

Myoelectric Immediate Postsurgical Procedure: A Concept for Fitting the Upper-Extremity Amputee¹

D. S. Childress, Ph.D.,
F. L. Hampton, C.P.,
C. N. Lambert, M.D.,
R. G. Thompson, M.D., and
M. J. Schrodt, M.D.

The advantages of immediate postsurgical fitting in the management of upper-extremity amputees have been pointed out by Sarmiento *et al.* (4) and Loughlin *et al.* (3). These advantages, which are similar to those for the lower-extremity amputee, are: reduction of postoperative pain, control of postsurgical edema, early use of a prosthetic appliance, early psychological adjustment to the disability, reduction of hospitalization time, and, hopefully, a higher rate of prosthesis acceptance by the amputee, particularly the unilateral amputee. Thranhardt (1) has confirmed the psychological and economic advantages of this procedure and has suggested that the problems of adapting present upper-extremity components for use with rigid dressings be examined.

It would seem that almost any upper-extremity component could be adapted for use with rigid dressings. Indeed, it would appear that externally powered devices, if they offer significant benefit to the patient, could be used as well as body-powered units. One of the authors (Hampton) suggested that an externally powered prosthetic appliance, controlled myoelectrically, might be used to significant ad-

vantage with immediate postsurgical fitting of the upper-extremity amputee. The application of myoelectric control would encourage the early use of muscles remaining in the stump, which should improve circulation and reduce stump muscle atrophy.

This paper summarizes the experience of the authors with the immediate postsurgical fitting of myoelectrically controlled prostheses. One primary amputation and a stump revision have been managed in this manner with very satisfactory results.

MYOELECTRIC IMMEDIATE POSTSURGICAL FITTING CONCEPT

Basically, the technique is to place sterile electrodes on the skin over the remaining stump muscles immediately following wound closure. These metal electrodes are held in place by a tubular elastic bandage underneath the rigid plaster dressing. This makes it possible to detect myoelectric activity from proximal muscles in the stump and to use these signals to control an externally powered prosthesis.

Electrode positioning must be guided solely by anatomical considerations when they are positioned immediately following wound closure. Therefore, optimum positioning of the electrodes with this technique may be difficult. Consequently, it is desirable to use a myoelectric amplifier

¹ This report was submitted by the Northwestern University Prosthetic-Orthotic Center, 401 East Ohio St., Chicago, Ill. 60611. The work was supported by Veterans Administration Contract No. V1005M-1079.

of moderately high sensitivity and to use rather large electrodes that are spaced some distance apart in order to detect signals from a wide area. Electrodes 1 in. x 1/2 in. in dimension, spaced approximately 1 to 2 in. apart, are presently being used. A myoelectric unit that operates the terminal device when the peak-to-peak input signal is greater than 50 uv has proven to be satisfactory.

Poor positioning of the electrodes may result in inadequate separation of the myoelectric signals from various muscles in the stump of a below-elbow amputee. The myoelectric activity of supinator-pronator muscle groups may produce the same effect as the activity of the flexor-extensor groups. This is not a major problem, since the rigid plaster cast dressing of the Munster type (2) does not allow supination or pronation of the stump. However, the amputee should be instructed to use the flexor-extensor groups (assuming two-electrode systems are used) so that new control methods do not have to be learned should a permanent myoelectric prosthesis be prescribed.

It is preferable that the pick-up electrodes be sterile and that they do not require conducting paste. Therefore, the attached electronic equipment must be compatible with electrodes of this type. Systems using either one set or two sets of electrodes are practical. In the procedure described in this paper, a two-electrode, commercial system was used (Viennatone) because it met the requirements, was readily available, and was convenient to use.

CASE HISTORY

Mrs. G. M., a 27-year-old female, first noticed a small nodule on the dorsum of the left fourth metacarpophalangeal joint at age 7. At age 22, this became dark brown and painful and was locally excised. She was told it was a fibroma. The pain recurred in October 1967, at age 25, and a nodule over the dorsum of the left fifth metacarpophalangeal joint was excised, along with the fourth digit and metacarpal. This was reported to be a low-grade fibrosarcoma. The wound ulcerated and tumor tissue reappeared at the wound edges. In September 1968, the fifth digit and metacarpal were excised. Again, the report was

