A Case Study: Use of a Terminal Device to Augment a Paralyzed Hand

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ABSTRACT

A split-hook terminal device was used to allow writing skills for a C-6 level quadriplegic. In this case, the subject has his right upper limb, but could not use his natural hand for printing. Any use of the hand, even with the aid of a support device, would cause spasms of the hand, which would not allow him to write. The voluntary opening style hook is attached to an arm support, parallel to the right arm, with the hook being placed next to the palmar side of the hand. A prehensile support for holding is in the hook, and not in the spastic hand. The orthosis is cable driven, and utilizes all traditional hardware except for the arm socket, which is replaced with a pivoting arm support. The pivoting arm support will allow the hook to turn out of the way when the subject desires to operate his wheelchair with his natural hand.

INTRODUCTION

The subject of this project is a 40-year old male who is classified as a partial quadriplegic. In 1965, the subject suffered through an automobile accident that crushed the sixth cervical vertebrae and caused his quadriplegic condition. Presently, he is an undergraduate student at Auburn University at Montgomery, Alabama, and the skill of independent writing, especially class notes and examinations, would greatly facilitate learning. Prior to the orthosis, the subject would attempt to print through the use of a pencil support device attached to his hand, but printing in this manner elicited spasms in the hand. After three to five minutes of writing, his right hand would become fatigued, and begin an uncontrolled spasm until he stopped the task. Typing would generate a milder spasm than that elicited when printing, but it proved to be extremely difficult to take a typewriter to class for the purpose of notetaking.

In addition, the use of a typewriter for Algebra, Statistics, and Physical Sciences, courses that required mathematical and scientific notation, could not be handled by a standard typewriter. The problem facing the subject's academic advisor, Dr. Katz, was to develop an orthosis that would allow the subject to print alphabetical letters, as well as scientific notation at home or in the classroom without inducing debilitating hand spasms. The orthotic device described in this article was constructed and fitted by Mr. Perkins. All materials used were readily available from a prosthetic/orthotic facility.

DESIGN DESCRIPTION

The orthosis can be viewed as having four main parts: 1) the hook and wrist assembly; 2) the bracket and rotating rod assembly; 3) the arm attachment cuff assembly; and 4) the cable harness assembly (Figure 1).

