Chapter 11 - *Atlas of Limb Prosthetics: Surgical, Prosthetic, and Rehabilitation Principles*

Normal Version

Adult Upper Limb Prosthetic Training

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The impact of the sudden loss of a hand or arm upon a person cannot be overstated. The loss of fine, coordinated movements of the hand, tactile sensation, proprioceptive feedback, and aesthetic appearance can only be compensated for to a limited extent by three types of prostheses that are currently available.[7]

As outlined in previous chapters, the three prosthetic options include (1) a passive cosmetic arm and hand; (2) a cable-controlled, body-powered prosthesis; and (3) an electrically powered prosthesis controlled by myoelectric sensors or specialized switches. In reality there are no perfect or ideal replacements that take the place of the exquisite mechanisms and function of the human hand.[5]

An unusually high rejection rate of upper-limb prostheses can often be attributed to the following reasons: development of one-handedness, which removes the functional need for the prosthesis; lack of sufficient training or skill in using the prosthesis; poor comfort of the prosthesis; a poorly made prosthesis; the unnatural look or profile of the prosthesis; and the reactions that the wearer gets from other people.[2]

It is felt that successful outcomes in rehabilitation for the unilateral and bilateral amputee can be attributed to the following reasons:

- Early post-traumatic intervention
- Experienced team approach
- Patient-directed prosthetic training
- Patient education
- Patient monitoring and follow-up

The focus of this chapter is to stress the importance of postoperative, preprosthetic, and prosthetic training principles. Listening to and acknowledging the patient's psychological and functional needs will be critically important in determining the success or lack of success with prosthetic acceptance and function.

POSTOPERATIVE THERAPY PROGRAM

Awareness of postoperative and subsequent preprosthetic principles of care is crucial to successful management of an individual who has just sustained traumatic limb loss. This phase of care is one where the patient has little control over what is happening and must depend upon the health care team to provide the best treatment possible.

Treatment goals of postoperative care can be addressed by any member of the rehabilitation team, which may include the physician, nurse, and occupational or physical therapist. The goals are as follows:

1. Promote wound healing.
2. Control incisional and phantom pain.
3. Maintain joint range of motion.
4. Explore the patient's and family's feelings about a change in body image.
5. Obtain adequate financial sponsorship for the prosthesis and training.[4]

Promote Wound Healing

Wound healing is generally monitored by the surgeon who performed the amputation and by the nurse. The role of the nurse cannot be overemphasized since she is the member of the team having continuous contact with the patient during this stage of healing. The nurse will need to be active in the patient's rehabilitation program so that those activities taught to the patient by the occupational and physical therapists may be carried over successfully to the nursing unit situation.[8]

Control Incisional and Phantom Pain

Acute incisional pain is generally managed by narcotic agents given intravenously or intramuscularly. This is necessary for the first 3 to 4 postoperative days. Transcutaneous electrical nerve stimulation (TENS) has also been used to decrease incisional and phantom pain in the amputated limb. This modality can be used alone or in conjunction with oral analgesics.

The difference between a phantom limb and phantom pain should be clearly explained to the amputee. A phantom limb is the feeling or sensation that the limb is still present, and phantom pain is differentiated by the sensation of pain in the phantom limb. Significant success in decreasing phantom pain has been achieved by using amitriptyline (Elavil) at doses of 50 to 150 mg daily at bedtime. Elavil is involved in serotonin production and is believed to modify pain perception.[4]

Phantom limb pain may also be controlled by isometric exercise. These exercises can be started within 5 to 7 days following surgery. Residual wrist extensors and flexors as well as residual biceps and triceps are the muscles of choice to use in isometric exercise in transradial and transhumeral amputees, respectively. These exercises should be performed every other hour for 10 to 20 repetitions.

Maintain Joint Range of Motion

Maintaining adequate range of motion in all joints of the upper limb is critical. This is particularly true in the burn patient. Full range of motion is frequently lost at the glenohumeral and elbow joints. Additionally, scapulohumeral mobility must be maintained and strengthened. Full flexion and extension at the elbow combined with maintaining maximum pronation and supination of the forearm cannot be overemphasized. These motions are crucial for terminal device placement and subsequent function.

An active exercise program should be initiated by the physical or occupational therapist. This can begin as early as the second postoperative day. The program should be closely supervised and include active and ac-tive-assistive joint range of motion. Gentle isometric contractions can begin on the fifth postoperative day, and isotonic contractions can be encouraged 7 to 10 days postoperatively. Active exercise practiced several times daily can begin shortly thereafter and should be thoroughly reviewed with the patient.

Explore the Feelings of the Patient and Family

The emotional impact of limb loss on the patient and his family is overwhelming. Often there is a period of depersonalization that may occur during this time when other limbs and body systems may be involved following severe traumatic injury. Reassurance and support are vitally necessary not only at this time but throughout the rehabilitation process. All members of the team should respect the individual's dignity, support the patient and family throughout the grief process, as well as offer encouragement and realistic optimism with respect to his future generally. It is premature to discuss prosthetic component options at this time. Often the patient and his family are not ready to hear about or see prostheses until the acute postoperative phase has passed.

Financial Sponsorship

It is important to identify and explore third-party sponsorship at this time. Specialized prostheses are often costly. Sponsorship must be sought early, and these devices must be adequately described to the payer so that a comprehensive rehabilitation program can be realistically pursued.

PREPROSTHETIC THERAPY PROGRAM

From the time the sutures are removed to the time the prosthetic prescription is being discussed there are many goals that are important to address. The occupational therapist is the primary person who will be managing and monitoring this program for the upper-limb amputee. Nursing is an important adjunct, however, and all shifts of the nursing staff should be thoroughly familiar with each of these areas.

The goals of the preprosthetic program are as follows:

1. Residual limb shrinkage and shaping
2. Residual limb desensitization
3. Maintenance of normal joint range of motion
4. Increasing muscle strength

5. Instruction in proper hygiene of the limb
6. Maximizing independence
7. Myoelectric site testing (if myoelectric components are prescribed)
8. Orientation to prosthetic options
9. Exploration of patient goals regarding the future

This phase generally occurs 2 to 3 weeks after surgery. Healing has essentially occurred by the 21st postoperative day and should allow a vigorous program for prosthetic preparation.[4]

Residual Limb Shrinkage and Shaping

Shrinking and shaping of the residual limb is usually accomplished by compression from an elastic bandage, intermittent positive-pressure compression, or a tubular elastic bandage. If an elastic bandage is used, it is important that the proper technique be taught to the patient, family, and nursing staff. A figure-of-8 wrap is one that applies more pressure distally than proximally; elastic bandaging should never be done in a circumferential manner.

The wrapping process begins with the end of the bandage placed diagonally at the distal end of the residual limb. The wrap should encircle the limb from behind and wrap diagonally upward to cross over the end of the bandage. This figure-of-8 process should continue, with each pattern overlapping the previous one by approximately two thirds the width of the bandage (**Fig 11-1.**). The bandage is then secured with tape or special clasps.

Fig 11-1. Figure-of-8 elastic bandage wrapping technique.

