

Implementation of Prosthetics in Underdeveloped Countries

Chetan Siddhardh Muvvala¹, Jothsna Kethar^{2#} and Dr. Subhashini Ganapathy^{2#}

¹B. Reed Henderson High School

^{2#}Advisor, Gifted Gabber

ABSTRACT

The job of prosthetics is to restore an amputee to be at a functional capacity in their cultural environment while looking as cosmetic as possible. Western prosthetics cannot be used in third-world countries. Availability of materials, resources, accredited personal, and cultural differences prohibit western prosthetics from being used in underdeveloped countries. Implementing prosthetics in third-world countries requires additional changes to be made. Reducing the cost of prosthetics to make them easier for repair and manufacturing allows underdeveloped countries to create and maintain prosthetics. In addition, cultural and environmental factors need to be taken into consideration to create prosthetics that can be long-term and economically affordable for underdeveloped countries.

Introduction

If you lost a limb what would be the first thing you would look for? Most people would say prosthetics. However, prosthetics have become a luxury item. Prosthetic limbs cost from a range of \$5,000 to \$50,000 and only survive for three to five years. Even though roughly 30 million people require prosthetic devices, 75 percent of developing countries do not have any opportunities for prosthetic limbs. In 1976, the World Health Organization (WHO) decided to include rehabilitation in their goal of “Health for all by the year 2000”. This occurred because it was later stated that 90% of all disabled people in developing countries were neglected. A survey conducted by Mohan D showed that the number of amputees in India in 1981 was around half a million; by 1986, the number of people in need of prosthetics was rising rapidly, but the supply was not on par with the demand. The number of amputees without prosthetics is estimated to be increasing by 17,000 a year. Resources for medical care are severely limited in underdeveloped countries and are often used for primary health care, affecting a greater portion of the population. This means that the availability of prosthetics in third-world countries is minimal, and many amputees do not have the chance to obtain prosthetics. 75 percent of people in developing countries need prosthetics and cannot obtain them. Prosthetics are very limited and not easily accessible for most people, but by reducing the costs of prosthetics they can be easily implemented in underdeveloped countries. Making prosthetics less expensive makes it more affordable to be created in underdeveloped countries with little to no prosthetic availability.

A prosthetic limb is made up of three components: the socket, the extension, and the artificial limb itself. The socket is the interface between the limb and the mechanical support. The extension, or pylon, replaces the length of the lost limb and may include joints if needed. The supply of prosthetics is not on par with the demand meaning that there are not enough prosthetics for the ever-increasing demand. Prosthetics are not just one and done; people need multiple replacement limbs and repairs over a lifetime. A prosthetic replacement is typically needed every 6-12 months for children, and every 3-5 years for adults. For example, if a child needs prosthetics at the age of 10, he will need around 25 limbs throughout their lifetime. On the other hand, if that person was an adult, they would need about 15-20 limbs during their lifetime (Prosthetics in Developing Countries).

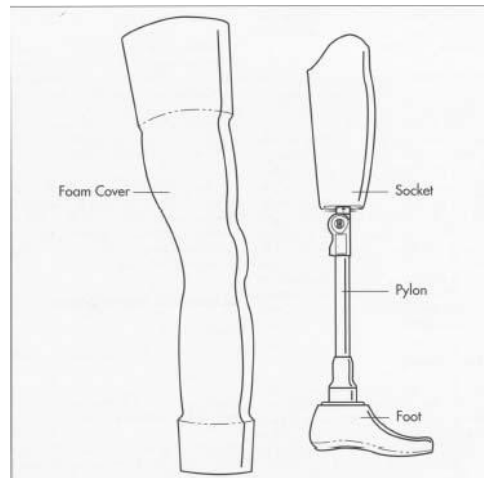


Figure 1. A typical above-the-knee prosthesis

A major problem with prosthetic limbs in developing countries is the lack of trained personnel. Studies by the World Health Organization (WHO) indicate that while the current supply of technicians falls short by approximately 40,000, it will take about 50 years to train just 18,000 more skilled professionals (Walsh 2003). Obtaining prosthetics is just one part, but properly constructing, fitting, aligning, and adjusting a prosthetic requires a trained professional. There are very few training programs in developing countries to help increase the number of qualified technicians. Importing prosthetics from other countries is more expensive and not designed for the different lifestyles in different countries. Developing countries and poorer countries have agriculture and labor-based economies. In these environments, cheap wooden prosthetics only have a lifespan close to 18 months. Family income in developing countries is nowhere near the amount needed just for the initial prosthetic. People in these countries work very labor and physically demanding jobs. Losing a limb can have a grave impact on a person's ability to work and survive.

