Orthotics and Prosthetics, Vol. 40, No. 4, pp. 28–34.
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Full Cuff Control

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INTRODUCTION

In times where choices are not only welcomed, but literally demanded by patients and rehabilitation teams alike, we are now seeing many exciting and useful new terminal devices and assistive devices for upper extremity amputees. In the fabrication of prostheses, we have been afforded various options in socket design, construction material, and hardware, in order that we may choose the variations most suitable to our patients' needs, desires, and lifestyles.

There have been only two popular options for activation of below-elbow terminal devices—either electric (i.e. myoelectric or switch control), or body powered (i.e. cable and harness). The asset of an electrical control system is its elimination of the irritating and restricting harness, as well as the actuation of the terminal device regardless of the attitude of the sound shoulder or involved humerus and forearm. Some less desirable traits of the electrical control system include weight, reliability, and expense.

The body powered appliances, however, maintain popularity because of their padded sock fits, light weight, ruggedness (less moving parts), and affordability. Their two obvious shortcomings are what make the electrical system an option. They require restrictive harnesses, commonly accentuating uncomfortable pressure on the seventh cervical vertebra and the sound side axilla area. They also require the amputee to maintain his/her shoulders and involved arm in a manner of mechanical advantage in order for the control line to operate the terminal device. Admittedly, supracondylar below-elbow appliances do eliminate some harnessing, but still involve the sound side shoulder. The need for the aforementioned mechanical advantage and a solution for the definite problem with clothing, if worn under a fitted shirt or blouse, are still present.

DISCUSSION

Circumferential cuff ("Full Cuff") control, as applied to body powered prosthetics, is the focus of this discussion. The cuff mechanism works on the same principal as the harness system, in that both can be described as having constant length control lines traveling across active joints; the difference is in simplicity. With the traditional below-elbow harness arrangement, the control line is typically activated through scapular abduction, gleno-humeral flexion and/or forearm extension. The cuff system concentrates on forearm extension only (Figure 1). In this instance, the fewer the variables to consider, the more direct, positive, and reliable the system.

Pivoting on two Hosmer-Dorrance forearm lift posts, each mounted over an epicondyle, the cuff is placed in the same relative position as the typical triceps cuff used with a "Figure 8" harness. These posts may be laminated in position or riveted onto any existing supracondylar below-elbow socket. The cuff plays little, if any, role in suspension; rather, it is the anchor point for the control line itself. The customary action of the forearm extension for control, as well as the not-so-customary flexion for control, may be employed (note: any terminal device available for traditional body powered prostheses will function with this system).

FABRICATION

The cuff material of choice, at this time, is 1/8″ thickness Ortholen®. This has been chosen for its combination of flexibility, strength, and workability. One must remember that not only is the ease of circumferential adjustment crucial after donning and before doffing, but that the integrity of the pivot point must be maintained as well. For these reasons, rigid vertical uprights on a flexible cuff are essential. Although the hinges have little to do with the function of the cuff and attached control line, they have everything to do with cuff placement. Flexible hinges will allow migration of the cuff under load, regardless of the tension, and can only lead to loss of function after only a few articulations.

Residual limb measurements, moulding, and cast modifications are identical to those of accepted supracondylar design. The cuff design and fabrication, on the other hand, is quite different. Considerations for an anterior overlap and underlap should be made, and a positive foundation for the control line, making for the best control action, is planned. Deformation of the anterior cuff, away from the arm, during activation can result in a spongy, unreliable opening of the terminal device. Overlapping will resist such deformation if the control line base plate is mounted on the lateral, underlapping, flap and reinforced by the slotted, overlapping, medial flap. This arrangement allows one to release the Velcro® brand fastener secured medial flap when donning or doffing, easily snugging the cuff to the desired fit once the patient is in the socket.