No elastic bandage should be used for more than 48 hours without being washed with mild soap and lukewarm water and thoroughly rinsed with clean water. Bandages should not be twisted, but laid flat to dry. Washers and dryers decrease their longevity and ruin their elasticity.

The wrap should be reapplied every few hours or more frequently if it slips or bunches. The elastic bandage should be worn all day and all night except when bathing. A preparatory prosthesis might also be applied early in the shaping process; however, a compression bandage is generally preferred because it affords better monitoring of skin healing and points of pressure.

Residual Limb Desensitization

An equally important yet often overlooked factor is desensitization of the residual limb. It can be accomplished with gentle massage and tapping techniques (**Fig 11-2.**). Desensitization can also be accomplished by vibration, constant touch pressure, or the input of various textures applied to the sensitive areas of the limb. The patient should be

encouraged to do these techniques himself. He is aware of his tolerance and can become more "in touch" with his body by practicing this regularly. When healing has occurred, aggressive massage will prevent adhesions from occurring and provide additional sensory input. It should be explained that this will improve the patient's tolerance to the pressure that will be placed on the residual limb by the prosthetic socket.

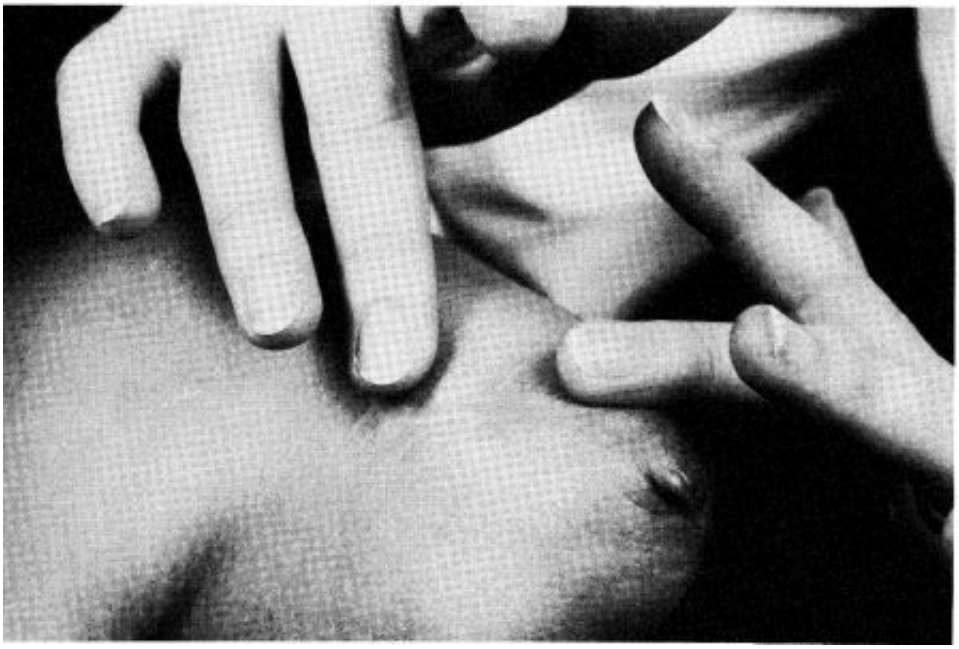

Fig 11-2. Desensitization accomplished by gentle massage and tapping.

Maintenance of Joint Range of Motion

When establishing an effective treatment program, the maintenance of joint range of motion is essential. As stated earlier, scapular, glenohumeral, elbow, and forearm range of motions are crucial to maintain in order to aid in the prosthetic control motions and to maximize the functional potential of the prosthesis.

Increasing Muscle Strength

Increasing upper-limb muscle strength can be accomplished in conjunction with the range-of-motion program. Active resistance applied by the therapist or cuff weights attached to the limb can be utilized.

Instruction in Proper Hygiene of the Limb

Education in proper hygiene and care of the residual limb is equally important at this time. The limb should be washed daily with mild soap and warm water. It should be rinsed thoroughly and patted dry with a towel. This provides additional sensory input into the residual limb as well as allows the patient to become more familiar with the changes in his body.

Maximizing Independence

Another important element in the preprosthetic phase of care is maximizing functional independence. Instruction in change of dominance and teaching one-handed activities are often indicated when working with the unilateral amputee. The bilateral acquired upper-limb amputation presents a unique challenge to the amputee team. Before receiving his prostheses, this amputee is essentially dependent in all activities of daily living, and this results in very real anxiety and frustration. It is important to express reassurance, support, and realistic optimism to these individuals during this time. Independence can be significantly enhanced by a simple device such as a universal cuff utilized with an adapted utensil, toothbrush, pen, or pencil.

Myoelectric Site Testing

If a myoelectric prosthesis is being considered, this is an appropriate time to utilize a myotester to gauge the electric potential generated by various muscles. The myotester results should be discussed with a prosthe-tist, particularly for the proximal levels of amputation. The occupational therapist, physician, and prosthetist should jointly determine the best positioning for the electrodes and discuss the issues of prosthetic socket design.

Orientation to Prosthetic Options

This is an important time to orient the amputee patient and his family to prosthetic options available to him. The unique differences between body-powered and electric components should be comprehensively described, and examples of each should be shown and demonstrated if possible. Photographs or slides may be reasonable substitutions, but being able to touch the device and understand how it operates is extremely helpful and informative for the amputee. An overview of the advantages and disadvantages of body-powered and electric components should be clearly explained.

A careful inventory of the patient's life-style, support system, educational background, and future goals should be explored and discussed. The amputee patient is an integral part of the decision-making process of this prosthetic prescription. Involving the patient in decisions that affect his own health care will help to restore a sense of control over his life.

DETERMINING THE PROSTHETIC PRESCRIPTION

The discussion of the prosthetic prescription is ideally accomplished in the presence of the patient, physician, therapist, prosthetist, family, and third-party payer. Many amputees who have sustained work-related injuries have the unique advantage of having a rehabilitation insurance nurse or case manager assigned to their care. This individual is a valuable liaison between the patient, insurance carrier, and medical providers. It is important to include these insurance representatives in the discussion of the prosthetic prescription because they have a direct influence on the financial approval of the prosthesis and the rehabilitation treatment plan.

The prosthetic prescription is based on a number of criteria that should be comprehensively addressed and recorded. These criteria frequently include the following:

1. Length of the residual limb
2. Amount of soft-tissue coverage
3. Presence of an adherent scar
4. Movement of proximal joints
5. Muscle strength in the residual limb
6. Muscle strength in the opposite limb
7. Adequate ability to learn and retain new information
8. Adequate sensation in the residual limb
9. Desire for function
10. Desire for cosmesis
11. Patient attitude and motivation
12. Vocational interests
13. Avocational interests
14. Third-party payer considerations
15. Family preferences[4]

Fabrication and Training Time

The steps involved in fabricating the prosthesis should also be explained at this time. Several steps are required from the time the prosthesis is prescribed to the time it is delivered to the patient. This process should be thoroughly explained to the patient and third-party payer, particularly if the patient lives out of town so that transportation can be arranged for prosthetic fitting and training.

