Pronator Assist[1]

by Edward C. Grahn

Director, Prosthetic Research and Evaluation
Northwestern University Prosthetic-Orthotic Center
Chicago, Illinois 60611

Robert Keagy, M.D.

737 North Michigan Avenue
Chicago, Illinois 60611

Diane C. Levy, O.T.R.

Senior Occupational Therapist
Rehabilitation Institute of Chicago
Chicago, Illinois 60611

Introduction

The quadriplegic patient frequently has active supination due to retained control of the biceps brachii, the supinator, and sometimes the brachioradialis muscles. The biceps and the brachioradialis exert their supinator effect along with an elbow flexion component (Fig. 1).

Since table-top work surface activities require placement of the pronated hand away from the body, this unopposed supination and elbow flexion restricts hand use. Degrees of contracture easily occur in the flexed and supinated position.

In the sitting position gravity

FIGURE 1—The quadriplegic patient showing the unopposed supination and elbow flexion which restricts hand use.

[1] Based on work performed under V.A. contract V101 (134) P-5.

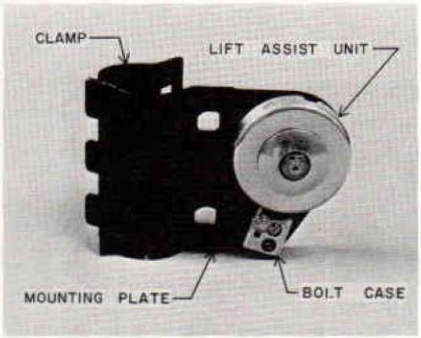

FIGURE 2—Partially assembled Pronator Assist showing the clamp, mounting plate, Lift Assist Unit, and bolt case.

may be a sufficient elbow extensor. Gravity will not pronate the hand, although a pronating effect can be produced by shoulder abduction.

The Pronator Assist presented permits orthotic pronation to be supplied without encumbering the hand with a significant weight increase, additional harnessing, or interference with elbow extension. One end of a cable can be attached to a wrist cuff or the forearm component of a grasp-release orthosis, while the other end of the cable can be attached to the wheelchair. The entire device is easily understood and appreciated by the patient and his attendants. It is applied as easily as the hand splint. Its torsion adjustment are simple: the hand knob is simply turned until the forearm pronates.

Enough rotary force can be exerted to correct mild supination contractures, and the continuous torsion will gradually release more severe contractures. It may be necessary to modify the cuff or forearm component of the device to provide a broad surface on the dorsum of the radius and a broad surface on the volar aspect of the forearm to permit the application of the force couple exerted by the torsionally loaded cable.

Patients can be fitted bilaterally. This device is sufficiently simple and well tolerated so that it does not threaten the patient's "gadget tolerance." It does not interfere with clothing, since it leaves the arm and elbow entirely free of encumbrance.

Design

The device is designed to keep the fabrication of parts to a minimum. Most of the parts are available from either a supplier of prosthetic components or a hardware store.

The torque required to pronate the wrist is supplied by the energy stored in both the Forearm Lift Assist Unit* (Fig. 2) and the steel

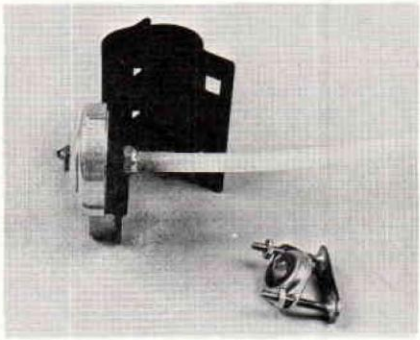

FIGURE 3—Completed Pronator Assist showing the addition of the polyethylene tubing and music wire. In the foreground is the base plate and its mounting plate for the distal attachment of the tubing and music wire as shown in Fig. 5.

music wire inside the polyethylene tubing (Fig. 3). This torque is easily adjusted to meet the individual patient's needs. The unit is

* A. J. Hosmer Corporation, Campbell, California.

attached to the wheelchair frame with a simple clamp (Fig. 2). The plate to which the Forearm Lift Assist Unit is attached can be either brazed to this clamp (as shown in Fig. 2) or held there with the screws used to clamp the unit to the wheelchair. The mounting plate is shown in detail in Fig. 4. The material can be 3/64-inch to 1/16-inch thick steel or 3/32-inch to 1/8-inch thick aluminum alloy.