Measurement of the humeral area is the same as for a traditional triceps cuff. Proximal and distal circumferential measurements along with a height measurement are required. The height of this cuff does play an important role in terms of energy transfer. As the terminal device is activated, control line tension is transferred to the posterior cuff, in the form of pressure, and absorbed by the soft tissue in the triceps area of the arm. Obviously, the more pinch force required by the user, the greater the pressure compensating area required of the cuff. It is interesting to note that the cuff pressure is absorbed by the very muscle group, triceps brachii, initiating this energy transfer through their actions of elbow extension. As these muscles fire and become more tense, they are more resistant to pressure and displacement by the cuff. A broad posterior cuff foundation is necessary for positive and calculable terminal device control. The height of the anterior cuff is less crucial, therefore, a height of 2″-2¼″ successfully

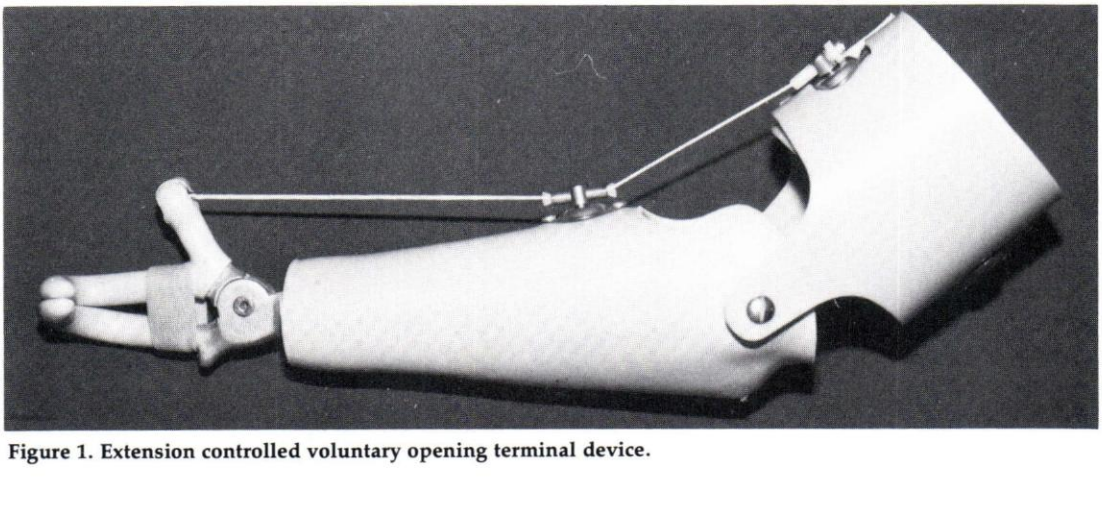

Figure 1. Extension controlled voluntary opening terminal device.

accommodates the 1¼″ base plate and two-inch wide Velcro® adjustment band. However, one area of concern in the anterior cuff is in the inferior border. The patient should be able to flex his/her elbow to the same degree, without cubital fold pinching, as she/he would in a supracondylar socket alone.

On folded paper, at a distance equivalent to the height of the posterior cuff desired, mark two horizontal lines representing the proximal and distal edges (Figure 2). Average the proximo-distal humeral circumferences and extend the horizontal lines to half of this value. At midline of this folded tracing, draw a descending vertical line to represent the elbow joint upright. This line should be more than adequate in length, as it can be trimmed during fitting. The uprights should be approximately one inch wide (½″ on each side of vertical line). Extend the tracing 1¼″-1½″ to create the anterior over- and underlapping flaps.

Note that at this point, the inferior border of the "flap" tracing is raised to provide relief in the cubital fold of the elbow during flexion. One inch is a good starting value. More may be taken away on larger cuffs, but recall the two inch minimum when fabricating smaller cuffs.

Radius the corners of the uprights into the cuff, blending the anterior edge of the upright as one smooth arc into the inferior border of the flap extension. Unfold the tracing onto a ⅛″ Ortholen® plastic sheet. Finish the edges with a deburring tool and propane torch glazing (Figure 3).

FITTING

In fitting, we are looking for the hanging angle and range of motion (ROM) characteristics and fit similar to that found in typical supracondylar sockets. Place the cuff around the arm in the relative location selected during the measurements. Mark the inside of the cuff uprights as they lie over the pivot posts (forearm lift posts) in both extension and flexion. Between these marks, center and drill a ¼″ hole and mount the cuff (Loctite® or a similar adhesive is advised once a permanent installment is established). Although the cuff tension is a preference adjustment, one should check that it doesn't impinge upon the biceps bunching during full elbow flexion.