This is also an appropriate time to discuss the options of outpatient vs. inpatient hospitalizations. Generally, all unilateral upper-limb amputee patients can be managed on an outpatient basis. It is strongly recommended that all bilateral upper-limb amputees be trained on an inpatient basis. The bilateral upper-limb amputee has not only issues of functional independence to address but emotional issues as well. These can be more closely monitored on an inpatient basis, with the family and patient becoming involved with the social worker or psychologist on the amputee team. Recommended and approximate training time schedules are as follows:

- Transradial, 5 hours
- Transhumeral/shoulder disarticulation, 10 hours
- Bilateral transradial, 12 hours
- Bilateral transhumeral, 20 hours

Ideally this training should be managed on a daily basis for 1 to 2 hours a day.

This is also an appropriate opportunity for the new amputee to meet others with similar levels of limb loss who have worn a prosthesis for a period of time. Common reactions, frustrations, and anxieties can be shared. Positive achievements should be stressed, however. It must be remembered that one amputee's experience does not directly parallel another's. These encounters should be followed by an opportunity for the amputee to discuss his feelings and reactions with an experienced psychosocial professional in amputee rehabilitation.

ADULT UPPER-LIMB PROSTHETIC TRAINING

Before initiating a program of upper-limb prosthetic training, one must realistically orient the patient to what the prosthesis can and cannot do. If the individual has an unrealistic expectation about the usefulness of the prosthesis as a replacement arm, he will be dissatisfied with the ultimate functioning of the prosthesis and may reject it altogether. On the other hand, if the expectations of the amputee are more realistic at the beginning of training, then the ultimate acceptance will be based upon the ability of the prosthesis to improve the individual's performance. It is imperative, then, that the therapist be honest and positive about the function of the prosthesis. If he "believes in" and understands the functional potential of the prosthesis, success can be more realistically achieved.

Initial Assessment

During the therapist's first encounter with the amputee patient in therapy, the following issues need to be discussed and documented if they have not already been accomplished.

- Etiology and onset
- Age
- Dominance
- Other medical problems
- Level of independence
- Range of motion of all joints of the residual limb
- Muscle strength of the remaining musculature
- Shape and skin integrity of the residual limb
- Status of the opposite upper limb
- Phantom pain or residual limb pain
- Previous rehabilitation experience
- Revisions
- Viable muscle sites (for myoelectric control)
- Previous information regarding prostheses
- Background education and vocational goals
- Goals and expectations regarding the prosthesis
- Home environment and family support

Although this list may appear unreasonably long and too lengthy to document, the assessment will make a significant difference in the therapist's awareness of the individual with whom he is working. The nature of patient-therapist rapport and subsequent success of therapy will be greatly enhanced if this information is gathered before therapy actually begins.

The period of time from casting until final fitting of the prosthesis is characterized by eager anticipation and hope that the artificial arm will enable the individual to function as before the amputation. Unfortunately, the finished prosthesis is often a disappointment for the patient. It is perceived as "artificial looking," heavy, uncomfortable, and awkward to operate. If the patient is appropriately oriented to the realities of the prosthesis, how it looks and operates, acceptance of the limitations of the prosthesis are more readily achieved following delivery.

Initial Visit

When the upper-limb amputee visits the occupational therapist for the first time, he will probably be carrying the prosthesis in a bag or sack. It is important to understand this awkwardness and reluctance in putting it on with others "watching." A quiet, nondistract-ing room with a mirror plus an atmosphere of acceptance and understanding is preferable.

During the first couple of visits the following goals should be addressed: orientation to prosthetic component terminology, independence in donning and doffing the prosthesis, orientation to a wearing schedule, and care of the residual limb and prosthesis.

Orientation to Prosthetic Component Terminology

In view of the fact that the prosthesis has not become the patient's "arm," it is important that the patient learn to identify the major components of the prosthesis appropriately. Any orientation to identifying such basic aspects as the figure-of-8 harness, cable, elbow unit or elbow hinge, wrist unit, terminal device, and hook or hand will suffice at this time.

Independence in Donning and Doffing the Prosthesis

It is important that independence be established early in donning and doffing the prosthesis by the "pullover sweater" method. As an alternative, the "coat" method may also be used (**Fig 11-3.**). Bilateral amputees most often use the "sweater" method.

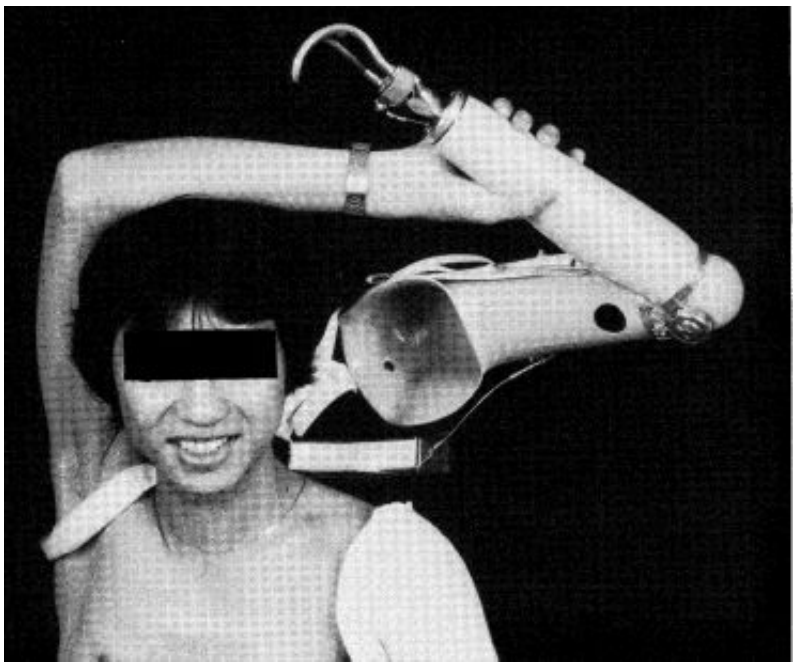

Fig 11-3. "Coat" method for donning and doffing a prosthesis.

Prosthetic Wearing Schedule

Development of a wearing schedule is an extremely important aspect of this first visit. Initial wearing periods should be no longer than 15 to 30 minutes, with frequent examination of the skin for excess pressure or poor socket fit. This is particularly important for the amputee with insensate areas and adherent scar tissue. If redness persists for more than 20 minutes after the prosthesis is removed, the patient should return to the prosthetist for socket modifications. If no skin problems are present, wearing periods may be increased in 30-minute increments three times a day. By the end of a week, the upper-limb amputee should be wearing his prosthesis all day.

Care of the Residual Limb and Prosthesis

Following amputation, the skin of the residual limb is subject to irritation and sometimes to further injury and infection.

