I Can. I Will. i-LIMB

Over the course of hundreds of years, man has strived to replicate the human body and create a so-called “bionic man”. In the TV series *The Six Million Dollar Man*, the half human was fitted with several artificial limbs and a robotic eye which allowed him to attain super-human strength and agility. While this degree of technology is currently not available, advances have been made in the field of prosthetics, and artificial limbs that allow the patient to regain almost all of their mobility have been invented. One such device, created by Touch Bionics, is known as the **i-LIMB** hand. The i-LIMB hand costs between $50,000 and $70,000. The cost of the hand is high, but the performance and reliability of the prosthetic are unmatched by other devices. This prosthetic hand has dramatically improved the quality of life of many individuals and is the only technology of its kind on the market today.

The Otto Bock Hand

Figure 1. The Otto Bock Hand was a simple design using the same technology as today’s prosthetic devices.

The first electric-powered prosthetic hand, developed in the early 1970’s, was known as the Otto Bock hand (Figure 1). The prosthetic hand used state-of-the-art technology of the time. The Otto Bock hand used myoelectric control and it was run solely on a battery placed in the forearm of the prosthetic. With the limited technology available at the time, the Otto Bock hand only had three fingers that moved; the thumb and two additional fingers. The covering of the hand had five fingers to make the prosthetic more lifelike. Since there were only three moveable fingers, the Otto Bock hand was only able to open and close its hand in a grasping motion. Today’s prosthetic devices use some of the same concepts of the Otto Bock hand, such as myoelectric control.

Myoelectric Control

Often times, after a limb is amputated, the patient has sensations that the limb is still attached to the body. These are known as ‘phantom’ feelings. Phantom feelings occur when the body creates electrical signals which move through the muscles and attempt to move the missing limb as if it is still

attached to the body. These sensations are reported from patients who are missing anything from a digit, such as a finger or a toe, to an entire limb.

The technology used by today's prosthetic devices harnesses the muscle signals, or phantom feelings, through two metal electrodes which are placed on the skin of the patient's residual limb. The electrodes must be strategically placed on the patient's limb in order to detect the strongest electrical signals. These signals are then translated into commands for the motors in the prosthetic device. The motors then interpret the commands and move the prosthetic. This technology is known as myoelectric control (Figure 2).

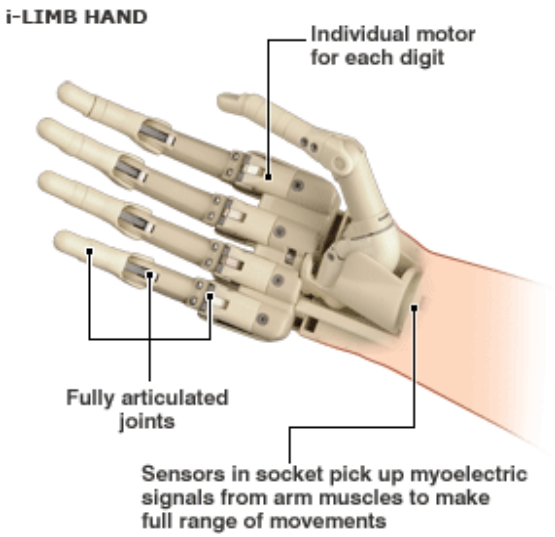

Figure 2. The diagram above illustrates the basics of the myoelectric system in the i-LMB hand

The unique feature of the i-LIMB hand is that every digit is individually controlled and powered. The individual fingers allow separate fingers to be removed and repaired without the entire hand having to be out of commission for an extended period of time. Also, the individual fingers are capable of moving separately, and they are able to adapt to a variety of situations.

Each finger is controlled by a small direct current motor and a transmission system. With the use of the small motors, the hand can obtain a stronger grip than most prosthetic devices. Also, the i-LIMB hand is able to react quickly to the user's commands. Built into each finger is a sensor that uses stall detection. This sensor is able to detect the amount of pressure exerted on an object and when the optimum pressure exists, the fingers stop moving and lock in place, until the wearer of the prosthetic triggers the fingers to release. With the addition of stall detection, the patient is able to have greater control of his or her prosthetic device when using it with everyday tasks. With this technology, the i-LIMB hand is able to pick up an egg without breaking it. Also, since the fingers are more agile, the prosthetic is capable of grasping unconventional objects such as a wine glass or a disc.

Grip Patterns

The i-LIMB hand is able to grab and hold many objects because of the agility of the fingers, but also as a result of different grip patterns. The key grip, the precision grip, the power grip, and the index point are the four grips that the i-LIMB hand is designed to perform.