Figure 3. Cuff layout and finished cuff including hardware, slotted flap, and Velcro.®

CUFF LAYOUT (example)

Proximal Humeral Circumference	**10⅛″**
Distal Humeral Circumference	**9⅞″**
Averaged Humeral Circumference	**10″**
Posterior Cuff Height	**4″**

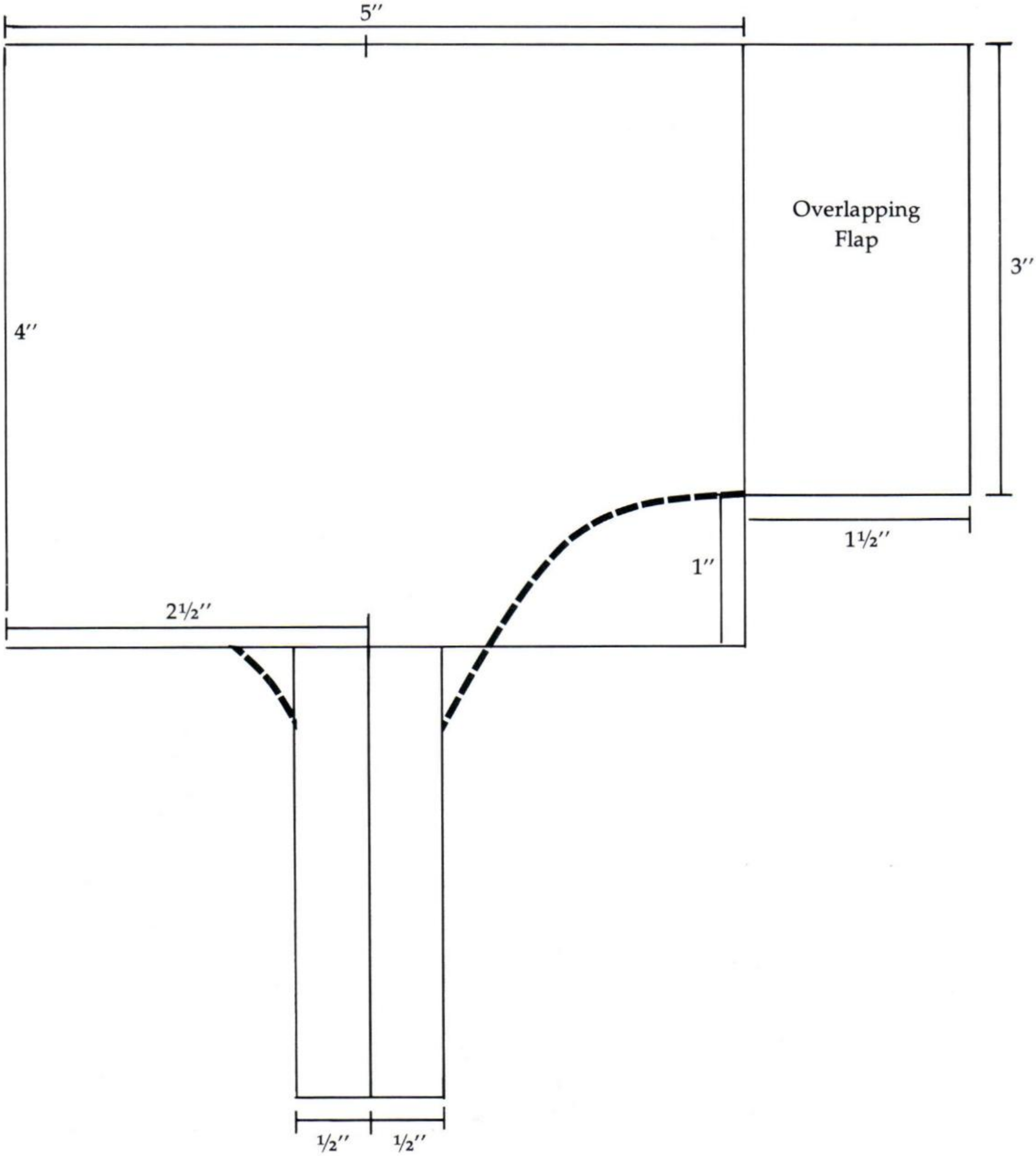

Figure 2.