Appropriate care of the skin is therefore a vital part of rehabilitation. The residual limb should be bathed daily, preferably in the evening. It is advisable to not wash the residual limb in the morning unless a stump sock is worn. Damp skin may swell and stick to the prosthesis and may be irritated by rubbing. The limb should be washed with mild soap and lukewarm water. It should be rinsed thoroughly with clean water. If soap is left to dry on the skin, it may be irritating. After rinsing, the skin should be dried thoroughly by using patting motions. Avoid brisk rubbing, which may irritate the skin. Lotions, creams, and moisturizers should not be applied to the limb unless specific orders are given by the physician or therapist.

The socket should be cleaned often, particularly if the individual perspires heavily. In warm weather the socket may require cleaning at least once or twice daily. The socket should be washed with warm water and mild soap. It should be thoroughly wiped out inside with a cloth dampened in clean warm water. The socket can be left to dry through the night or dried thoroughly with a towel inside if one plans to continue to wear the prosthesis immediately.

If stump socks are worn, several changes may be necessary during warm weather owing to perspiration. If possible, the sock should be washed as soon as it is taken off, before the perspiration dries on it. This will prolong the life of the stump socks. Mild soap and warm water should be used, followed by the sock being thoroughly rinsed. Allow the sock to dry slowly to avoid shrinkage.

The amputee should be encouraged to inspect his skin daily. If skin disorders develop, the physician should be called promptly. A minor disorder may become disabling if incorrect treatment is used. It will probably be necessary to adjust the prosthesis, and therefore the prosthetist is generally involved at this time as well. Strong disinfectants such as iodine should never be used on the skin of the stump.[3]

Body Control Motions

Prior to allowing the upper-limb amputee to practice prosthetic controls training, several motions need to be reviewed. This is best done before the prosthesis is actually applied.

1. *Scapular abduction.*-Spreading the shoulder blades apart in combination with humeral flexion, or alone, will provide tension on the figure-of-8 harness in order to open the terminal device.
2. *Chest expansion.*-This motion should be practiced by deeply inhaling, expanding the chest as much as possible, and then relaxing slowly. Chest expansion may be utilized in a variety of ways for the transhum-eral, shoulder disarticulation, or forequarter amputee. Harnessing this motion with a cross-chest strap is determined by the prosthetic design; in some instances of extensive axillary scarring, it may be preferred to the figure-of-8 harness.
3. *Shoulder depression, extension, and abduction.*- This is the combined movement necessary to operate the body-powered, internal-locking elbow of the trans-humeral prosthesis. It is advisable to have the amputee practice this motion by cupping one's hand under the residual limb and instructing the patient to press down into the palm. This will simulate the motion required to lock and unlock the elbow in the individual with transhum-eral amputation.
4. *Humeral flexion.*-The amputee is instructed to raise his residual limb forward to shoulder level and to push his arm forward while sliding the shoulder blades apart as far as possible. This motion applies pressure on the cable and allows the terminal device to open. Scapular abduction and humeral flexion are the basic motions to review with the transradial amputee.
5. *Elbow flexion/extension.*-It is critical to instruct the transradial amputee to maintain full elbow range of motion. This range will enable him to reach many areas of his body without undue strain or special modifications to the prosthesis.
6. *Forearm pronation/supination.*-In the long transradial amputee, it is equally important to maintain as much forearm pronation and supination as possible. This will enable the amputee to position the terminal device where he chooses without manually preposition-ing the wrist unit. If the amputee has retained more than 50% of his forearm, some degree of forearm pronation and supination is maintained.

Prosthetic Evaluation

Before beginning functional training, it is important to ensure that the prosthesis fits comfortably and that the components function in a satisfactory manner. Ideally this is accomplished with the occupational therapist and prosthetist together. A formal prosthetic checkout form for this purpose is available from Northwestern University.

The therapist is encouraged to communicate openly with the prosthetist on a frequent basis not only initially but whenever concerns regarding fit or operation arise.

Prosthetic Controls Training

Manual controls are important to review after the prosthesis is applied. One control should be taught at a time and then combined with others:

1. Positioning the terminal device in the wrist unit is accomplished by manual rotation with the sound hand. In the bilateral upper-limb amputee, a force against an object in the environment or between the individual's knees is necessary to accomplish this positioning.
2. Rotation at the elbow turntable is manually adjusted or controlled by leaning the prosthesis against an object.
3. The friction shoulder joint is manually adjusted with the sound hand or by applying pressure against an object or the arm of a chair.
4. If the prosthesis has a wrist flexion unit, this can be manually controlled by applying pressure on the button or, for the bilateral amputee, by applying pressure against a stationary object.

Active controls are equally important to review prior to functional training. The upper-limb amputee incorporates the body-control motions he learned previously while wearing the prosthesis. It is essential that the harness be adjusted properly before initiating these exercises:

1. In all proximal levels of upper-limb loss, body-powered elbow flexion is facilitated by a forearm lift assist that *counterbalances the weight of the forearm.* Elbow extension is accomplished by gravity if the elbow unit is unlocked.
2. Elbow lock/unlock is perhaps one of the most difficult tasks to learn in the operation of a transhumeral prosthesis. The pattern of "down, back, and out" is often stated to the amputee in an effort for him to repeat the shoulder depression, extension, and abduction pattern. This pattern not only locks but unlocks the elbow in an audible "two-click cycle." Practicing this task should occur in a quiet, nondistracting room where one can hear the clicks without difficulty. This pattern may need to be exaggerated at first, but soon it will be barely observable.
3. Before approaching terminal device operations, it is important for the amputee to practice locking and unlocking the elbow in several positions.
4. In the shoulder disarticulation and forequarter amputee, the mechanism to lock and unlock the elbow is often a nudge control "button" attached to the thoracic shell. By depressing this button with the chin, one is able to position and lock the elbow where desired.
5. It is important to clearly explain that the elbow must be locked first, in the proper position, before one is able to operate the terminal device. As described previously, biscapular abduction and/or humeral flexion causes the conventional terminal device to open, while relaxing allows it to close (**Fig 11-4.**).

Controls Practice

A form board is frequently utilized to perfect prepo-sitioning as well as tension control of the terminal device (**Fig 11-5.**). Prepositioning involves both manual and active controls to place the prosthesis in the most optimal position for a specific activity. Close attention must be paid to the individual's awkward or compensatory body motions when he approaches an object. Often the amputee will "adjust" his body rather than repositioning the elbow and wrist unit positions. A mirror can be effective in assisting the amputee to see the way his body is positioned. It is helpful to instruct the patient to "think" how his own arm would have been positioned to approach the object. It is often necessary to remind him to maintain an upright posture and to avoid extraneous body movements.