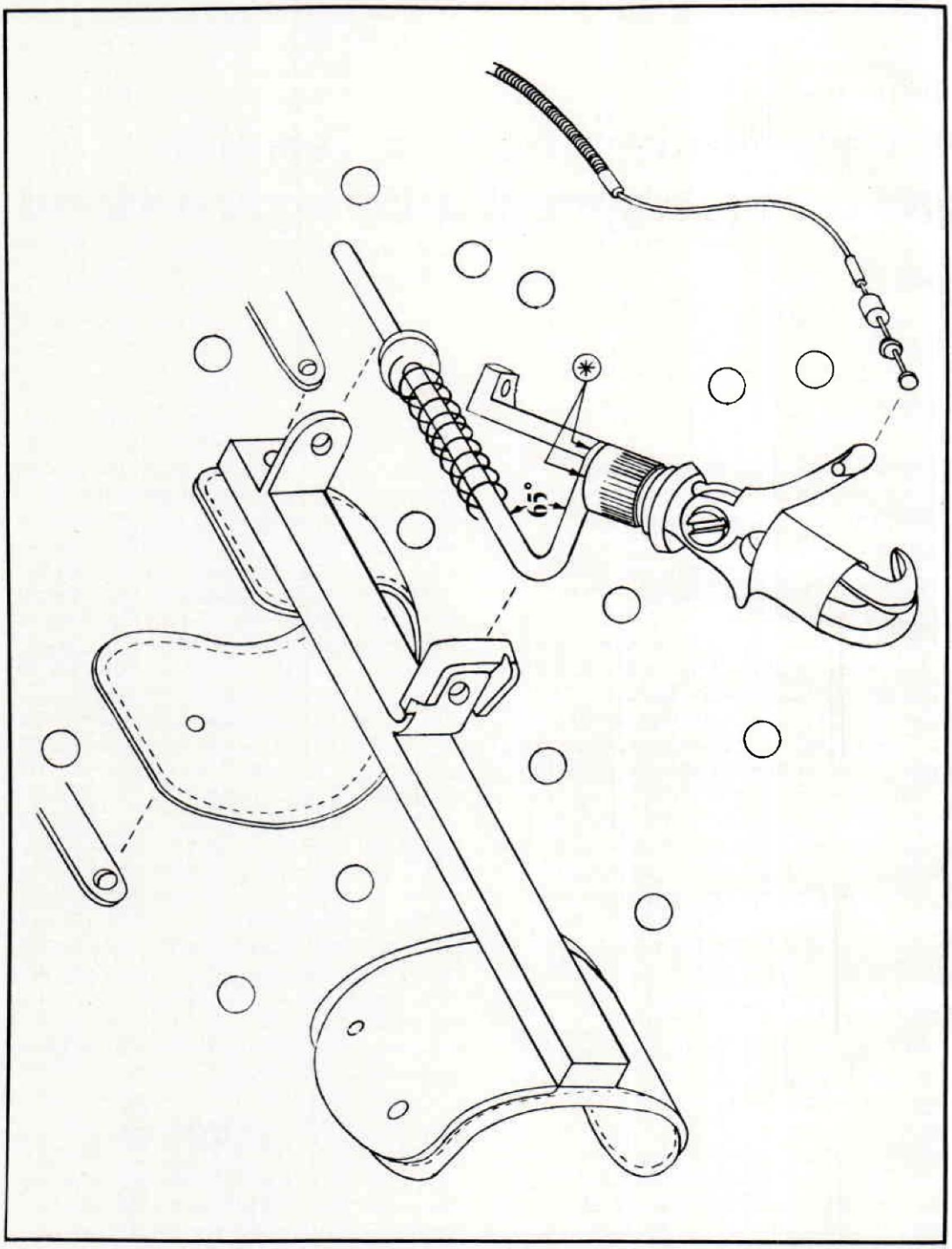

Figure 1: Exploded isometric drawing of the orthosis emphasizing the hand, rotating rod, and arm attachment assembly.

The Hook and Wrist Assembly

- A Hosmer Dorrance #99X hook was used. The smaller sized appliance was more appropriate since space was crucial when the hook was folded out of the way for propelling the chair. Three hook-tension bands (approximately 7.5 pounds prehension) were used to hold a pencil and comfortably open the appliance via the shoulder harness.
- An FM 100 wrist unit attached the hook to the rotating support. The wrist unit was welded to an angled end tab of the support rod (See Figure 1 for the site of the weld).
- A one-inch rubber lock washer was inserted between the terminal appliance and wrist to suppress hook rotation while writing.
- The cable was attached to the thumb of the hook in the traditional fashion.

The Rotating Support Rod

- A 6" × ¼" stainless steel rod was used to support the hook and give it its swivel action. The forward two inch section of the rod was bent back 65 degrees and angled down from the center line of the arm; this position aimed the tip of the hook away from the natural hand so that the hand would not interfere with the activity of the hook.
- The rod was housed inside a 3⅜" × ⅝" × ⅛" steel bracket and sheathed with a 3½" spring.
- The distal end of the bracket terminated in a two position gate allowing the rod to lock in a writing position (Figures 2 and 3), or rotate and lock behind the natural hand in a clearance position (Figure 4).
- A 3½" spring provided pressure for locking in both positions. The spring was held in place by a pin and washer

