

# PROSTHETIC DEVICES

## FOR UPPER-EXTREMITY AMPUTEES

IF YOU HAVE HAD A HAND OR AN ARM AMPUTATED, YOU WILL NEED TO DECIDE AT SOME POINT WHETHER OR NOT YOU WANT TO USE AN ARTIFICIAL LIMB (A PROSTHESIS). YOU BASICALLY HAVE FOUR OPTIONS:

- LIVE WITHOUT A PROSTHESIS
- USE A PASSIVE PROSTHESIS
- USE A FUNCTIONAL PROSTHESIS
- DO A COMBINATION OF THESE THINGS.

**P**assive prostheses are generally considered to be devices that are worn purely for cosmetic purposes. Functional prostheses, on the other hand, are devices that enable an amputee to perform tasks. These devices may or may not also serve a cosmetic purpose.

Functional prostheses are either body-powered or electric-powered. Body-powered devices are operated using cable and harness systems that require the patient to use body movements (moving the shoulders or the arm, for example) to pull the cable and make the terminal device (a hand, hook or prehensor) open or close much in the way a bicycle handbrake system works.

Mechanical body-powered terminal devices are voluntary-opening or voluntary-closing. Voluntary-opening means that users must open the terminal device by applying force through their cable system. The terminal device then closes on its own with the aid of rubber bands, which limit the grip strength of the device to the strength of the rubber bands. With a voluntary-closing terminal device, force must be applied to close it instead of to open it, making the grip strength dependent not on the strength of rubber bands but on the strength of the person using it.

Voluntary-opening devices that are closed with the aid of rubber bands offer only visual feedback to the user for control since the bands do the work of closing once an object is grasped, thus taking the body out of the

feedback loop.

Because they close by the user's own strength, voluntary-closing devices provide a tension feedback to the body similar to that "felt" when using bicycle handbrakes. Since users can "feel" the force they are applying, they can also control their grip incrementally, applying more or less force as needed.

Electric-powered terminal devices open and close by battery power.

### **Should I Use a Body-Powered or Electric-Powered Prosthesis?**

When choosing between a body-powered or electric-powered prosthesis, you should carefully consider the advantages and disadvantages of each.

#### **Typical Advantages of Body-Powered Devices**

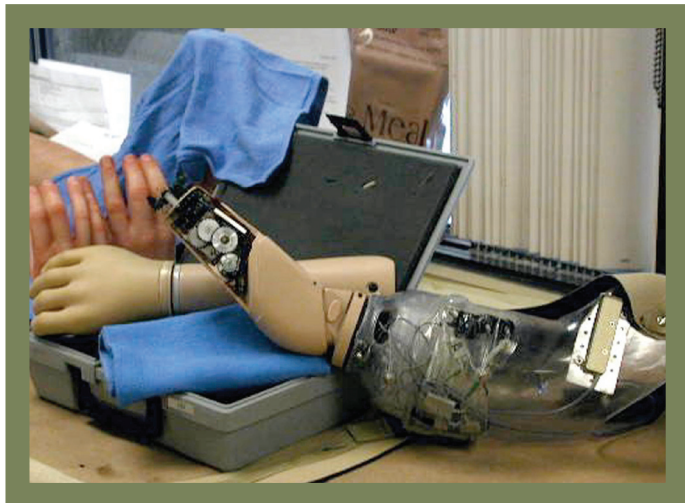
- Lower Initial Cost
- Lighter
- Easier to repair
- Offer better tension feedback to the body

#### **Typical Disadvantages of Body-Powered Devices**

- Mechanical appearance
- Difficult to use for some people because they depend on the user's physical ability

#### **Typical Advantages of Electric Devices**

- Do not require a harness or cable and can, therefore, be built to look more like a real arm



- Battery-powered so body strength and body movement are not as important for their operation
- Provide a strong grip force

### Typical Disadvantages of Electric Devices

- Higher initial cost
- Heavier (Improved batteries have, however, helped reduce their weight and increase their capacity and voltage.)
- Higher repair cost
- Dependence on battery life

A major improvement in electric prostheses is the use of multiple methods of control to operate them. Electric prostheses are not all myoelectrically controlled, as some people think. It can be explained that myoelectric means that you pick up a myo signal off the surface of the skin from the muscle that you intend to use to control the speed and direction of the prosthesis. But not all electric systems are myoelectric systems. Some use pressure, a switch and a harness, a positional servo device or a strain gauge.

Prosthetists today are often using more than one kind of control system for a single patient. For example, they might use myoelectrodes to control the hand and a positional servo transducer to control the elbow, which are now independent controls. The patient can control them simultaneously. In the past, you had to do one thing at a time

movements.

### What Kind of Terminal Devices Are Available?

Terminal devices for arm amputees fall into three basic categories:

- Hooks
- Prehensors, which are defined here as those devices that consist of a thumb-like component and a finger component and that may resemble lobster claws, pliers or a bird's beak
- Artificial hands.

Each type is available in body-powered or electric-powered devices.

