Prosthetic Limbs

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Key Points
➢ Materials used in the engineering of prosthetics. ➢ Scope of 3D-Printing in prosthetics. ➢ Developments introduced to enhance prosthetics. ➢ Impediments of prosthetics.

Introduction:

Prosthesis is an artificial gadget that can be implanted to restore normal functioning of an amputated body part. It offers amputees an opportunity to regain use of their limbs. Prosthetics restore normalcy in their life, allowing them to perform challenges a person typically faces in daily routine.[1] Amputation can be due to a number of reasons, i.e pathophysiological diseases, trauma or in some cases it can be congenital. Prosthetic limbs basically link mechanical engineering with human muscles and nervous system to reinforce the motor sensations lost. When it comes to engineering prosthetics, the following things have to be kept in mind like research, material, design and cons. Prosthetics can be built by hand or with the help of software interference also known as 3D printing.

Materials:

Several metals such as Magnesium, Copper, Aluminum, Titanium and Silver have been used for the manufacture of prosthetic limbs. Titanium stands out to be the most favorable metal as it has good strength to weight and density ratio, excellent corrosion resistance. It is also lightweight and has biocompatibility that makes it optimum for the manufacturing of prosthetic limbs. Titanium has low modulus of elasticity which allows the skeletal load of its user to be distributed evenly; this ensures a more natural gait cycle.

Polymers are usually used to make smaller components such as phalanges or joints, and are also used to add special features to prosthetics. Common polymers used are poly vinyl chloride (PVC), which is used as a coating, polyoxymethylene (POM) and polyurethane (PU). Polyethylene is a more flexible form of plastic and it is ideally used in larger quantities when the prosthetic needs to be water resistant.

Carbon Fibers is a lighter weight bearing material for prosthetics. It has many properties which were similar to those of titanium, further advocating their use. Carbon fiber reinforced composites and also have very high specific tensile and compressive strengths, as well as high responsive elastic deformation. The only drawback of using carbon fibers is that they are much more expensive than other materials used for prosthetics.

While choosing a prosthetic, one of the major goals of biocompatibility is to ensure that the selected material or device does not harm the extremities around it. As prosthetics are under constant motion, materials used for interaction with the skin are very significant as their properties and friction matter a lot when it comes to skin safety. This includes the supporting materials used in prosthetics. After evaluating their performance under compression testing Spenco, Poron, Nylon-

reinforced silicone, Nickelplast are the most commonly used supporting materials.[2]

Figure1: Alumnus' Design of Powered Prosthetics Leg Aims to Give Amputees More Control
(Sources: engineering-magazine.utdallas.edu)

3D Printing:

The traditional methods for the prosthesis of the upper limbs are not that advanced, time consuming and less cost effective primarily in the developing countries, which is why many people resort to 3-D printing technology. Not only is 3-D printing cost effective, it also gives people an option to customize and personalize the prosthetic limb ensuring that the comfort levels are also not compromised. Although 3-D printing has been readily accepted in the area of prosthetics, it is still yet to be commonly implemented in developing countries due to the lack of advancement in technology. The use of 3-D printing can curb the need of traditional methods of prosthesis, only if such programs are implemented properly.[3]

Advancements:

Touch Sensing: The absence of proper sensory feedback can adversely affect human behavior as revealed by recent neuroscience studies. As the development of sensitive, elastic and cost-effective tactile receptors is integral for prosthetic rehabilitation, a quantitative and qualitative growth in flexible artificial growth touch sensing technologies has been observed over the years. Although mimicking the human nervous system is near to impossible, many scientists are working to invent a smart touch sensing system for prosthetics. Several materials and strategies for development of tactile receptors have also been identified for enhancements of prosthetics. But, nonetheless the practical uses of newly invented techniques and materials are hampered by complex manufacturing process and lack of proper data processing.[4]

Targeted muscle re-innervation: Upper limb amputation is a very disastrous injury leaving the patient with the novelty of choosing between a passive prosthesis, a traditional body powered prosthesis, or a Myoelectric prosthesis. A myoelectric prosthesis is the one which is driven by electromyography signals generated by underlying muscles. Targeted muscle re-innervation (TMR) has the sole objective of surgically creating reliable and strong signals to enhance the gait cycle of moving limb.

We take a review of the TMR performed on seven patients at the Alfred hospital. Patient demographics, injury, surgical complications and outcomes were examined. Comparison was made to preoperative prosthesis use. These patients came to Alfred hospital between 2015 and 2018. pre-TMR EMG signal numbers ranged from 1 to 2, and post-TMR signal numbers ranged from 3 to 5. Of the seven patients 6 were able to gain six degrees of movement while one gained four. On top of that no surgical complications were observed.

Thus, according to the above-mentioned study use of TMR has proved very effective in increasing impulses to prosthetics and thus allowing more degrees of movement.[5]

Cons:

While discussing the disadvantages and the causes of abandonment of upper limb prosthetics, the main areas to look into are the batteries and the motors which make them heavier than the normal body-powered systems; they can be water resistant but not waterproof; they require more maintenance than the normal body does; they need to be charged daily and

they are very expensive. Moreover, as prosthetics are very complex, they are also more prone to breaking and require a lot of personal attention.[6] Adding onto that, the major reasons of abandonment are also the fact that they are less comfortable when worn which results in excessive perspiration at the surface of skin which is not preferred by the majority of the people. On top of that, the traditional prosthetics also lack the features of providing sensations to the affected area, another reason for it to not be opted for by most people.[7]

Conclusion:

Over all, it may seem as if prosthetics have more pros than cons and can restore normal function to some degree; it all comes down to personal satisfaction. Prosthetics can compromise a sense of touch over that specific area, can be heavy due to their weight and are not that cost effective. With ongoing research in this field, scientists are confident of coming up with innovations that would not only help the amputees attain artificial limbs but also ensure their personal comfort and reliability.

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