Reducing the material cost of prosthetics and making prosthetics for specific regions allows for more people in need of prosthetics to obtain them and use them for their daily needs. Each country has its own limitations on getting and using prosthetics. By reducing the cost of prosthetics and catering them to underdeveloped countries, prosthetics would be more affordable and effective for people to use.

History of Prosthetics

Prosthetics have been used for generations. They were developed for function, cosmetics, and to provide a psychological sense of wholeness. Amputees have existed from the dawn of time. Ancient civilizations used forms of prosthetics, but it is hard to know when it began as many ancient civilizations had no written records. Ancient prosthetics began as simple crutches as depicted in some of the earliest recovered pottery. From here prosthetics grew into modified crutches or pegs for hand-free functioning. In the wrappings of Egyptian mummies were prosthetic limbs made of fiber. In France, a drawing dating back to 500 BC was found depicting a man working in a field with wooden support under his knee (Prosthetics In Developing Countries). The ability to have functional movement has been a necessity for the longest time. The Dark Ages used prosthetics for battle and to hide deformities. With the emergence of the Renaissance, the scientific development begun by the ancients was revitalized. Advancements in medicine including surgery and prosthetic science greatly improved. The American Industrial Revolution brought about many prosthetic advances that were fueled by the money available to amputees after the American Civil War. After WWII, many soldiers returned to America with missing limbs from the war. During this time the use and need of prosthetics became much more aware as a problem that needed to be addressed. The escalated number of amputees forced the development of functional prosthetics that could be created for large numbers of people. Prosthetics changed from

heavy, immovable limbs to lighter, more functional limbs. Today prosthetics use materials like carbon fiber and plastics to create strong but lightweight limbs that can withstand harsh environments. However, with these new materials is a price increase. Prosthetics have become so expensive to obtain and maintain that the majority of people are unable to afford prosthetics.

Who Uses and Why?

In developed countries, the main cause for lower limb amputation is circulatory dysfunction. These people are usually much older and into their sixth decade or older. Most have additional health problems that limit their mobility. Soldiers and military occupants also need amputations from military injuries. On the other hand, most amputees in developing countries were in an industrial or traffic injury. Many people in developing countries have trauma-induced amputations from work injuries. Countries in war zones have many amputees from war mines and other related injuries. Amputations are permanent medical operations that will affect a person's life for the rest of their life. Even though modern prosthetics allow amputees to be functional in society, many are unable to get prosthetics and many prosthetics do not take into consideration a person's lifestyle being labor-intensive like in underdeveloped countries.

Cost of Prosthetics

Over the years the demand for a better-quality prosthetic has increased the cost of prosthetics. Tremendous technological advancements have made prosthetics much more comfortable for people to use. However, with these advancements comes a spike in the cost of prosthetics, and the prescription of prosthetics makes many people need custom prosthetics. Custom prosthetics greatly increases the cost for an amputee. There are two main categories of prosthetics, socket-suspended or osseointegrated (bone-anchored). Socket-suspended prosthetics function by using a mechanism consisting of a socket, suspension, a knee, and other components. Socket-suspended prosthetics have non-microprocessor and microprocessor-implemented versions. Non-microprocessor prosthetics require much more attention during walking. On the other hand, microprocessor prosthetics require less attention and reduce the risk of falling. Microprocessor-implemented prosthetics are designed with a sensor in the shin to allow the movement of the user to be monitored. Even with these developments, some users may still experience discomfort using socket-suspended prosthetics. Another type of prosthetic is bone-anchored prosthetics (BAP).