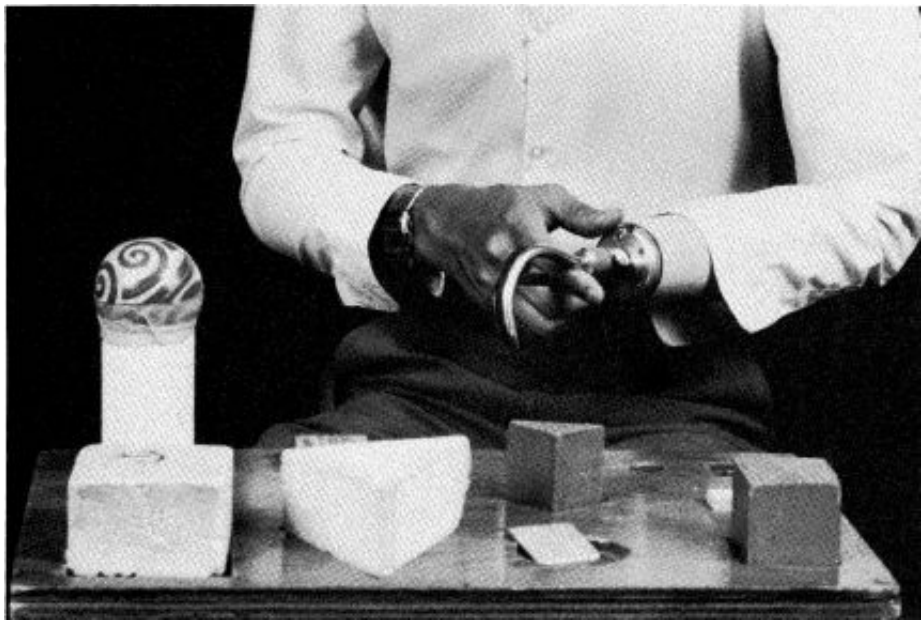

Fig 11-5. Form board with various-shaped items.

The five motion elements that are primarily used in hand manipulation are reach, grasp, move, position, and release. A form board can be used in training to orient the individual to approach, grasp, and release objects differing in shape, weight, density, and size. Prehension control can be practiced with a sponge or paper cup. The amputee is instructed to maintain constant tension of the terminal device control cable so as not to crush the object being held. Approach to an object should be such that the stationary hook finger makes contact with the object and the movable finger actually "grasps" it. Flat objects can be moved to the edge of the table and then grasped with the terminal device in a horizontal position. Prehension force is generally controlled by rubber bands, which can be added as tolerated. Springs may be used as an alternative.

Controls training for the bilateral upper-limb amputee is an aspect of therapy that may require a period of time to perfect. To learn to separate the controls motion of two prostheses is a complex and coordinated motor process that may need to be practiced frequently. Passing an object back and forth, such as a rule, may help in reinforcing this pattern.

Functional Use Training

Functional use training is the most difficult and prolonged stage of the prosthetic training process. The individua'ls acceptance and usage of the prosthesis is dependent upon (1) the motivation of the patient, (2) the comprehensiveness and quality of the tasks and activities practiced, and (3), of critical importance, the experience and enthusiasm of the occupational therapist. The training experience is most effective if the same therapist remains with the patient throughout the entire process.

It is extremely important to reinforce to the unilateral amputee that his prosthesis will play a nondomi-nant functional role. The prosthetic terminal device is most useful for gross prehension activities and to hold and stabilize objects, while the sound limb performs fine motor prehension activities. It is unreasonable to expect the prosthesis to assume any more than 30% of the total function of the task in unilateral upper-limb activities. The sound hand will always be dominant for all activities performed. The therapist must be realistic and convince the patient to view the prosthesis as a "helper."

Unilateral patterns of independence occur quickly in the amputee who has lost an arm or hand. It is therefore essential, if possible, to fit the unilateral amputee within 1 to 2 months of the amputation. These individuals definitely show a greater propensity for wearing and successfully using their prostheses. This applies to all amputees fitted with body-powered or electric components.[1]

It is appropriate to practice activities of daily living that are useful and purposeful. Realistic situations should be pursued so that the individual will automatically use the prosthesis when he encounters the same activity in his daily routine. Examples include the following:

1. Cutting food
2. Using scissors
3. Dressing
4. Opening a jar or bottle
5. Washing dishes
6. Hammering a nail and using tools
7. Driving a car

The importance of prepositioning, prior to approaching these tasks, cannot be overemphasized. The amputee should be instructed to orient the components of the prosthesis in space to a position that resembles that of a normal limb engaged in the same task. As a rule, most difficulties in use are a result of improper positioning.

A valuable and comprehensive guide in orienting the therapist to the specifics of training the amputee is the *Manual of Upper Extremity Prosthetics,* ed. 2, 1958 (Santschi W, Winston M, eds.). This is a publication of the Engineering Artificial Limbs Research Project at the University of California at Los Angeles.

Cutting Food

It is easiest to cut food by holding the fork in the hook, with the hook fingers grasping the flat surface of the fork handle and the upper handle of the fork resting on the dorsal surface of the thumb of the hook. The knife is held by the sound hand.

Using Scissors

When using scissors, the material to be cut should be placed in the terminal device. The scissors are held by the sound hand. To avoid "flopping," the area to be cut should be as close to the area grasped as possible. The material should be repositioned as cutting angles are changed (**Fig 11-6.**).

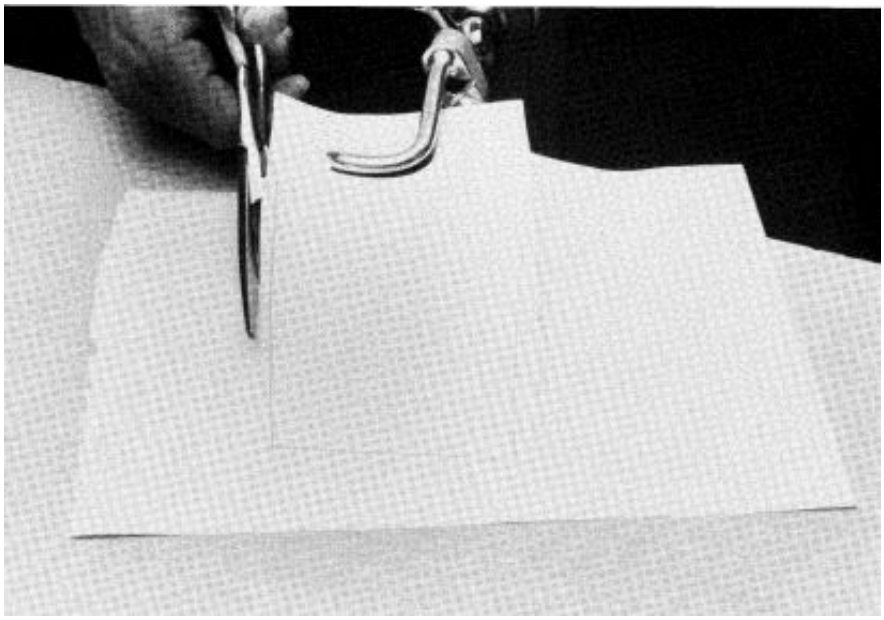

Fig 11-6. Scissor-cutting method.

Dressing

Dressing activities such as fastening trousers are accomplished by the terminal device holding the waistband or belt loop while the sound hand tucks in the shirt and fastens the waist hook, snap, or button. The terminal device can "pinch" the fabric at the bottom of the zipper to facilitate zipping with the sound hand. A buttonhook may be used to assist in buttoning cuffs on the sound side (**Fig 11-7.**). With the proper preposi-tioning, the cuff can be buttoned rapidly and reliably. Buttonhooks are particularly helpful for the transhum-eral and shoulder disarticulation amputee.