The Forearm Lift Assist Unit is not modified in any way. A left Lift Assist Unit is used on the right side and a right Lift Assist Unit is used on the left side. This unit is attached to the mounting plate with a #10 hexagon-head screw at least 1¼-inch long. The screw is drilled in two places with a #55 (.052-inch) drill to accept the proximal end of the music wire. One hole is drilled through the center of the screw and the other just through the head as shown in Fig. 2. The music-wire size can vary from 15 gage (.035-inch diameter) up to 23 gage (.051-inch diameter), depending upon the requirements of the patient. The small diameters allow the greatest flexibility for hand placement; the

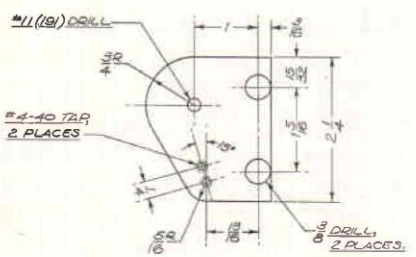

FIGURE 4—Drawing of the mounting plate for the Lift Assist Unit and bolt case. It can be used for either the left or right side.

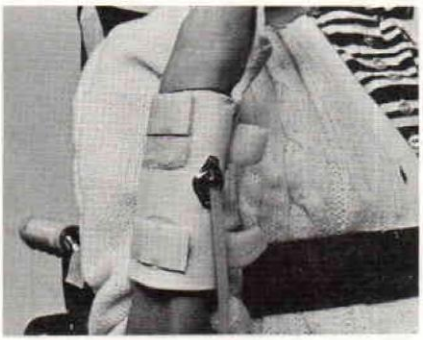

FIGURE 5—Distal attachment of the polyethylene tubing and music wire.

large diameters are less flexible, but allow a greater torque to be applied to the wrist. The plastic tubing is high-density polyethylene, ¼-inch outside diameter by .062-inch wall thickness, tapped on one end for the #10 screw. This plastic tubing adds additional stiffness to prevent the music wire from "coiling," however it does not contribute nor interfere with the torsional load. The distal end of the music wire is attached to the hand orthosis or wrist cuff, using a standard prosthetic housing retainer and base plate. To attach the base plate, braze two #4-40 flat-head screws to a thin strip of steel (Fig. 3) and insert through the wrist cuff and base plate. The most distal screw is used to anchor the music wire as shown in Fig. 5.

Assembly

Determine the length of polyethylene tubing required by having the patient extend his arm actively as far forward and to the contralateral side as possible. Measure the distance between the wrist and the wheelchair frame where the unit will be attached. Do not

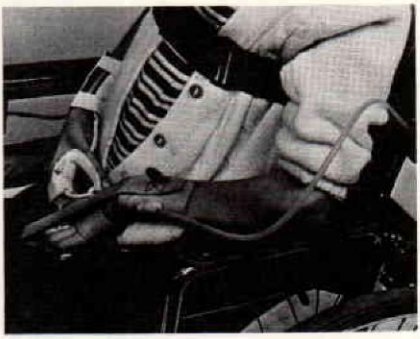

FIGURE 6—The finished device installed on the wheelchair and orthosis, and adjusted to obtain maximum pronation.

measure in a straight line, but rather measure the curved path that the tubing would follow and cut the tubing to length. Cut the music wire approximately five inches longer. Insert the music wire through the center hole in the screw, bend back one inch from the end, insert into the other hole in the screw head, wrap the wire one turn counterclockwise (viewed from head end) around the screw body, and cut off the excess. Fig. 3 shows how the music wire looks after it is fastened to the screw. Insert the music wire and screw through the Forearm Lift Assist Unit and secure firmly with a nut. Insert this in turn through the plate and secure it **loosely** with a lock nut; it must be free to rotate. Slip the polyethylene tubing over the wire and thread onto the screw. Push a one-inch length of Standard Cable Housing* halfway into the other end of the tubing. Attach the bolt case of the Forearm Lift Assist Unit to the plate (Fig. 2). Attach the base plate to the wrist cuff or forearm component of the orthosis and cut off the proximal screw flush with the nut. Thread the housing retainer on the housing and insert into the base plate. Wrap the music wire around the distal screw clockwise two turns, cut off excess, and secure with a nut (Fig. 5). Cut off the excess screw and cover the wrist attachment with leather or some other appropriate material as shown in Fig. 6.

* A. J. Hosmer Corporation, Campbell, California.

Clinical Evaluation

Miss G. is a sixteen-year-old female with an incomplete cervical 5-6 quadriplegia as a result of a diving accident in September 1969. The patient spent eight months in two hospitals for acute care and progressive rehabilitation before being admitted to the Rehabilitation Institute of Chicago in May 1970.

At the time of admission Miss G. displayed poor hand placement abilities bilaterally due to muscle weakness, tightness, and contractures. Bilaterally, the patient had tight and weak (grade three-plus) scapulo-humeral musculature, grade four elbow flexors which were also tight, and forearm supination contractures. The left upper extremity had grade three-plus radial wrist extensors. The right upper extremity, which was previously the patient's dominant extremity, had grade three radial wrist extensors. She had no active finger or thumb motion bilaterally and was unable to perform any prehension activities. Prior to admission to the Rehabilitation Institute of Chicago, Miss G. had been taught to brush her teeth and sign her name using

a utensil holder. This device had to be put on her right upper extremity which was maintained in supination due to muscle contracture.

