Prosthetics

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Prosthetics
What is it?

Prosthetics is the branch of medicine that deals with the artificial replacement of a missing body part. A prosthesis is the general term for the artificial part itself that replaces the body part usually lost to disease or injury. Prosthetic replacements for a wide assortment of body parts are available, from artificial limbs to glass eyes, and the functionality of a prosthesis can vary. In some cases, the replacement may be purely aesthetic, while in other instances, it may help restore functionality, as in the case of a prosthetic limb which is equipped with biosensors, allowing the wearer to manipulate the limb.
Early History

The use of prosthetics is ancient. Ancient literature contains reference to prosthetic limbs in stories and poems, but some of the earliest historical accounts of prosthetic limb use were recorded in Greek and Roman times. There’s the historical account of Marcus Sergius, a Roman general who lost his right hand in the second Punic War. Famously, he had a replacement hand fashioned out of iron for the purpose of holding his shield and was able to return to battle and keep fighting. Egyptian tombs show evidence of the use of prosthetic body parts for people with disabilities, as in the case of a wooden toe found attached to the nearly 3000 year old mummified remains of an Egyptian noblewoman. Prosthetics in the Dark Ages (nearly 2000 years later) were bulky and made of iron and not very functional. These were actually used more for the purpose of hiding the lost limb, which was considered at the time to be an embarrassing deformity. During this time there was little advancement in prosthetics other than hook hand and peg leg made famous by Hollywood exaggerations.
The Renaissance times (1400s to 1800s) were considered to be the rebirth in the history of prosthetics. The Renaissance ushered in new perspectives of art, philosophy, science, and medicine. French Army barber/surgeon Ambroise Pare (1510-1590) is considered to be the father of modern amputation surgery and prosthetic design. He introduced modern amputation procedures to the medical community and made prosthesis for upper and lower extremity amputees. He also invented an above knee device that was a kneeling peg leg and foot prosthesis that had a fixed position, adjustable harness, knee lock control and other engineering features that are used in todays devices. The main damper to progress during the next few centuries was pain management, which complicated physicians’ abilities to properly prepare amputees’ limbs for prosthetic attachment. In the 1840s, with the advent of gaseous anesthesia and improved sterilization, surgery time was lengthened, allowing doctors the opportunity to perform amputation with greater precision. Moving towards modern times there was great increase in the production and advancement of prosthesis as the many wars resulted in an ever increasing amount of amputees. During and after World War II, newer and lighter materials like plastics and aluminum were joined to newly updated mechanical joints, and for the first time, prostheses became more comfortable and easier to use and the need for prosthetic advancement became a mainstream issue.
Modern Day Prosthetics

Myoelectric prosthesis represent a major advancement in artificial limb technology. They use electromyography (EMG) signals from voluntarily contracted muscles within the amputee’s residual or reaming part of the limb to control movement of the artificial limb. A small electrode attached to the surface of the skin records an EMG signal. The signal is amplified and processed in motors located in the hand, wrist, or elbow to produce movement.

Myoelectric Prosthesis video
Types of Artificial Limbs

**Transradial**- A transradial prosthesis is an artificial limb that replaces an arm missing below the elbow. Two main types of prosthetics are available. Cable operated limbs work by attaching a harness and cable around the opposite shoulder of the damaged arm. The other form of prosthetics available are myoelectric arms.

**Transhumeral**- A transhumeral prosthesis is an artificial limb that replaces an arm missing above the elbow. Mimicking the correct motion with an artificial elbow is very difficult and offers less control than a transradial prosthesis.

**Transtibial Prosthesis** - A transtibial prosthesis is an artificial limb that replaces a leg missing below the knee. Transtibial amputees are usually able to regain normal movement more readily, due in large part to retaining the knee, which allows for easier movement.

**Transfemoral Prosthesis** - A transfemoral prosthesis is an artificial limb that replaces a leg missing above the knee. Transfemoral amputees can have a very difficult time regaining normal movement. In general, a transfemoral amputee must use approximately 80% more energy to walk than a person with two whole legs. This is due to the complexities in movement associated with the knee.
Making Prosthetic Limbs

Because each patient and his or her amputation is unique, each prosthetic limb must be custom fitted and then built. This is the task of a prosthetist, who specializes in the creating and fitting of prosthetic limbs. Because prosthetists work and interact with artificial devices with the human body, they need a wide range of skills in areas such as engineering, anatomy, and physiology. The design and creation process consists of several different steps and begins with a precise measurement process later used to design the prosthetic limb. If possible, a prosthetist begins taking measurements before the patient's limb is even amputated, so that the creation process can get started. After the amputation surgery, once the wound has had a chance to heal and the swelling has gone down, a plaster mold is taken of the remaining part of the limb. This mold then serves as a template for making a duplicate of the residual limb. The duplicate of the residual limb is then used to test the fit of the prosthetic limb as it's being built. Careful attention is also paid to the structure of the patients remaining limb, including the location of any muscles, tendons, and bones often with the help of MRI, CT, and similar scans.
Attachment To The Body