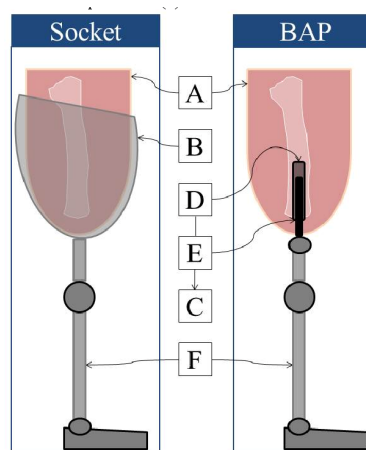


Figure 2. Differences between a socket and bone-anchored (BAP) prosthesis

BAP is directly attached to the residual limb by a surgical procedure known as osseointegrated fixation. This type of prosthetic does not use a socket and is instead attached to the user. Compared to socket-suspended, BAP has

proven to be more beneficial in quality of life, user ease, and sustained extended daily activities. However, it does carry the risks of surgical infection, implant instability, and the probability of breaking fixation parts. A study conducted by American researchers found that the price of regular custom-made socket-suspended prosthetics is around \$6,000 to \$20,000. The price may differ due to the prescription of prosthetics that are unique for the individual, age, comfort, and any additional aesthetic features or attachments. These advanced prosthetics are available in developed countries; however, underdeveloped countries are limited to the types of prosthetics available. A prosthetic made in a developing country costs around \$2,000. This may seem minimal, but it is over six times the average income of a family living in those countries. Any replacement limbs or repairs would lead to thousands of dollars of debt.

Already developed cost reduction

The advancements in prosthetics have made them seem to come straight from science fiction. Even the standard prosthetics in wealthy nations are complex and cost thousands to tens of thousands of dollars. However, such expertise and advancement prosthetics cannot exist in developing countries whose incomes are less than \$300 a year. Bhagwan Mahaveer Viklang Sahyata Samiti, an organization based in India that makes prosthetics called the Jaipur Foot, has tried to create a prosthetic made specifically for developing countries. The organization has distributed more than 20,000 prosthetics every year and has distributed more than half a million since 1975 throughout developing nations. The prosthetic foot costs less than \$50 to make, is durable enough to last a few years, and looks similar to a real one. Despite its success, the design is over 50 years old and is handmade. This leads to inconsistent quality and one study found that 56 percent of the Jaipur Foot had poor fitting or craftsmanship. Amos Winter, a mechanical engineer at MIT, was approached by the makers of Jaipur Foot in 2011 to help improve the design. Winter worked with amputees and the organization; he developed a prosthetic foot that was cost-competitive with the original Jaipur Foot. The new design predicts what prosthetic would best fit a person based on a person's weight, feet size, and leg length. The design minimizes the discrepancy between an able-bodied walking and one with a prosthetic foot. Winter and his colleagues used computer models and data of joints in able-bodied limbs to create a prosthetic that looks normal when walking. Conventional designs try to recreate the ankle which requires complex and expensive devices. However, the new approach allows researchers to treat the foot as a single object. In the end, the engineers built a prosthetic foot from a single piece of nylon that flexes like a spring.



Figure 3. A low-cost alternative to a prosthetic foot

Sockets have been a limiting factor in prosthetic construction. Sockets provide the interface between the residual limb and the prosthetic. Sockets require casting, molding, and multiple fitting sessions which makes them expensive in time and finance. In addition, any changes in limb growth, weight gain or loss, limb maturation, etc. would cause the socket to no longer fit and a new one would be needed. A socket often requires frequent follow-ups which is an added difficulty as many amputees have to travel far distances for prosthetic care. The socketless holder

arm prosthetic uses a metal frame shaped to the remaining forearm. A reaction pad is placed over the distal radius, and a Velcro strap secures the device. The end is bolted onto the metal frame of the device and a tricep cuff is used with the standard harnessing. This type of system can be fit by prosthetic technicians who have received a limited amount of prosthetic training. The life expectancy of this system is around 10-15 years. Because of the life span of this system, it can be used to help people experience prosthetics to determine if the user would be an effective prosthetic user.