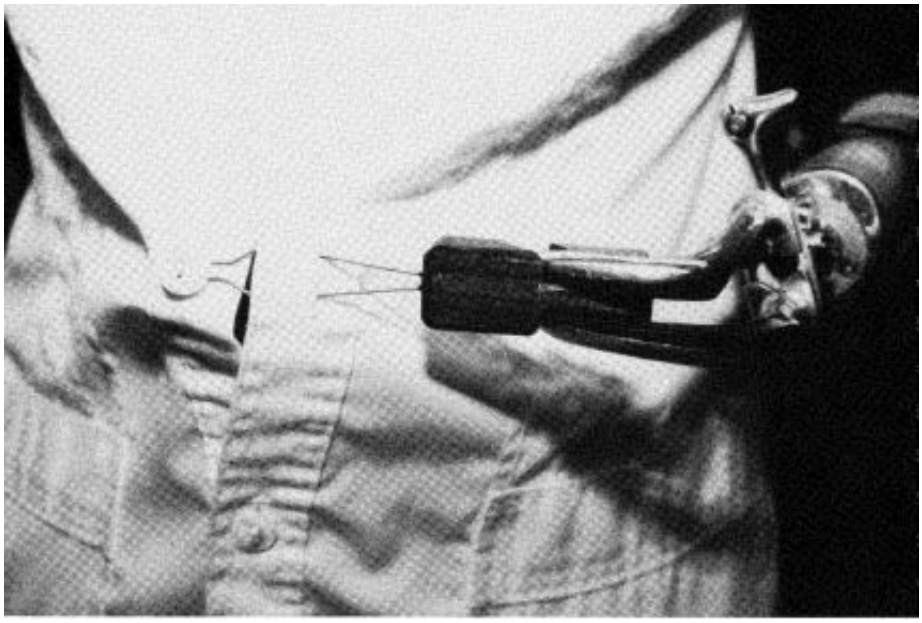

Fig 11-7. Buttonhook.

Opening a Jar or Bottle

When opening a jar or bottle, the middle of the container is grasped by the terminal device, and the sound hand unscrews the lid. All tension should be removed from the cable to ensure maximum grasp on the container.

Washing Dishes

To achieve the greatest security of grasp while washing dishes, the dish should be held in the sound hand. Depending on the individuals preference, a dishcloth or sponge is held and manipulated by the terminal device. Submerging the hook in water should be avoided because detergents dissolve the lubricating oils in the hook and wrist units. Periodic cleaning and oiling of the stud threads and bearings may be necessary for the amputee who engages in frequent dishwashing activities. When drying dishes, the sound hand holds the dish while the terminal device grasps the towel.

Hammering a Nail and Using Tools

Hammering nails is accomplished by holding the nail in the hook fingers, rubber band guard, or special attachment of the no. 3 or no. 7 Hosmer-Dorrance work hook. The hook should be pronated to 90 degrees so that the nail is perpendicular to the wood. When correctly positioned, the tip of the nail should just contact the wood.

As demonstrated (**Fig 11-8.**), the head of a large bolt may be secured in the hook terminal device while the wrench is held in the sound hand to tighten or loosen the bolt. Again, the amputee may need to be reminded that the prosthesis and terminal device are merely "functional assists" to aid in stabilization. The sound limb always becomes the dominant and active limb (**Fig 11-9.**).

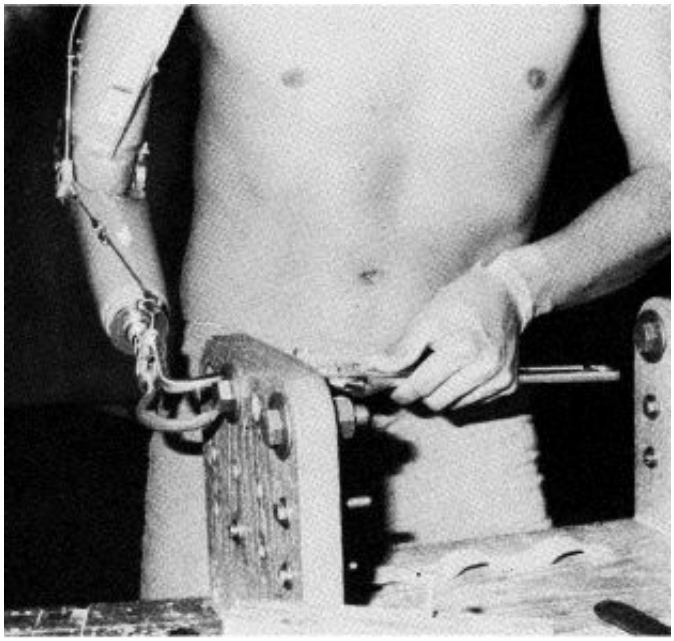

Fig 11-8. Securing the head of a screw while loosening a bolt with a wrench.

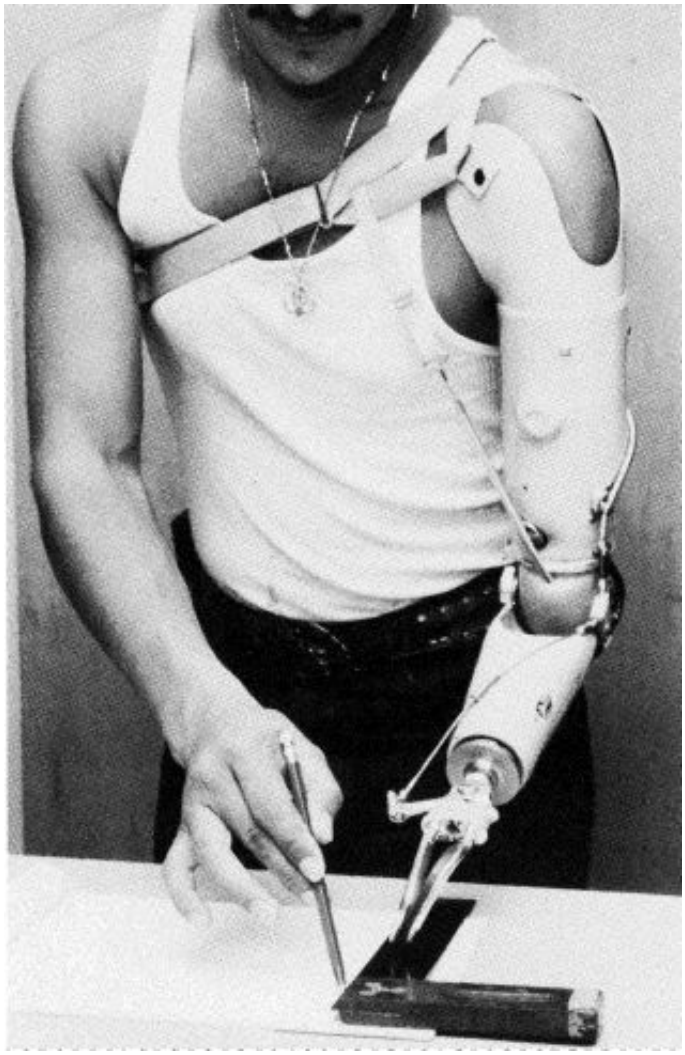

Fig 11-9. Terminal device as a "functional assist."

