Harnessing The Power:
Control Systems for Upper Extremity Prostheses

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The higher the level of amputation, the more difficult it is for the amputee to control the functions of the limb. Conventional (body powered) prostheses require the upper extremity amputee to expend energy to manipulate the cable and harness which allow the elbow to extend or flex and the terminal device to open or close. For a below elbow amputee, one cable operates the hook or hand. For the above elbow amputee, more exertion and greater gross body motion are required to operate an elbow plus a terminal device.

After training, many amputees find the required body motions become second nature. However, where the physical limitations of the amputee are such that a conventional control system is less practical, as in a high level bilateral amputation, the option to move to an externally powered device becomes an excellent alternative.

When an electric or myoelectric (externally powered) prosthesis is indicated, control issues are simplified in some ways and become more involved in others. Three basic options are available to operate a powered prosthesis: switch control, myoelectric control, or a combination. Switches come in a variety of designs such as harness switches, push button switches which can be mounted inside or externally on the socket, and membrane push switches which are internally mounted. A switch requires some gross body motion to operate, for example, the push button is depressed by a chin, opposite limb, residual limb, or digit. A pull switch is cable operated and requires a few degrees of excursion, less than with a conventional prosthesis.

Many amputees regard the use of high technology devices and the convenience that they offer as desirable and beneficial in the appropriate setting. Myoelectric controls reduce gross body motions and limit harnessing. The trade-offs are speed and weight. A conventional prosthesis is faster than a motor driven device, and the electric prosthesis may weigh more than the conventional because of the addition of the power supply and the powered devices themselves. For the below elbow amputee, a self-suspended myoelectric prosthesis entirely eliminates the need for a harness. It utilizes the natural muscle flexion in the residual limb to produce the signal to open and close the electric terminal device.
The above elbow amputee fitted for an electric prosthesis may use myoelectric control or switch control for the electric devices, or a combination of the two. A typical configuration would be myoelectric control for the elbow function and switch control for the terminal device. The myoelectric electrodes would be placed on the interior of the socket, over flexor and extensor muscles. Slight flexion of the muscle would control the pistoning of the forearm. The terminal device switch would be controlled by a cable and harness, requiring a small amount of excursion or gross body motion, significantly less than a conventional prosthesis. Alternately, both the elbow and the terminal device could be controlled by myoelectric signals, with the electrodes positioned over separate EMG sites, selected carefully for the potential signal produced. The decision on the appropriate type of control system is often a combination of the physical characteristics and limitations of the amputee, the level of amputation and the selection of the terminal device.

Each amputee is evaluated individually on a case by case basis. What works for one person may not be the best possible design for the next. Working with the rehabilitation team, the prosthetist and the patient will determine the ultimate combination of control options to make the unique choices appropriate for the definitive prosthesis.

About the author...

Catherine Wooten is Director of Communications for Hosmer Dorrance Corporation. Established in 1912 by D. W. Dorrance, inventor of the first split fingered prosthetic hook, Hosmer Dorrance is a leading manufacturer of prosthetic and orthotic components. Ms. Wooten has been with the company over 15 years and directs communications, advertising and customer service.

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