Prosthetics in Underdeveloped Countries

Why some countries don't use prosthetics

Prosthetics have now started to be produced with the factor of culture taken into consideration. A lot of extra work is needed to fulfill the goal of returning the amputee to be functional in their environment. In countries in tropical areas, walking barefoot or using open-toed sandals is very common. In addition, footwear is generally removed when entering a place of worship or even a home. Prosthetics like prosthetic feet need to be detachable for these reasons and in addition, they need to be durable. This is because in tropical and underdeveloped countries labor-intensive work is very common. The Jaipur Foot prosthetic takes these problems into account. The Jaipur Foot has a removable heel to allow for amputees to wear but also remove shoes. (Sethi, 1989) The Jaipur Foot also allows for squatting and even walking on uneven ground. Underdeveloped countries usually do not have the best roads, and many do not even have sidewalks. The ground is very uneven which makes the Jaipur foot perfect for these conditions. In addition, the Jaipur Foot is very durable and can withstand continuous walking in these poor conditions. Due to its dorsiflexion capacities and the grip of the rubber sole, climbing trees is possible for amputees. This is an essential activity for some to be able to pick fruit or collect leaves or branches. (Sethi et al., 1978; Sethi 1989)

In some countries, young people have to kneel before their elders as a sign of gratitude and respect. Failing to do this can be seen as disrespect and can be considered an insult. In addition, having simple and durable designs is crucial for rural communities. People in these communities usually live a large distance away from any prosthetic care center, and usually cannot afford to leave work in the fields to go to the clinic for routine repairs. These communities usually have local craftsmen that find themselves becoming temporary prosthetic technicians. Making prosthetics out of plastics and other such materials makes them much less prone to rust or rot. This is very important in communities where much of the work is done in poor conditions that include walking through mud and rivers daily. (Sethi, 1989; Meanley, 1991) Prosthetics are not just a tool but become part of a person. Cultural requirements have to be taken into consideration when creating prosthetics. Right now the normal prosthetic designs do not take into consideration some cultural requirements like taking shoes off and kneeling before elders. In addition, many prosthetics are not made to be used on uneven terrain or to be able to walk through mud and rivers daily.

Ways to reduce amputees in underdeveloped countries

An overwhelming number of prosthetics are needed in developing countries. The best way to reduce amputees in underdeveloped countries is to prevent them from occurring in the first place. For example, Cambodia has the highest number of amputees per capita in the entire world and the main cause is the explosion of landmines leftover from the war. The majority of casualties are civilians and mainly civilians who cannot afford functional prosthetics that can be used for their daily activities. Detecting and destroying the mines would be the best action to reduce the number of amputees in Cambodia and other war-torn countries. In India, most upper limb amputations are caused by a lack of knowledge of operating new farming machines. (Narang et al., 1986; Vohdra, 1992) If there was an increase in training and safety procedures then many of these casualties could be avoided. Underdeveloped countries have many casualties

that cause people to become amputees. By preventing these casualties' fewer people would become amputees, and fewer people would require prosthetics in underdeveloped countries.



Figure 4. A landmine sign in Cambodia

Conclusion

The need for prosthetics in underdeveloped countries is immense, and although much is being done to address this problem, there is a severe lack of services for amputees in underdeveloped countries. The costs of prosthetic limbs to manufacture and export make them an item that only a few can obtain. 75 percent of people in developing countries cannot obtain prosthetics or even get the chance. Prosthetics are very limited and not easily accessible for the majority of people; however, by reducing the costs of prosthetics they can be easily implemented in underdeveloped countries. Making prosthetics less expensive makes it more affordable to be created in underdeveloped countries with little to no prosthetic availability. Current designs of prosthetics do not take into consideration the cultural and occupational differences in developing countries. Reducing the cost of materials of prosthetics and the complexity of the designs allow developing countries to easily implement prosthetics and repair them. Much is to be done to improve prosthetics to make them accessible in underdeveloped countries. Sethi, the creator of the Jaipur Foot, stated that “needs for alterations kept on arising and we were ready to respond to them” (Sethi, 1991).

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