An alternative design in terminal devices is illustrated by the voluntary-closing Grip II (**Fig 11-10.**). This device is specifically designed by Therapeutic Recreation Systems, Inc. (TRS, 2860 Pennsylvania Ave, Boulder, CO 80803), to hold and manipulate objects by using body power to close rather than to open the hook.

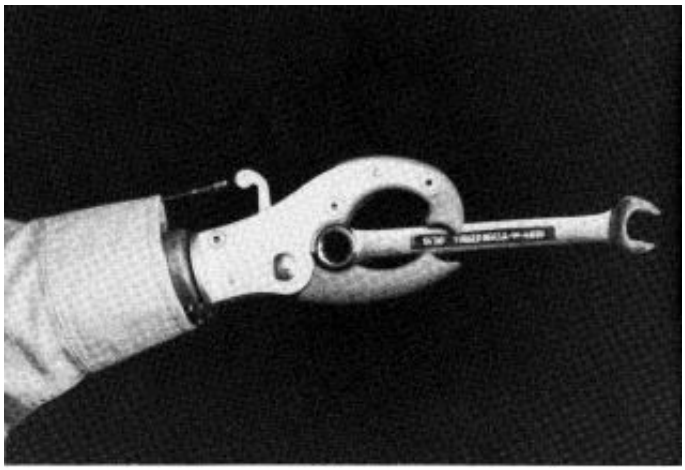

Fig 11-10. TRS Grip II terminal device.

Driving a Car

Driving a car is an important goal for the individual who has lost an arm. The actual turning of the steering wheel should be done by the sound limb. If the prosthesis has sufficient function, performance can be improved by using the prosthesis to assist the sound arm. A driving ring is available from most prosthetic suppliers. The fingers of the hook are secure in the ring for turning but can easily slip out in emergencies.

A list of activities and a rating guide designed by Northwestern University are helpful adjuncts to the therapy plan in determining which activities are important for the unilateral amputee to accomplish (**Fig 11-11.**).

Single Upper-Limb Amputation—Activities of Daily Living

Name	Age	Sex	Occupation
Type of Amputation	Type of Terminal Device		
Therapist	Date(s) of Test		

RATING GUIDE

0. Impossible
1. Accomplished with much strain or many awkward motions
2. Somewhat labored or few awkward motions
3. Smooth, minimal amount of delays and awkward motions

PERSONAL NEEDS:	0	1	2	3
Put on shirt				
Fasten buttons, cuff and front				
Put on belt				
Put on glove				
Put on coat				
Lace and tie shoes				
Tie a tie				
File fingernails				
Polish fingernails				
Set hair				
Clean glasses				
Squeeze toothpaste				
Put on bra and fasten				
Use zipper				
Hook garters				
Take bill from wallet				
Light a match				
Open pack of cigaretts				
EATING PROCEDURES:				
Carry a tray				
Butter bread				
Cut meat				
DESK PROCEDURES:				
Use dial telephone				
Use phone and take notes				
Use pay phone				
Sharpen pencil				
Use ruler				
Use scissors				
Remove & replace ink cap				
Fill fountain pen				
Fold and seal letter				
Use card file				
Use paper clip				
Use stapler				
Wrap a package				
Type				
Write				
COMMENTS:				

GENERAL PROCEDURES:	0	1	2	3
Use key in lock				
Open and close window				
Play cards and shuffle				
Wind a clock				
Assemble wall plug				
HOUSEKEEPING PROCEDURES:				
Wash dishes				
Dry dishes				
Polish silverware				
Peel vegetable				
Cut vegetable				
Open a can				
Manipulate hot pots				
Sweeping				
Use dust pan				
Use vacuum cleaner				
Use wet mop				
Use dry mop				
Set up ironing board				
Iron				
Wash and wring out laundry				
Hang up and take down laundry				
Thread needle				
Sew on button				
USE OF TOOLS:				
Layout				
Saw				
Plane				
Sand				
Drive screws				
Hammer				
File				
Drill				
Power tools				
Gravel pit				
CAR PROCEDURES:				
Drive				
Change tire				
Use jack				

Fig 11-11. Performance rating of daily living activities for the unilateral upper-limb amputee.

Vocational Activities

Discussing vocational needs and expectations with the amputee is very important. Unfortunately, this is an area that is often overlooked or given only brief attention during the rehabilitation process. This discussion should occur later in the training continuum when the individual begins to acknowledge and accept his disability. Although not everyone can return to the exact job held prior to the injury, a review of job responsibilities and expectations can be explored with the therapist. It may be possible to break down the tasks of a job into a step-by-step process that can be practiced and reinforced in therapy. An example of how effective prosthetic hooks can be for drafting is illustrated in **Fig 11-12.**. If the therapist can do an on-the-job site evaluation, it would be a valuable addition to the amputee's comprehensive

rehabilitation.

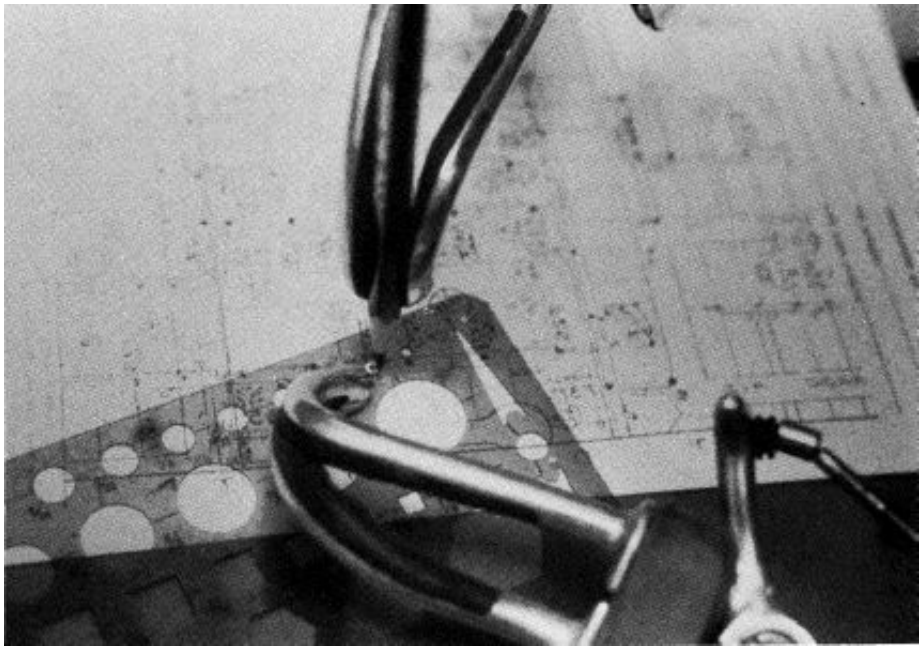

Fig 11-12. Fine motor ability with hooks.