Each type of terminal device has advantages and disadvantages and is better for some situations than others. Though no one device is able to fulfill all of the functions of a human hand perfectly, it is often possible for amputees who have more than one terminal device to easily and quickly switch from one type of device to another with the various quick-disconnect wrist units that are available and have become standard in the industry. You might, for example, use a functional hook or electric prehensor to perform some kind of work task, then disconnect it and switch to a natural-looking hand with artificial hair, freckles and skin color to go out to dinner a few hours later. As a result, you have many more options than amputees did in the

or sequentially. You flexed the elbow, stopped flexing the elbow, switched to the hand, opened the hand, closed the hand, and then extended the elbow. With the multiple input concept, you can do more than one thing at a time and, therefore, have smoother, simultaneous

past when they were often limited to choosing one device or another.

### Hooks

The split-hook design, first patented by David W. Dorrance in 1912, enables amputees to hold and squeeze objects between the split hooks. Though many people prefer artificial hands for cosmetic purposes or electric hands for greater grip, split hooks also have many advantages.

### Typical Advantages of Split Hooks

- Functionality
- Efficiency of use
- Ability to grasp small objects
- Durability
- Lower maintenance and repair costs
- Lighter
- Better ability of user to see what he or she is trying to hold (The size and thickness of artificial hands sometimes block the user's view of what he or she is trying to pick up. Because artificial hooks and hands can't feel, being able to see what one is doing is especially important. This also makes hooks – which often have a nitrile coating to prevent slippage – generally better for picking up smaller objects.
- Because hooks are usually made of metal, amputees don't have to be as careful around heat, which can melt artificial hands.

There are also companies that make electric split hooks that provide true proportional myoelectric control. One such hook weighs only 13.23 ounces and has a pinch force of up to 25 pounds, which is much greater than that of most body-powered split hooks. One company offers an electric split hook that has water-resistant housings.



## Prehensors

Photo courtesy of TRS



Prehensors, like hooks, are not as cosmetically pleasing as artificial hands, but they offer many of the same advantages over hands as hooks do. They are much more functional than hands and, like hooks, offer better visual feedback to the user. When compared to hooks, prehensors also have some typical advantages and disadvantages.

### Typical Advantages of Prehensors

- Do not look as threatening
- Not as likely to scratch objects
- Not as likely to accidentally get caught on things

### Typical Disadvantages of Prehensors

- Not as good for picking up and working with small items
- Do not offer as much visual feedback because they are usually bulkier at the end
- Not as good for typing

## Hands

Though artificial hands are generally less functional than hooks and prehensors, some people choose them because of one major advantage: They look more like the human hand.

Today, there are a wide variety of artificial hands to choose from. One company offers a hand with an automatic grasp feature. "It has sensors inside the hand that recognize pressure or how much grasp the hand is applying to an object being picked up," explains Pat Prigge, CP.

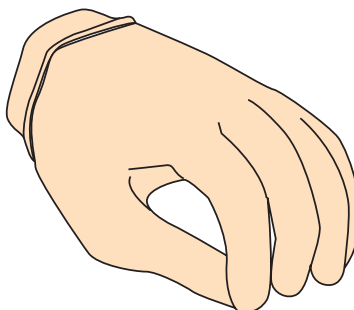
Just as a real hand would squeeze a cup a little harder when it gets heavier as water is poured into it, Prigge explains, this hand "automatically

monitors grip force and grabs harder when objects get heavier so that they don't fall out of the user's grasp. As a result, users don't have to be as precise with their grip force." This solves one of the most difficult problems for myoelectric users, Prigge says, by helping to ensure that they don't squeeze too little and drop something or too hard and crush something.

The same company also has grip force control system that can be used with an artificial hand. "This system is programmed into the hand so that the grip force strength – how much grip force the hand applies to an object – is directly correlated to the signal strength that they put into the arm," Prigge explains. "The harder they contract, the higher the grip force is, so if they want to pick up something light, all they have to do is generate a small signal and the hand will close down to a light grip force and then stop."

### What Does the Future Hold?

Rutgers University engineering professor William Craelius, who is assisted by a team of students and former students, invented an experimental hand known as the Dextra. Though this hand is far below the level of that of the Six Million Dollar Man in the 1970s TV show, it's a small step in that direction: It is a bionic hand that can be controlled through human thought.



Though an amputee was able to tap out the notes of *Mary Had a Little Lamb* on a piano keyboard using the experimental hand, a lot of problems still have to be addressed before a thought-controlled hand that can take almost any shape can become a viable reality. "We are still far from approximating a human hand," Craelius says.

Because current artificial hands generally make use of only a pinching or squeezing function, rather than the use of each individual finger, Craelius' work and the possibility of bionic control devices that can simultaneously control all of the joints of all of the fingers is extremely important. It could one day make the difference between terminal devices that are really pinchers (even though they might look like a hand) and terminal devices that really function like a hand and offer the multitude possibilities of hand movement. The Dextra is not there yet, but the long-term future is promising.

—by Rick Bowers