Key Grip

The key grip is obtained when the user of the prosthetic triggers the thumb to move to the side of the index finger, as one would grab a pinch of salt. The key grip is useful when a patient need to hold a thin object such as a key, a credit card, or even a piece of paper (See Figure 3).

Figure 3. The key grip can be used to hold a key and unlock a door.

Precision Grip

Figure 4. The precision grip is useful for holding small objects such as a grape.

The precision grip is configured when the user of the prosthetic device brings the tip of the thumb to either the tip of the index finger or the tip of the middle finger. When the patient triggers the i-LIMB hand to form the precision grip, the resulting hand arrangement is identical to when one makes an "ok" sign (Figure 4). A patient who uses the precision grip is able to pick up and hold small objects such as a coin or a marble.

Power Grip

The power grip is used to carry heavy objects such as a bag or a briefcase. Also, the power grip can be used to grasp any cylinder-like object such as a can or a bottle. The power grip is achieved when the user of the prosthetic hand prompts all the fingers and the thumb to close down together. When all the fingers of the i-LIMB hand close down to create the power grip, the action is similar to making a fist (Figure 5).

Figure 5. The power grip can be used to hold a mug or a briefcase.

Index Point

The last grip available to any user of the i-LIMB hand is the index point. The index point grip is used by wearers of the prosthetic device to type on a keyboard, use a telephone, or press buttons on an ATM machine. To achieve the index point grip, all of the fingers, including the thumb, close down except the index finger. The index finger stays in an upright position and locks in place (Figure 6).

Figure 6. The index point grip has allowed many amputees to have a much greater freedom of motion.

An important feature of the i-LIMB hand is the ability of the thumb to close down on the side of the side of the hand and lock in place. When the thumb is on the side of the hand, patients who use the i-LIMB hand are able to put on clothing such as a sweater, without the thumb getting caught on something such as a fold in the fabric or a loose string.

With every grip the i-LIMB hand performs, the fingers are constantly limiting the amount of pressure exerted on an object with the use of stall detection. Also, the fingers lock in place until the user of the prosthetic triggers the fingers to release. When the fingers lock, the prosthetic device's grip patterns have more strength and stability. Patients who use the i-LIMB hand are able to perform many everyday tasks without much difficulty.

Gloves

The i-LIMB hand has some of the most advanced technology on the market today. It also has the most lifelike appearance compared to other prosthetic devices. The makers of the i-LIMB hand, Touch Bionics, and the people in LIVINGSKIN and ARTech Laboratories are the first people to try and imitate the appearance, accuracy, and movement of the skin on the human hand. The materials used to make the skin must be durable, strong, and appealing to the eye, yet they must be supple enough to contour to every curve in the human hand. Also, the skin must be able to flex with the movements of the prosthetic. The cover of the i-LIMB hand is known as a cosmesis glove. There are currently two types of gloves manufactured by Touch Bionics.

Cosmesis

For the people who would like the prosthetic to simulate the human hand's appearance, there is a glove that appears more natural and human-like than any other custom cosmesis in the world today. The custom cosmesis created for the i-LIMB hand can be manufactured with the proper skin tone, veins, hair, and fingernails (See figure 7). The i-LIMB cosmesis can be made to look like an exact replica of the patient's remaining hand.

Figure 7. The cosmesis covering of the i-LIMB hand has allowed patients to blend into their environment.

i-LIMB Skin

A second option that patients have for the type of cosmesis to wear with their prosthetic device is a semi-transparent glove known as the i-LIMB skin. The semi-transparent appearance of the i-LIMB skin allows for the inner robotics of the prosthetic to be seen by the wearer of the prosthetic and by other people (Figure 8).

Figure 8. The i-LIMB skin gives the prosthetic device a futuristic appeal.

The glove not only allows for the wearer of the prosthetic to blend into his or her environment, it is also a necessity of the i-LIMB hand because it protects the mechanical aspects of the prosthetic. The glove shields the prosthetic device from impurities such as dirt and dust. Also, the glove protects the prosthetic device from liquids.

The cosmesis glove allows the hand to have a much sturdier grip on everyday items. The glove helps the hand grip items without their slipping.

The i-LIMB hand has helped hundreds of people live relatively normal lives. With the use of individually powered fingers, the i-LIMB hand is able to conform to many objects and hold them firmly. The four grip patterns (the key grip, the index point, the power grip, and the precision grip) allow for the user of the prosthetic to expand the limits of what can be done with a prosthetic device. Patients who use the i-LIMB hand are able to unlock a door, drive a car, even type on a computer keyboard without much difficulty. Even though today's prosthetic devices are not going to create a "bionic man", the i-LIMB hand has significantly enhanced the quality of life of amputees around the world.

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