

Immediate Postsurgical Management of Upper-Extremity Amputation: Conventional, Electric and Myoelectric Prosthesis¹

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Approximately 6-10,000 upper-extremity amputations are performed each year in the United States (6,9,18). Successful rehabilitation after upper-extremity amputation has significant economic impact both to the amputee and society, since most upper-extremity injuries occur in young working males (5,11).

Although the success rates for fingertip, finger, and hand replantation exceed 90 percent in most centers, the success rate for replantation above the wrist averages 50 percent or less in most institutions (2,4,8,13,14).

The current success rate for rehabilitation after upper-extremity amputation with fitting of conventional prosthetic devices is 50 percent or less (1,3,5,7-9,15). Although slightly more than 100 cases of rapid or immediate postsurgical prosthetic fitting after upper-extremity amputation have been reported, there appears to be a relative lack of interest in this area (9). In addition, although there have been many significant improvements in the quality, function, and reliability of externally powered upper-extremity prosthetic devices during the last five years, most of this technological advancement has been lost on contemporary

surgical and prosthetic care. The purpose of this report is to review our experience with upper-extremity immediate postsurgical fitting utilizing conventional, electric, and myoelectric components.

MATERIALS AND METHODS

PATIENT DATA

Between April 1, 1979 and December 31, 1980, twelve patients with traumatic or elected upper-extremity amputations were treated with immediate postoperative prosthetic components (Table 1). The etiology for upper-extremity amputation included trauma (eight), stroke (two), brachial plexus injury (one), and tumor (one). The one patient with a brachial plexus injury required simultaneous shoulder arthrodesis in order to obtain shoulder stability for elbow control.

During this same period seven additional patients, all of whom were prior users of conventional prosthetic devices, were fitted with electric and myoelectric components for testing and evaluation (Table 2).

TABLE 1
TRAUMATIC AND ELECTIVE UPPER-EXTREMITY AMPUTATION

Amputation Level	#	PROSTHETIC TREATMENT			
		Conventional	Electric	Electric Myoelectric	Myoelectric
Below Elbow	4	—	2	2	—
Above Elbow	7	3	—	2	2
Forequarter	1	—	1	—	—
	12	3	3	4	2

TABLE 2
CONVERSION FROM CONVENTIONAL
TO EXTERNALLY POWERED PROSTHETIC COMPONENTS

Amputation Level and (Number)	Employed	Use Prosthesis Work/Recreation*	Prefer Power**
Wrist Disarticulation (1)	1	1/1	1
Below Elbow (3)	3	3/3	3
Above Elbow (3)	3	3/3	3
			7/7 100%

*Use conventional for water and rugged activities
**See text for comments on dependability

SURGICAL TECHNIQUE

Although maximum limb length was usually preserved, amputation stumps were modified as needed *at the time of surgery* to permit optimal fitting and fabrication of the prosthetic components to be used. All amputations were closed primarily when possible, and a myoplasty, myodesis, or both were performed in all cases. The postoperative prosthetic devices used immediately after surgery were constructed so that they could be removed to allow frequent wound inspection and permit rapid prosthetic modification or repair (Fig. 1).

PROSTHETIC TECHNIQUE

Standard immediate postoperative prosthetic techniques (IPOP), as utilized in lower-extrem-

ity amputation, form the basis for the initial upper extremity cast (11,12). The IPOP cast consisted of Owen's silk against the skin as a separating agent, lamb's wool for distal stump padding, felt pads for relief for bony prominences, a Spandex stump sock, and Elastioplast for construction of the outer plastic shell. An attempt was made to provide cosmesis in constructing the original plaster prosthesis at all amputation levels (Fig. 1). Below-elbow prosthetic devices were attached to the IPOP cast using a flexible acrylic-laminate shell which was secured to the cast with tape or plaster or both (Figs. 2 and 3). Above-elbow prosthetic devices were attached to the IPOP cast through the use of a flexible polypropylene sleeve which was secured to the elbow turntable by metal band clamps and the IPOP cast with tape and/or