compatible with fibrosarcoma. The patient was first seen at Presbyterian-St. Luke's Hospital in Chicago in March 1969, with the complaint of knife-like pain at the area of the old surgical scar and a palpable mass. This was biopsied and reported as fibrosarcoma. On March 24, immediately after a left-wrist disarticulation, a myoelectric prosthetic fitting of the left hand was done. Tissue examination revealed tumor cells above the site of the disarticulation. Therefore, she was readmitted to the hospital, and on April 17 the extensor muscle group to the 2nd, 3rd, 4th, and 5th digits of the left hand was excised. Again, the patient underwent immediate postsurgical fitting of the myoelectric prosthesis. The final pathology specimen showed that the tendons had been excised well above the level of the tumor. The patient was discharged from the hospital on the fourth postoperative day.

PROCEDURE AND EXPERIENCE

A left-wrist disarticulation was performed. Following closure of the wound, approximately 3/8 oz of sterile lamb's wool

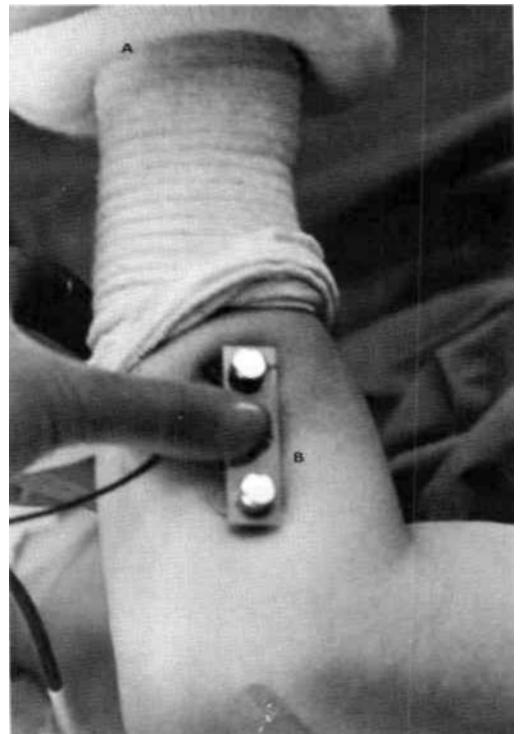


Fig. 1. View of forearm immediately following wrist disarticulation surgery. The tubular bandage has been pulled over the stump, and a stump sock has been positioned at the distal end (point "A"). A set of electrodes is shown being positioned near point "B". (The electrode pair is turned over to show the metallic surfaces.)

was applied over the dressing at the distal end of the stump. A length of sterile tubular elastic bandage (Tubigrip), closed at one end, was pulled over the stump, and a sterile stump sock was positioned for application, as shown in Figure 1, point "A." The electrodes were then positioned on the stump (Fig. 1, point "B"). The lateral set of electrodes was positioned approximately 2 in. distal to the epicondyle and 1/2 in. anterior to this point. The medial set of electrodes was placed approximately 1 1/2 in. distal to the medial epicondyle. The ground electrode was placed posteriorly on the stump between the two sets of electrodes. The electrodes were held in place by non-allergenic paper tape and then covered with the tubular elastic bandage. Experience showed that the commercially available electrodes (Viennatone) created too much local pressure on the skin of the stump, and a modification of this tech-



Fig. 2. A rubber cushioning material, attached to the stump sock, protects sensitive areas of the stump.

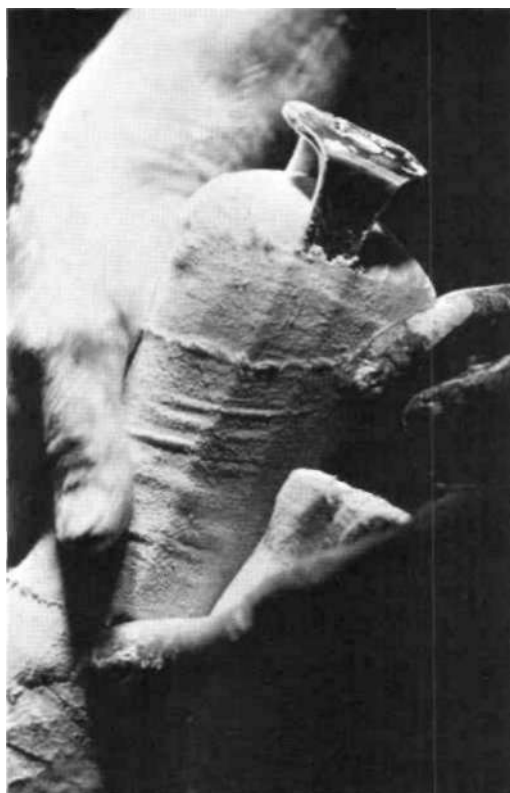


Fig. 3. View showing the attachment of the wrist connector to the plaster cast.