The patient was referred to Occupational Therapy where she was placed on a program of graded activities to improve joint range-of-motion, muscle strength and endurance, hand placement, and self-care abilities. Prehension activities with any orthoses were impossible for Miss G. due to supination contractures and lack of prehension musculature.

In cooperation with the Northwestern University Prosthetic Research and Evaluation Center, Miss G. was fitted bilaterally with Pronator Assists to position both forearms in pronation. The left Pronator Assist was attached to the wrist cuff of a temporary Rehabilitation Institute of Chicago tenodesis orthosis of Orthoplast,* which had been fabricated by the occupational therapist. This orthosis provided a three-point prehension for grasp and release activities. Following training in the use of the temporary orthosis with attached Pronator Assist, the patient was able to pick up utensils and a glass to feed herself, pick up a telephone receiver, and perform prehension activities such as table games. As Miss G. became more proficient in performing these activities, the temporary tenodesis orthosis was discarded and the Pronator Assist was attached to the wrist cuff of a laminated plastic Rehabilitation Institute of Chicago tenodesis orthosis (Fig. 6) (1).

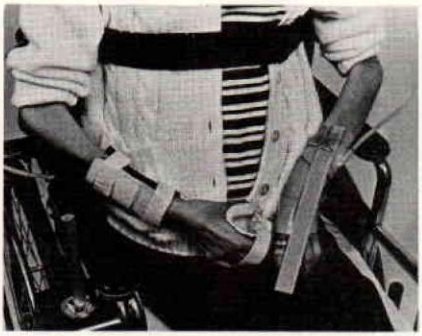

FIGURE 7—Anterior view of the patient in Fig. 6.

A temporary right volar Orthoplast static orthosis was also fabricated by the occupational therapist. This orthosis maintained the patient's hand in a functional position. It also supported the patient's wrist in 30° extension, maintained a satisfactory thumb-web space, provided an attachment for utensils, and incorporated a wrist cuff to which the Pronator Assist was attached (Fig. 7). Miss G. used this orthosis to write, to dial a telephone, and to operate her electric wheelchair. The patient could also type on an electric typewriter using both upper extremities with wooden dowels and operate a cassette tape recorder that was modified with extension levers (2). The only activities for which Miss G. did not need the Pronator Assists and orthoses were washing her face and hands and brushing her teeth. For the latter activity the patient used a toothbrush inserted into a leather utensil cuff which she could put on herself.

The Pronator Assist allowed the patient's forearms to move through

* Registered Trademark of Johnson and Johnson, New Brunswick, New Jersey.

maximum passive joint range-of-motion at the elbow and maintained the increased passive joint range-of-tion that was gained through passive stretching by the physical therapist. Following are the passive joint range-of-motion measurements taken at the time of admission to and discharge from the Rehabilitation Institute of Chicago:

	5-22-1970	10-13-1970
Passive Forearm Pronation	Right 0-55° Left 0-52°	Right 0-60° Left 0-70°
Passive Elbow Flexion	Right 30°-163° Left 26°-168°	Right 18°-168° Left 15°-165°

Some additional pronation was gained when Miss G. performed humeral abduction. While wearing the bilateral orthoses and attached Pronator Assists, the patient was able to actively supinate when it was necessary.

During the course of therapy Miss G. improved in muscle strength, endurance, and passive joint range-of-motion. After training with the orthoses with bilateral Pronator Assists, the patient displayed adequate hand placement to perform many activities. At the time of discharge from the Rehabilitation Institute of Chicago Miss G. was able to feed herself with standard eating utensils and a glass, pick up a telephone receiver and dial the phone, operate an electric typewriter and adapted tape recorder with dowels, operate an electric wheelchair which had adapted controls, write with fair legibility, and participate in table games. Miss G. wore the right orthosis and Pronator Assist throughout the day. The left orthosis and Pronator Assist were worn during meals and table-top activities. As the patient herself was unable to put on the orthoses with cables attached, family members were instructed in applying the orthoses to the patient and setting the two springs of the Pronator Assists to attain maximum forearm pronation.

In summary, the Pronator Assist:

1. Maintained optimal joint range-of-motion that had been gained through therapy.
2. Improved hand placement.
3. Permitted the use of a Rehabilitation Institute of Chicago tenodesis orthosis, which enabled the patient to perform prehension activities with the left upper extremity.
4. Allowed use of a static orthosis for the right upper extremity, which enabled the patient to write and operate adapted equipment.

References

1. Sabine, C. L., Addison, R. G., Fischer, H. K. J.: A Plastic Tenodesis Splint. *Orthopedic and Prosthetic* Appliance Journal, 19:137-141, June, 1965.
2. Grahn, E. C.: Tape Recorder Modifications for Use by Quadriplegics. *The American Journal of Occupational Therapy*, XXXIV: 360-361, July-August, 1970.