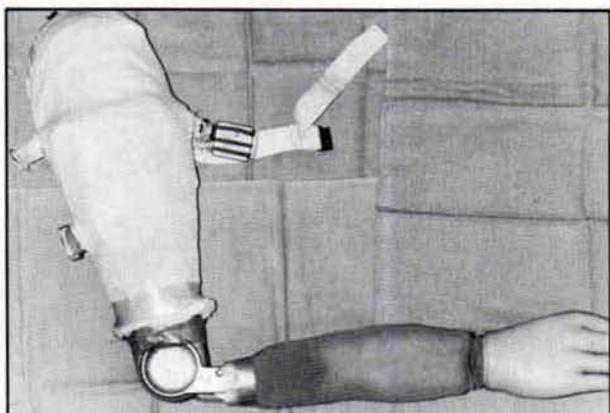


Fig. 1. Standard above-elbow Liberty Mutual/Otto Bock removable prosthesis.

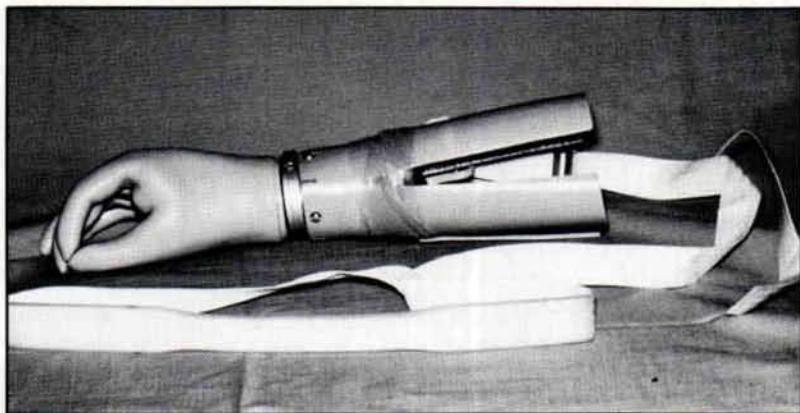


Fig. 2. A preassembled below elbow immediately postoperative prosthesis with electric hand and flexible acrylic laminate forearm.



Fig. 3. Below-elbow prosthetic components are attached to the IPOP cast via flexible laminate acrylic shell with either tape or plaster.

plaster (Figs. 4, 5, and 6). All IPOP prosthetic limbs were constructed to allow interchange of hand and hook.

Our initial patients were fitted with components with either electric or myoelectric controls, but we now fit our patients with com-

ponents that have been adapted for *both* switch (electric) and *myoelectric* control systems.

Below-elbow IPOP casts are locked at 90 degrees of flexion to obtain a self-suspending below-elbow prosthesis. A single axillary harness is used for switch and/or cable control.