Most artificial limbs have a socket which is the portion of the prosthetic device that interfaces with the patient's limb stump or residual limb. Because the socket transmits forces from the prosthetic limb to the patient's body, it must be perfectly fitted to the residual limb to ensure that it doesn't cause irritation or damage to the skin or underlying tissues. A soft liner is typically situated within the interior of the socket, and a patient might also wear a layer of one or more prosthetic socks to achieve a more snug fit. The suspension system is what keeps the prosthetic limb attached to the body. The suspension mechanism can come in several different forms. For example, in the case of a harness system, straps, belts or sleeves are used to attach the prosthetic device. For some types of amputations, the prosthetic is able to stay attached just by fitting around the shape of the residual limb. One of the most common types of suspension mechanisms relies on suction. In this scenario, the prosthetic limb fits snugly onto the residual limb, and an airtight seal keeps it in place.
Alternative Method of Attachment

Direct bone attachment or osseointegration is a new method of attaching the artificial limb to the body. The stump and socket method can cause significant pain in the amputee, which is why the direct bone attachment has been explored extensively. The method works by inserting a titanium bolt into the bone at the end of the stump. After several months the bone attaches itself to the titanium bolt and an abutment (structure built for support) is attached to the titanium bolt. The abutment extends out of the stump and the artificial limb is then attached to the abutment.
Physiotherapy

Physical therapy after an amputation and prosthetic device fitting is extremely important. Learning to walk with a prosthesis can be an especially difficult undertaking, requiring several months of rehabilitation and training. Therapy might also focus on using the prosthetic device to perform important everyday activities. For a leg prosthesis, the prosthetist carefully monitors the walking gait of the patient and makes adjustments as necessary. Once the patient is accustomed to having a prosthesis, the therapist will focus on balance and work to restore a normal walking pace when walking so the amputated area is not aggravated. The long term goal is to restore confidence and independence. For upper extremity amputations, the physiotherapist will work with the patient to regain strength and motion in the affected area. While strength and motion is being restored, patients will also focus on the use of their artificial limb.
Living With An Artificial Limb

The loss of a limb is devastating. Amputees can experience a wide range of emotions after losing their limb. Common feeling include sadness, anger, grief, anxiety, and depression. Many report that these feelings diminish over time, particularly when more independence and confidence is found. After an amputation, a patient’s limb will typically shrink over the course of several months as swelling begins to diminish. It’s possible that new sockets may be needed to accommodate for the reduction in size of the limb. A prosthetist must work especially close with children, to make sure that their prosthetic limbs are resized and replaced to keep up with their natural growth. A patient will continue to visit the prosthetist throughout his or her life, since limbs can always change shape and prosthetic devices eventually break down. An average prosthetic device has a life span of only 3 years.
Animal Prosthetics

In humans, an artificial limb can be rehabilitating physically and emotionally. Animals experience similar affects. With the amount of information from human prosthetics, veterinarians and engineers have been able to develop effective and technologically advanced animal prosthetics. In most instances, three legged animals are able to get about almost as well as four legged ones, but the irregular motion and weight distribution involved eventually take a toll on the rest of their body, ultimately shortening life spans and reducing the quality of life. There are a wide range of animal prosthetics all the way from artificial legs for dogs to artificial recreations of the two flukes at the end of a dolphins tail.
Prosthetic Social Programs

Social programs such as the War Amps are designed to assist amputees. The War Amps is a Canadian registered non profit organization, established to meet the need of war amputees in 1918. The charity provides financial and advisory services to those who lost a limb or total eyesight in military service during war and to provide similar services to Canadians who have undergone amputations. The War Amps is funded solely through public support and does not receive government grants.
Inquiry Process

- What does Prosthetics mean?
- The term for an artificial limb?
- When were they first used?
- History of usage? Any ancient accounts of prosthesis usage?
- Change in prosthetics over time?
- Advancements? When did Prosthetics become a mainstream issue?
- A type of modern day prosthesis? How does it work?
- Types of artificial limbs and how they are classified?
- Process in making an artificial limb? Skills needed for a career?
- How is it attached to the body? Are there multiple ways?
- Physiotherapy? What does an amputee have to go through once its attached?
- Living with the artificial limb? Do the limbs need replacing?
- Animal prosthetics? Are they similar to humans? Level/quality of the prosthesis?
- Is there social assistance for amputees?