nique, which is discussed later, had to be developed. The stump sock was then pulled over the stump to the mid-humerus level and held under tension. Patches of 1/8-in., self-adhering foam rubber were placed over the olecranon, the medial and lateral epicondyles, and the distal end of the stump (Fig. 2). The stump was then wrapped with a roll of elastic plaster bandage, beginning distally, and this was reinforced with a roll of standard plaster bandage. A Hepp-Kuhn (Munster-type) socket was molded, with the elbow maintained in approximately 90 deg of flexion during the molding procedure. After plaster hardening, the wrist connector was contoured to the shape of the cast and bound to the rigid dressing with additional wraps of plaster bandage (Fig. 3). The hand was then attached (Fig. 4). The resultant overall prosthetic length was ap-



Fig. 4. Hand being attached in operating room.

proximately 1 in. longer than the remaining normal arm. The patient is shown in Figure 5 on the third postoperative day.

A cosmetic glove was not used during the early postoperative period. The electronics and battery were carried in a pouch with a shoulder strap.

The patient operated the prosthesis six hours following surgery, and used it on the first postoperative day for handling mail, for eating, and for other activities of daily living. She continued to use the prosthesis in her room and in physical therapy until her hospital discharge on the fourth postoperative day.

The patient used the hand frequently at home (*e.g.*, holding baby food bottles while opening), and indicated that she got more function from the prosthetic hand

than from her original, physiological hand, since there had been considerable pain in the hand due to the presence of the tumor.

The first cast was removed on the ninth postoperative day. Skin healing was good except for a small amount of granulation at the exit site of the Penrose drain. The stump was free of edema. However, deep indentations in the skin were evident at the site of the medial and lateral electrodes. Apparently, the concentrated pressure of the electrodes inside the confining, rigid cast was too great. Consequently, a conventional prosthesis was fitted, incorporating a Dorrance 5XA terminal device, a shoulder harness, and a harness "quick disconnect."

On the twenty-third postoperative day, the second cast was removed. The amputation site had healed well, as had the electrode-pressure reaction sites. The stump appeared to be in good condition. However, postsurgical laboratory tissue tests revealed the presence of tumor cells above the amputation site. A second surgical procedure was therefore necessary. Following this surgery, a second myoelectric fitting was performed, at which time flat electrodes constructed of thin (0.001 in.) stainless-steel foil were used. One of these flat electrodes, the grounding electrode, may be seen at "A" in Figure 6 as it is being inserted beneath the tubular elastic bandage. The ends of the foil electrodes that extend from the openings in the bandage may be taped down together with the extensor electrodes ("B"). The other electrode pair may be seen at "C." The edges of the foil are folded over to eliminate sharp surfaces, and the lead wire is soldered directly to the foil. These electrodes have proven to be satisfactory for this application from both an electrical and a mechanical viewpoint.

The second myoelectric fitting was also successful. In addition to different electrodes, a smaller externally powered hand (Otto Bock), more suited for a woman wearer, was fitted. Again, the patient was discharged from the hospital on the fourth



Fig. 5. Patient on the third postoperative day. The electronics are at her side.

postoperative day. On the eleventh postoperative day, the cast was removed. The operative site was well healed, and the sutures were removed. The stump was in excellent condition, and therefore the myoelectrically controlled prosthesis was re-applied.

COMMENTS

The early and extensive use that the patient made of the myoelectrically controlled prosthesis is very encouraging. If proper electrodes are used, myoelectric immediate postsurgical fitting appears to have significant value for amputees. It appears to be an effective therapeutic tool for early rehabilitation. In the future, it may be practical to fit many upper-extremity amputees in this manner, followed

by definitive fitting of myoelectric prostheses.

This approach may be backed up with standard hardware and harnessing. Should the myoelectric system not function properly, the electric hand may be removed and replaced by a conventional terminal device with harnessing. Therefore, many of the advantages of the immediate fitting may be maintained in spite of any malfunctioning of the myoelectric prosthesis.