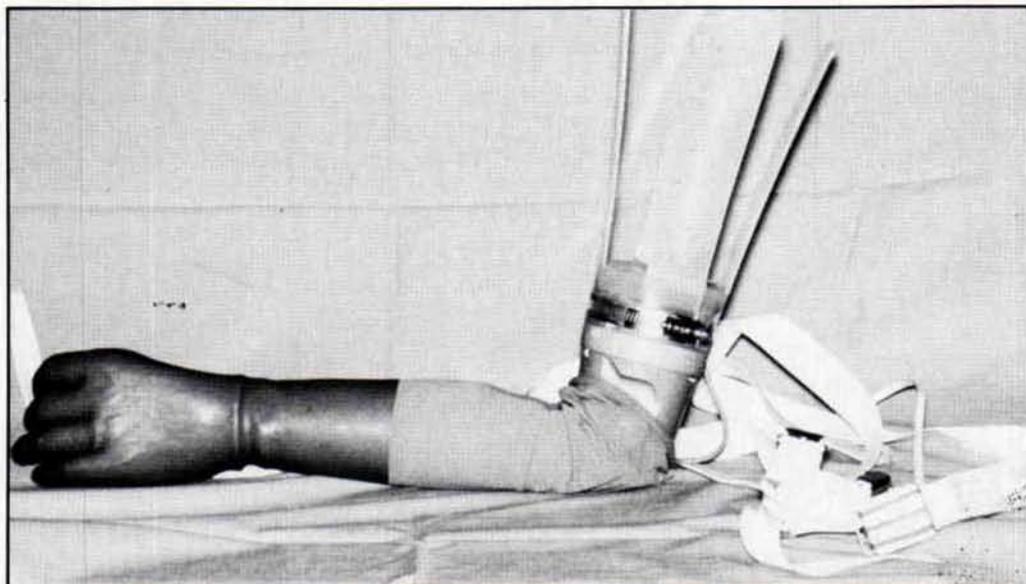


Fig. 4. A preassembled above-elbow immediate postoperative prosthesis.

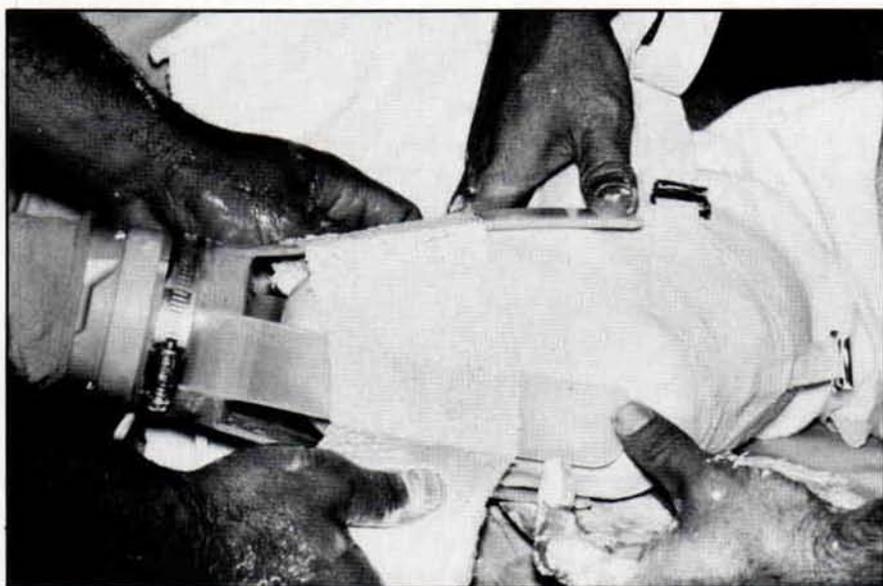


Fig. 5. The above-elbow prosthesis is attached to the prosthetic cast by incorporating the flexible polypropylene sleeve into the IPOP cast after appropriate length and position adjustment utilizing tape and/or plaster.