Home Instructions

At the conclusion of training, a home program of wearing, functional use, and care instructions should be reviewed with the amputee and his family. Specific instructions regarding which team member to contact when a problem arises should also be provided. A follow-up appointment should be arranged, and an explanation of what to expect during this visit is helpful in making the transition from the rehabilitation center to the home environment.

Care and Maintenance of the Prosthesis

The following points are important to review with the amputee who has been fitted with a body-powered upper-limb prosthesis. Several of these have been noted in the guide "Helpful Hints for the Upper Extremity Amputee" from the Occupational Therapy Department at the University of Florida.

1. The harness should be washed when soiled because perspiration stains permanently mark the straps. A household cleaner with ammonia works well.
2. Do not iron the Velcro closures on straps.
3. The elbow lock should be cleaned frequently and kept free from abrasive materials.
4. The cable should be examined frequently for cut or worn areas.
5. The neoprene lining of the hook may need to be periodically relined for a firmer grip. The neoprene is resistant to gasoline, oil, and other petroleum products. It should, however, be protected from hot objects.
6. When a rubber band wears out from use, grease, or injury, cut it off with scissors, and replace it with a new band. Rubber band applicators are obtained from the prosthetist. Each rubber band is equivalent to approximately 1 lb of pinch force.
7. Take the prosthesis to the prosthetist as soon as damage occurs.
8. Never use the terminal device as a hammer, wedge, or lever.
9. The prosthesis should be hung up by the harness rather than by the cable or cable strap.
10. Detergents should be avoided since they tend to dissolve the lubricating oils in the hook and wrist unit mechanism. When an amputee washes dishes frequently, the stud threads and bearings of the hook should be cleaned and oiled regularly.
11. Never reach for a moving object with the hook.
12. The cosmetic glove of a mechanical or myoelectric hand is easily stained. The following substances cannot be removed unless *immediately* washed with water or alcohol: ball point ink, shoe polish, egg yolk, carbon paper, colored lacquers, brightly dyed fabric, fresh newsprint, tobacco tar, mustard/ketchup, and lipstick.

Follow-Up Issues

Following discharge from the therapy program, the amputee is regularly monitored and reviewed in an outpatient clinic by the rehabilitation team. This is an appropriate time to discuss the amputee's present status and successes as well as problems that may have been encountered. The services of the prosthetist are available for consultation as well as for any repairs and modifications to the prosthesis that may be required. This is a crucial time for the upper-limb amputee, and patterns of prosthetic use and emotional well-being must be carefully re-evaluated at each visit. In an attempt to define prosthetic function in a quantitative manner, the author has designed the following use rating scale.

- 100%-Wearing all day, using well in bilateral tasks, incorporating well in the body scheme.
- 75%-Wearing all day, using in grossand fine-motor tasks.
- 50%-Wearing all day (primarily for cosmetic reasons), incorporating in gross activities (used as a leaning surface, i.e., desk/paper tasks).
- 0%-Not wearing or using the prosthesis. This individual is choosing to be essentially unilaterally independent.

Wearing patterns have been quantified as follows:

- Full-12 hours or more per day
- Moderate-6 to 12 hours per day
- Minimal-0 to 6 hours per day
- None-0 hours per day.

In addition to quantifying prosthetic function and wearing patterns, the following goals are equally important to address during the follow-up visit.[6]

1. Maximize prosthetic function.
2. Maintain prosthetic components.
3. Decrease assistive devices.
4. Resume previous vocation or explore new vocational options.
5. Resume avocational interests.
6. Re-enter the family and community environment.
7. Maintain a regular periodic follow-up with rehabilitation professionals.

The first follow-up visit is scheduled approximately 4 weeks after discharge from training. Follow-up visits are then scheduled at wider intervals, e.g., 3 months, 6 months, and eventually an annual visit. For the more complex amputee with specific skin, bone, or pain problems, more frequent return visits may be necessary.

CONCLUSION

The complete rehabilitation process for an amputee is, indeed, a long one. Early fitting is crucial to encourage successful functional outcomes for all upper-limb amputees. Rehabilitation should not be considered complete until a stable, independent life-style has been achieved and the individual's social and occupational niches have been re-established.[2]

The amputee's potential is limitless. It is not solely dependent upon the quality of the prosthesis, of medical care, or of therapy. All these areas ideally work in close harmony with one another. Motivation and the desire of the patient to be independent are perhaps the most important ingredients to cultivate and reinforce. It is the responsibility of all rehabilitation professionals involved to create a conducive environment that will not only encourage this process to occur but enhance it as well.

Acknowledgment

The majority of this text, as well as additional information, is published in two chapters entitled "Postoperative and Preprosthetic Therapy Programs" and "Adult Upper Limb Prosthetic Training" in the following: Atkins DJ, Meier RH: *Comprehensive Management of the Upper Limb Amputee.* New York, Springer Publishing Co Inc, 1989.

BIBLIOGRAPHY

Northwestern University Medical School: *Lower and Upper Limb Prosthetics for Physicians, Surgeons and Therapists-*

Controls Training. Evanston, Ill, Prosthetic-Orthotic Center, pp 233A-238C, 1986.

Occupational Therapy Department: *Helpful Hints for the Upper Extremity Amputee.* Gainesville, J Hillis Miller Health Center, University of Florida, 1979.

Santschi W (ed): *Manual of Upper Extremity Prosthetics.* Los Angeles, University of California, 1958, pp 241-265.

Therapeutic Recreation Systems Inc: *TRS Product Catalogue.* Boulder, Colorado, 1991.

Veterans Administration: A *Guide for the Arm Amputee.* Washington, DC, Veterans Administration, 1952.

Wilke HH: *Using Everything You've Got!* Chicago, The National Easter Seal Society, 1984.

Fig 11-4. Terminal device operation.

References:

1. Atkins D: The upper extremity prosthetic prescription: Conventional or electric components. *Phys Disabil Spec Inter OT Newslet* 1987; 10:2.
2. Burrough B, Brook J: Patterns of acceptance and rejection of upper limb prosthesis. *Orthot Prosthet* 1985; 39:40-47.
3. Levy W, Barnes G: *Hygienic Problems of the Amputee.* Washington, DC, American Orthotics and Prosthetics Association, 1961, p 9.
4. Meier R: Amputations and prosthetic fitting, in Fisher S (ed): *Comprehensive Rehabilitation of Burns.* Baltimore, Williams & Wilkins, 1984, pp 267-310.
5. Meier R: Amputations and prosthetic fitting, in Fisher S (ed): *Comprehensive Rehabilitation of Burns.* Baltimore, Williams & Wilkins, 1984, p 280.
6. Meier R: Amputations and prosthetic fitting, in Fisher S (ed): Comprehensive Rehabilitation of Burns. Baltimore, Williams & Wilkins, 1984, pp 303-304.
7. Millstein S, Heger H, Hunter A: Prosthetic use in adult upper limb amputees: A comparison of the body powered and electrically powered prosthesis. *Prosthet Orthot Int* 1986; 10:27-34.
8. Plainshed L, Friz B: The nurse on the amputee clinic team. *Nurs Outlook* 1968; 16:33-36.