At present, a major disadvantage of the described procedure is the high cost of the electronic system. Another disadvantage is the lack of variety in the externally powered components that are commercially available. Nevertheless, the use of myoelectric control of externally powered components would seem to have a place in

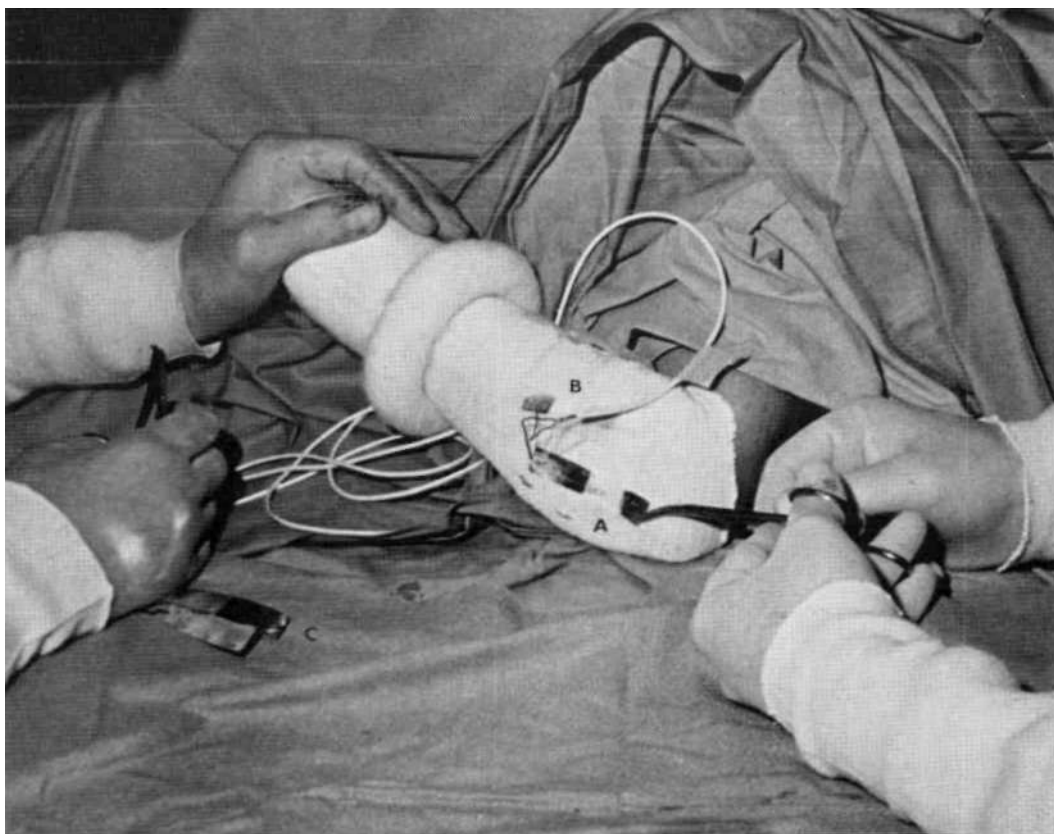


Fig. 6. View showing attachment of the foil electrodes following stump revision. At "A," the ground electrode is shown being pulled through two slits in the tubular bandage. The two extensor electrodes are shown near "B" after they have been taped down. The two foil electrodes for the flexor muscles are shown near "C."

immediate postsurgical prosthetics for upper-extremity amputees.

ACKNOWLEDGMENT

The authors wish to thank Miss Virginia Wilcox for her assistance with the manuscript.

LITERATURE CITED

1. Committee on Prosthetics Research and Development, *Immediate postsurgical fitting of prostheses*, A report of a workshop, National Academy of Sciences, Washington, D. C., May 1968, p. 4.
2. Kay, Hector W., et al., *The Munster-type below-elbow socket, a fabrication technique*, *Artif. Limbs*, 9:2:4-25, Autumn 1965.
3. Loughlin, Edward, James W. Stanford, III, and Marcus Phelps, *Immediate postsurgical prosthetics fitting of a bilateral, below-elbow amputee, a report*, *Artif. Limbs*, 12:1:17-19, Spring 1968.
4. Sarmiento, Augusto, et al., *Immediate postsurgical prosthetics fitting in the management of upper-extremity amputees*, *Artif. Limbs*, 12:1:14-16, Spring 1968.