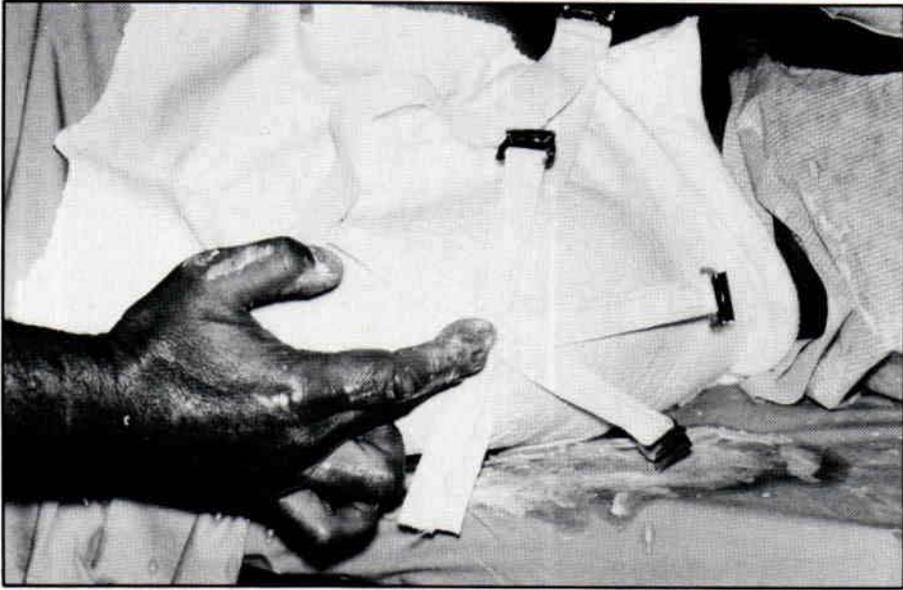


Fig. 6. In order to maintain adequate above-elbow suspension, the location of our three point harness is crucial and the usual location of the harness center point is shown in this photograph.

Harnessing for above-elbow amputees usually involves a figure-of-eight harness with axillary strap, but is individualized as required. Switch control is obtained from any point on the harness which will allow maximum patient function.

Myoelectric control points for all amputation levels are determined by standard myotesting procedures with the Otto Bock myotest unit.

For all amputation levels, switch control mounting sites are located carefully for hand and elbow components so that the standard physical motions required for utilization of a conventional hook and cable prosthesis are the same as required to utilize our electric components. When this type of standardized approach to training is used, all patients fitted with IPOP electric or myoelectric components can also be fitted with conventional hook-and-cable components and thus achieve immediate function of the conventional devices while waiting for their first temporary powered prosthesis which is provided in 4-6 weeks.

In general, we do not fit myoelectric prosthetic devices with electrodes at the time of surgery, but wait until the IPOP cast has dried for 24 hours or the time of first cast change (7-14 days postamputation). This approach has been adopted in order to avoid water damage

to the electronic components during casting and to allow time for myotesting and determination of adequate electrode sites.

Our basic prosthetic components include the Liberty Mutual "Boston" myoelectric elbow which has been modified to allow switch control, United States Manufacturing/Fidelity Electronics/VANU electric 12-volt hand and the Otto Bock electric/myoelectric 6-volt hand.

OCCUPATIONAL THERAPY

Occupational therapy is begun on the first postoperative day and is continued on a daily basis throughout the patients' entire hospital course. The primary goal of occupational therapy is accelerated training of the patient to use the prosthesis, which is followed by training in the use of the prosthetic device in a two-handed manner for activities of daily living and job training, rather than teaching one-handed skills and use of the prosthesis as an assistive device.

CENTER APPROACH

All patients are treated in a dedicated amputation rehabilitation center (9-12). While in the hospital, all patients are seen daily by all members of the amputation-rehabilitation team. When discharged from the hospital, pa-

tients are followed longitudinally by all members of the team. Outpatient care is organized by and is under the direction of the amputation-rehabilitation team coordinator (SJC). Our program coordinator also supervises the educational training that the patient and his family receive during the pre- and postoperative periods as well as provide liaison between our program and other community agencies.

RESULTS

All wounds that were closed primarily healed primarily (12/12, 100). None of the patients treated with immediate postoperative prosthetic casting techniques had any injury to the amputation stump due to the cast or the immediate fitting of prosthetic devices.

There were no operative deaths and no acute morbidity. One late stump revision (1 yr) was performed for ectopic bone formation.

All three above-elbow amputees fitted with immediate postsurgical conventional hook-and-cable prosthetic devices had complete function with the ability to lock the elbow in all positions as well as open and close the terminal device in all positions within an average of seven days (range 2-14 days). Patients fitted with immediate postsurgical electric hands and elbows were functional after 10-15 minutes of training, and patients fitted with myoelectric elbows and hands were functional within 12-48 hours after initial training and practice.

