fourier transform is the main tool that allows deciphering, interpreting and reproducing in an identical way the movements of the hand, which are generated by means of electrochemical impulses, and which produce the movement of the hand, using the nerve network as a channel and the muscles (Romo, Realpe, & Jojoa, 2007).

Currently, myoelectric prostheses use muscle wires as arteries, which have a thin structure and high mechanical resistance, since which are built with nickel and titanium alloys, which are called "NITINOL", which is characterized as one of the alloys with more memory (Aparicio, Caicedo & Cuy, 2004).

Conclusions

The use of electronic prostheses helps to significantly improve the quality of life of people, by adapting and rehabilitating an anatomically customized prosthetic element according to standardizations and regulations, providing the opportunity to continue performing their daily tasks.

Electronic prostheses based on theories and experimental criteria are created with veracity and usefulness for the population with disabilities, focused on improving and changing a lifestyle that was affected at the time of amputation, either in a surgical procedure or in a surgical procedure. accident, taking into account that each prosthesis varies its specifications to successfully meet the need of a specific person and that is part of its anatomy obtaining optimal control and mastery in the rehabilitation process, adding to the prosthesis a variety of elements and aspects to take into account in the creation of different materials and parts through electronics, bioengineering and microelectronics.

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