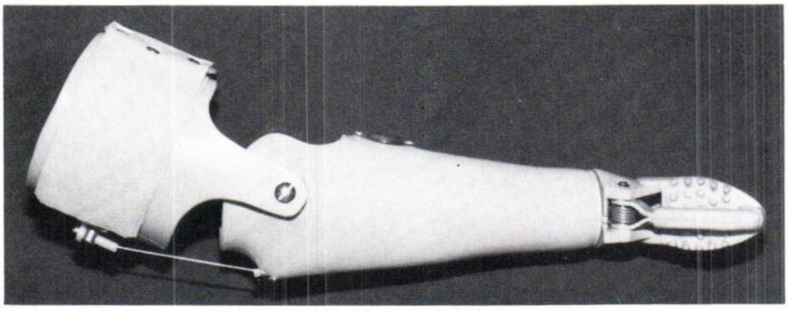

Figure 4A. Flexion controlled voluntary opening terminal device.

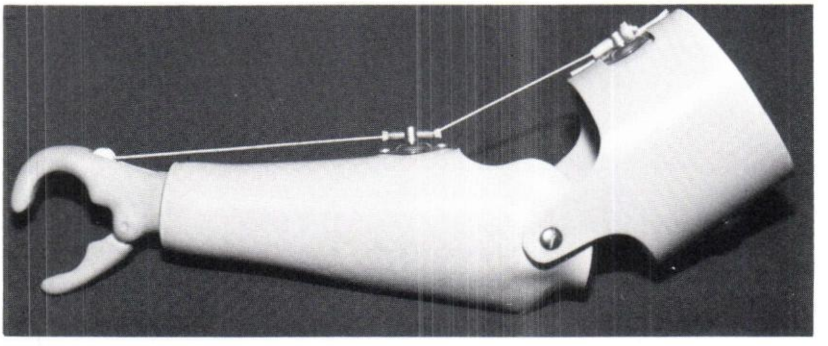

Figure 4B. Extension controlled voluntary closing terminal device.

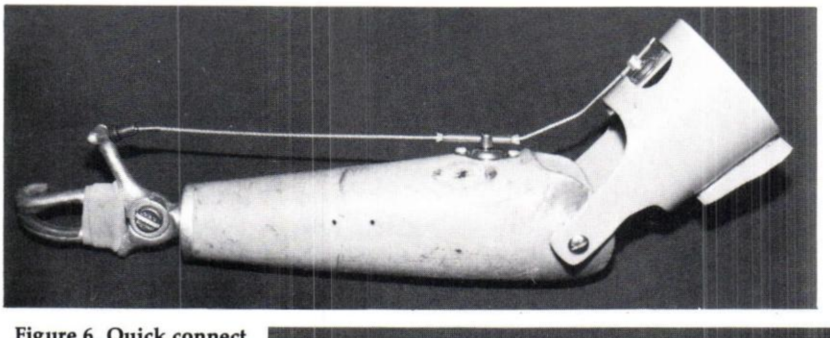

Figure 5. Adaptation of "Full Cuff" control to a pre-existing prosthesis.

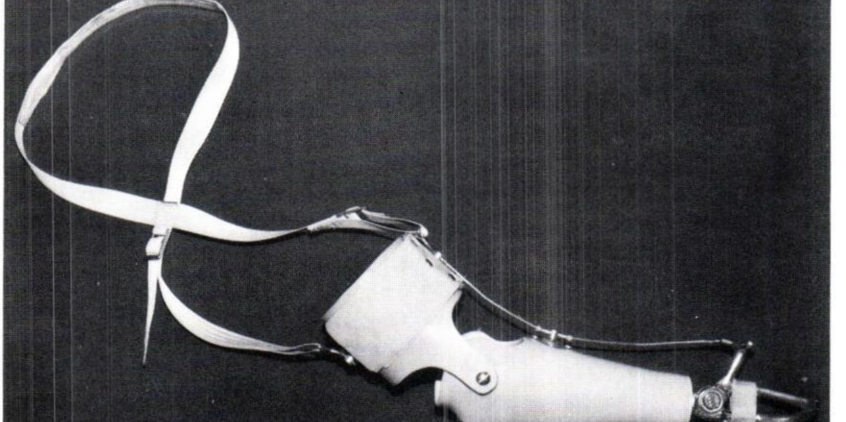

Figure 6. Quick connect "Figure 8" harness for heavy axial loading.