At one month after amputation, all of our patients were wearing their new prosthetic de-

vices effectively (12/12, 100%). Longterm followup shows the following: one above-elbow amputee died six months after hospital discharge in an automobile accident; however, at the time of death he was wearing his prosthesis 12-14 hours a day and using it for work and activities of daily living; one patient has quit wearing his forequarter prosthesis because of complicated medical and psychological problems which have required repeated hospitalization; all other patients (10/10, 100%) continue to wear their prosthetic devices 8-18 hours per day (average 12 hrs) and use them in all activities of daily life and work.

The rate of employment after traumatic or elective upper-extremity amputation for our group of patients is demonstrated in Table 3: Four of six patients employed before amputation have been successfully reinstated at their same job after amputation; two patients are in training for new jobs; three patients were students when injured and all three have returned to school; two patients were in retirement at the time of injury and have gone back to their postretirement activities; and one patient who was unemployed when injured was temporarily rehabilitated and employed. All employed patients use their externally powered prosthetic devices rather than their conventional prosthetic components for work and most activities of daily living. Time from amputation to work ranges from one week to one year (mean 3.8 months), and the length of time at work ranges from 3-18 months (mean 8.4 months) (Table 3).

TABLE 3
TRAUMATIC AND ELECTIVE UPPER EXTREMITY AMPUTATION
RATE OF EMPLOYMENT

Amputation Level and (Number)	Employment		Job Training	Student	Retired	Time From Amputation To Work (Months)	Length of Time at Work (Months)
	Before Amputation	After					
Below Elbow (4)	3	1	2	1	—	1	18
Above Elbow (7)	3	3	—	2	2	3,12,m	3*,6,12
Forequarter (1)	—	1	—	—	—	3	3**
	<u>6</u>	<u>5</u>	<u>2</u>	<u>3</u>	<u>2</u>	Mean = 3.8mo	Mean = 8.4mo

*Death 6 months after amputation

**Quit wearing at 6 months, unemployed prior to amputation

None of our surgical patients have developed painful phantom syndromes. In fact, many of these patients have transformed all sensory feeling from their phantom limb to their prosthetic device. This *sensory transformation* of phantom sensation to the prosthetic limb applies only to those patients fitted with immediate postsurgical prosthetic devices (fitted within *one month* of amputation) and was not seen in our seven patients who were fitted months to years after their original amputation.

Evaluation of our seven amputees who were prior wearers of conventional prosthetic devices and then provided externally powered prosthetic components is shown in Table 2. All seven patients are employed and all preferentially use their externally powered prosthetic devices for work, recreation, and/or activities of daily living.

Comparison of hand-versus-hook function by patients suggests that electric and myoelectric prosthetic hands provide increased function when compared to standard prosthetic hooks. Those patients doing heavy manual labor had some difficulty with their electric hands because of component failure and breakage. A few of these patients have returned to using their hook for heavy work; however, none of these patients want to give up their hand for light work, social functions, or activities of daily living.

As might be expected, all patients are extremely pleased with the cosmetic value of their externally powered components.

DISCUSSION

The success rates for rehabilitation after upper-extremity amputation vary with the quality of surgery, type of prosthetic fit, quality of fit, and the patient. In general, the success rates for rehabilitation after upper-extremity amputation are highest when the patient is fitted as rapidly as possible after injury (3,5,7,16-20). Conventional (soft or rigid dressing without fitting the terminal device until after complete wound healing and complete stump maturation) upper extremity-amputation and rehabilitation often result in late fitting of upper-extremity amputees. By the time an amputee is fitted with a prosthetic device in most settings where mean delivery time of the prosthesis is

six months (6), he has become skilled at being a one-handed individual and sees very little use for "assistive" prosthetic devices.