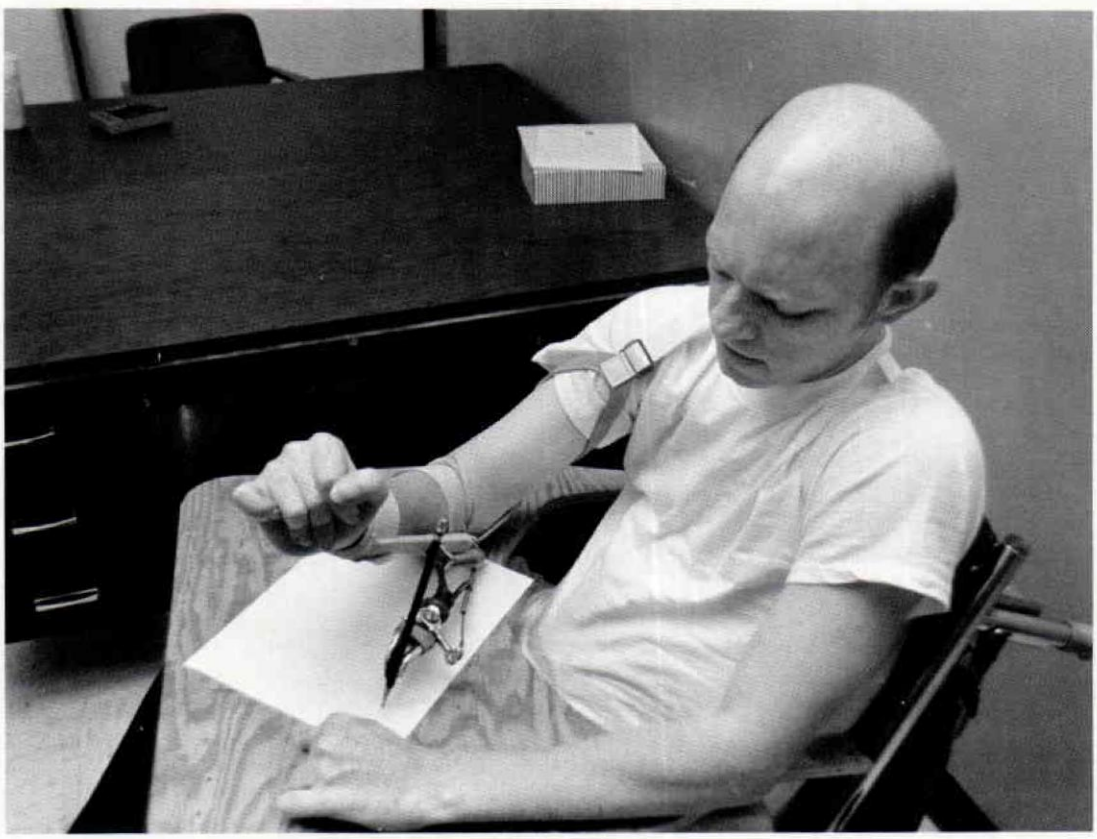

FIgure 2: The subject shown using the hook in the writing position.

Figure 3: Closeup of hook in writing position. Bracket and rotating rod assembly can be seen.

Figure 4: The hook in the clearance position, so that the subject can operate his wheelchair.

mounted at the proximal end of the rod.
- The cable guide was 1¾″ × ¾″ stainless steel rod welded to the back of the primary support rod.

The Arm Attachment Cuff Assembly

- An 8¾″ × ½″ × ¼″ bar was used as the main frame to support the rotating rod and bracket assembly.
- Two cuffs were riveted to the side opposite the hook and bracket assembly. The wrist cuff was 5″ × 2″ and the upper forearm cuff was 6½″ × 2″. Velcro® band material was used to secure the cuffs to the client's arm. The bar and cuffs were covered with gray leather which gives the prosthesis a comfortable fit and aesthetic appearance.

The Cable Harness Assembly

- A humeral cuff was attached to the upper forearm cuff by two straps. The cable was connected at the thumb of the hook with the cable housing run under the arm and connected to the outer side of the half cuff. A shoulder harness was connected to the upper arm half cuff by an inverted "Y" strap. The cable was attached to the left arm loop of the harness with a hanger connector. This is the same system used by amputees to operate the opening of a terminal device.

USING THE ORTHOSIS

With assistance from an attendant, the orthosis can be affixed to the subject prior to class. He has two wheelchairs—a motorized chair with a hand-operated four-way switch, and a standard nonmotorized chair that he can propel.

By grasping the rotating knob projection hand rims that extend from the wheels, he can exercise his arms and move his wheelchair about on flat surfaces. When the hook is not used for academic tasks, he can move it out of the writing position and into the clearance position by pulling forward on the hook with his left hand, which releases tension on the gate, and rolling the hook over the back of his right hand and locking it out of the way. He can propel his chair from class to class without removing the hook.

When class begins, he can grab the hook with his left hand, pull forward and roll the hook out of the clearance position and back into the writing position. When he flexes his back, the hook opens and he inserts a pencil into the appliance. Relaxing his shoulders, the hook grasps the pencil and he is ready to print letters or mathematical symbols. The downward angle of the hook allows him two points of contact on his writing board: the hook-held pencil and his right elbow. The arm is supported in a comfortable position which does not elicit spasms in the arm or hand.

SUMMARY

A voluntary opening hook terminal appliance was used in a nontraditional fashion to permit a partial quadriplegic patient to print. The subject has both of his natural arms and hands, yet has only minimal use of his hands for prehensile tasks. Hand spasms greatly limit the use of support devices that could augment the use of his hand. The hook was mounted on a rotating and locking bracket so that it could be moved out of the way without removing the appliance when he operated his wheelchair. This feature allowed the device to be placed on and off only once per day.

The subject is presently involved in training, which is sharpening his printing skills of both numbers and alphabet letters. Soon, he will be able to take lecture notes in class, write mathematical formulas, and take multiple-choice examinations by himself.

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