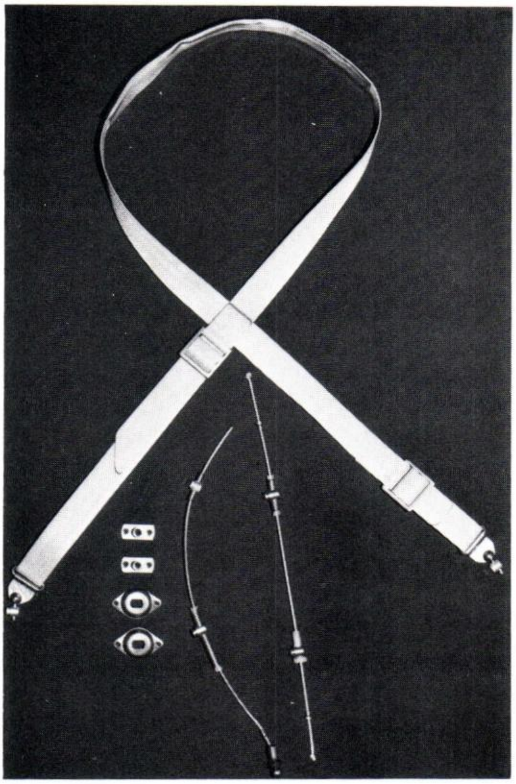

Figure 7. Sample harware: Dacron harness with retainer connections, nylon and wire control lines, base plates, and forearm lift posts.

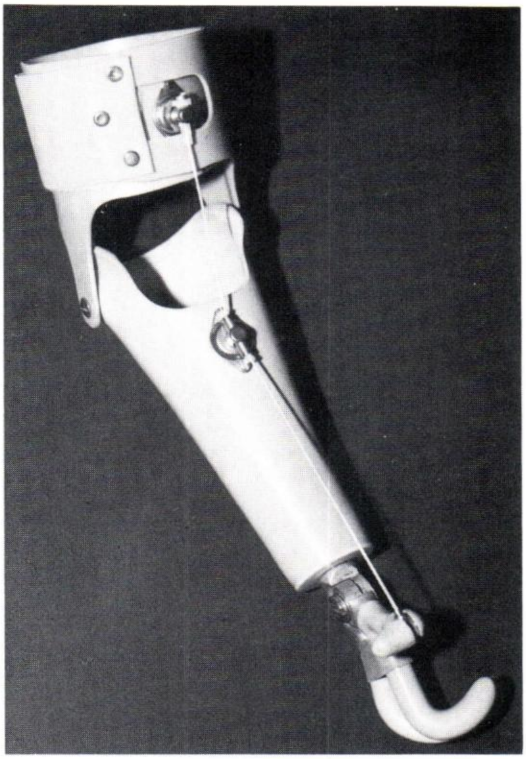

Figure 8. Finished prosthesis with laterally overlapping cuff.

Outfitting the device is simple and direct. With the terminal device pronated and the cuff fixed in extension, pass the control line from the terminal device through to the anterior cuff base plate. Secure the line with a temporary cable hanger and apply the device. Allow the patient to experiment, to his/her satisfaction, with varying combinations of cable tension, terminal device pronation, and elbow extension. Once a definitive cable length is established, install a permanent cable end. Clip the cable flush and buff the end, by wire wheel, for smoothness.

Like all unilateral upper extremity prostheses, its intended capacity is that of an assistive device to potential below-elbow candidates. These candidates should possess sufficient epicondylar prominence, or radio-ulnar styloid prominence in the cases of wrist disarticulations, for suspension. They should also exhibit healthy, active elbow joints and demonstrate that they are not inhibited by the modest limitation to range of motion common to supracondylar socket designs.

As with any device, there are definite limitations. Realistically, this device is seen only as an option: a cost effective, lightweight, and durable alternative to harnesses and battery chargers. Its simplicity makes it compatible with any voluntary opening or closing terminal device, in either an extension or flexion actuating mode, with either braided wire or nylon control line (Figures 4A, 4B).

Its real usefulness lies in the fact that it adapts quickly and inexpensively to any supracondylar below-elbow prosthesis for trial by the amputee (Figure 5). Beyond this feature is the feasibility of instantaneous conversion, back and forth, from a "Figure 8 or 9" harness set-up for work or play, involving heavy axial loading, to the

"Cuff Control" set-up for more comfortable and cosmetic, medium-duty activities. This option is accomplished by means of anterior and posterior base plates on the cuff itself, thus avoiding interruption of the control line during conversion (Figure 6). There are occasions when less can be more, and perhaps this is one.

AUTHOR

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