In a previous publication we noted that the overall rehabilitation data on 109 published cases of rapid and/or immediate postsurgical fitting for upper-extremity amputation documented a rehabilitation time which averaged ten days, a mean fitting time for permanent prostheses of approximately 12 weeks, and most importantly, an overall amputee rehabilitation rate greater than 90% (100/109) (9). During the past 20 months, our group has fitted all levels of traumatic upper-extremity amputation from below-elbow to forequarter with immediate postoperative conventional, electric, and myoelectric prosthetic devices. In addition, we have performed several elective above-elbow amputations with the fitting of externally powered devices in patients with neurologic dysfunction of their arm due to stroke or brachial plexus injury. All of our patients had rapid prosthetic function with rehabilitation times ranging from 10-15 minutes to 2 weeks, depending upon the type of device which was fitted to the patient. In general, the rehabilitation times for patients fitted with externally powered upper-extremity components is significantly less than that required for patients fitted with conventional hook-and-cable prosthetic devices.

Although our patient group is small and our data are preliminary and further longitudinal evaluation is required, our data suggest that patients fitted with immediate postoperative prosthetic devices and who were employed prior to amputation, can continue to be employed after amputation at their prior job in most cases. Several of our patients have had to undergo job training and have not been able to return to their original job, not because of physical incapacitation, but because of either specific instruction from legal counselors or because of local union-employer agreements regarding disability and rehabilitation.

The patients we have studied who have been conventional prosthetic users prior to receiving externally powered prosthetic components all prefer externally powered prosthetic devices for all but heavy work or water related recreational activities. In addition, all of our patients fitted with immediate postoperative prosthetic

components and then supplied with both conventional and externally powered prosthetic devices after rehabilitation prefer their externally powered components for most activities.

All of our patients who were provided with both an externally powered hand and a cable controlled hook prefer the electric/myoelectric hands for almost all activities.

We believe that, if possible, the amputation stump should be closed primarily with a myoplasty and/or myodesis technique. Adequate muscle stabilization is especially important when a myoelectric prosthetic device is to be fitted to the patient. In addition, we believe the amputation stump should be modified as required at the time of initial surgery in order to allow the best possible fit of the planned permanent prosthetic devices.

Early in our series, three above-elbow amputees were fitted with conventional prosthetic components. We no longer utilize conventional prosthetic components for immediate postsurgical fitting due to prolonged rehabilitation time with respect to prosthetic function compared to externally powered components and because our patients achieve greater functional capability through the externally powered components than is possible through the use of conventional hook-and-cable prosthetic devices.

When comparing stump wrapping after amputation of the upper-extremity and late fitting of conventional prosthetic devices to immediate postoperative fitting we believe that there are multiple advantages to immediate postoperative prosthetic application of either conventional or externally powered prosthetic devices for upper-extremity amputation including control of edema, decrease in postoperative pain and phantom limb sensations, accelerated wound healing, improved stump stability, enhancement of stump maturation, rapid patient rehabilitation, decreased length of hospital stay, decreased hospital costs, improved psychological outlook of the patient, increased prosthetic use, and maintenance of some type of proprioceptive input through the amputation stump.

In using externally powered upper-extremity devices it is important that the total weight of the final permanent prosthetic arm does exceed the weight of the amputated limb. In our exper-

ience it is possible to construct both myoelectric below-elbow prostheses and electric/myoelectric above-elbow prostheses (with power hand and 2 battery packs) which weigh the same or less than the amputated limb (2-2lbs, below-elbow, 5-5lbs, above-elbow). In addition, ancillary suspension techniques such as suction socket, partial suction socket, and Silastic sleeve suspension are all great aids in achieving increased patient range of motion and decreased overall prosthetic weight.

Most externally powered prosthetic devices have been durable and reliable. We have had few problems with the Liberty Mutual "Boston" myoelectric elbow, the Otto Bock electric/myoelectric 6-volt hand, and the United States Manufacturing/Fidelity/VANU 12-volt hand; however, the US Manufacturing/Fidelity Electronic/VANU electric elbow and electric elbow-hand combinations have been very disappointing and we no longer use those externally powered devices.

It is our overall feeling that further investigation into rapid rehabilitation and improved patient function with immediate postsurgical application of externally powered prosthetic devices for upper-extremity amputation is definitely warranted due to the potential advantages to the patient and society.

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Footnotes

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