An Improved Tenodesis Splint

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In the United States approximately 3,000 persons become quadriplegic yearly as a result of cervical spine trauma. The incidence of quadriplegia is further increased by cervical cord tumors, poliomyelitis and vascular and neurologic diseases.

As a result of modern medical, surgical and rehabilitation treatment, most of the cord injury patients now live for many years. Therefore, it is safe to assume the existence of several thousand patients who could be benefited by an orthotic device to restore function to the paralyzed hand.

One of the most disabling losses resulting from spinal cord injury is paralysis of the hands. All quadriplegic patients have some degree of hand and finger paralysis, but many patients retain the ability to extend the wrist. In the latter group, hand function may be restored by the use of an orthesis which harnesses the available tenodesis mechanism to provide grasp. This paper describes a simple device that is so constructed that it provides a three-jaw chuck type grasp when the patient extends his wrist.

Information gained during the development of the "Helping Hand" provided the basic ideas from which the tenodesis splint was constructed. Mr. Thomas A. Smith, a project engineer of the All American Engineering Company, designed the ingenious two-sectioned spring and the ball chain activating mechanism which are mounted on a hinged acrylic plastic splint. This unit is cosmetically acceptable to the patient and provides good functional use of the paralyzed hand.

The "Helping Hand," referred to above, was first described in the June 1960 issue of the *Orthopedic and Prosthetic Appliance Journal*. It is a hydraulically operated orthesis, designed to provide grasp for the patient who lacks wrist extensor function. The simple hydraulic system consists of nylon master and activating cylinders connected by nylon tubing. Tap water is used as hydraulic fluid and the displacement of 5 ml. of water by a one-inch piston movement opens the hand sufficiently to grasp a juice glass.

The activating cylinder is mounted in a beryllium alloy C-spring which holds the hand in the closed or pinch position until the plunger in the master cylinder is depressed to open the hand. The spring has great tensile strength and, after a critical heat treating process, will not change shape. The spring, if bent from its original shape, will return to the prebending configuration due to a "memory" property of the alloy which develops during heat treatment.

Finger wires are mounted on each end of the C-spring and to these wires latex finger boots are attached by the use of an apoxy. The latex is 0.021 inch thick and permits good touch sensation for the patient who has this sense preserved.

The C-spring with its attached finger wires, latex finger grips and activating cylinder is mounted as a unit on a contoured acrylic splint. The splint is held in place by leather wrist watch straps or velcro plastic strips. The hand unit attached to the patient weighs 4 to 4½ ounces, depending on the type of anchoring straps used to hold the splint to the forearm.

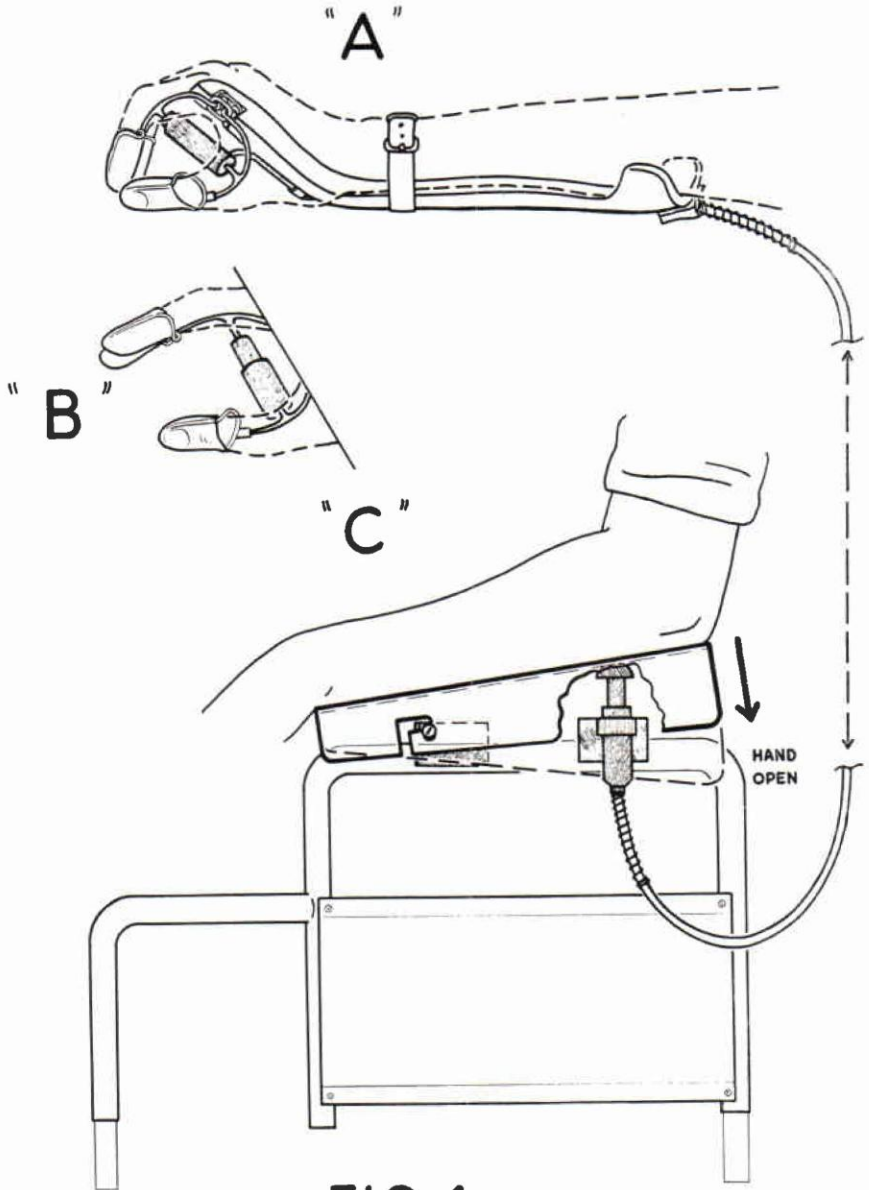

FIG. 1

Figure 1—A, B, and C. A and B show the hand open and closed. C illustrates the activating mechanism.

The wheel chair-bound patient opens the hand by depressing a lever mounted on the arm of the chair (Figure 1 A, B, and C). The ambulatory patient requires a different type master cylinder. Such a patient opens the hand by scapular abduction or shoulder elevation.

Fabrication of presently available tenodesis splints requires custom fitting of each part as the unit is assembled. This entails many hours' fitting time by the orthotist and greatly increases cost. In addition, frequent adjustments are necessary and cosmesis often is poor. A knowledge of these difficulties led us to design and develop a fitting kit and sizing splint from which a properly fitting hand could be assembled from measurements taken in the field (Figure 2). The sizing splint was designed to permit "sloppy" measurements. That is, errors one size greater or less than the ideal size are permitted without interfering with proper fit and function of the orthesis. There is also built into the sizing device a "no-go" gage which instantly alerts the orthotist when custom fitting is required. To date, this situation has been encountered only once in over twenty-five fittings. This patient had an abnormally wide hand and very short, sharply tapered fingers.

Figure 2—Fitting kit and sizing splint used to secure measurements for both the "Helping Hand" and tenodesis splint.

Measurements for fitting the tenodesis splint are obtained by use of the same splint and kit used to fit the hydraulic hand. The new orthesis also makes use of the same type acrylic splint, finger wires, and latex finger

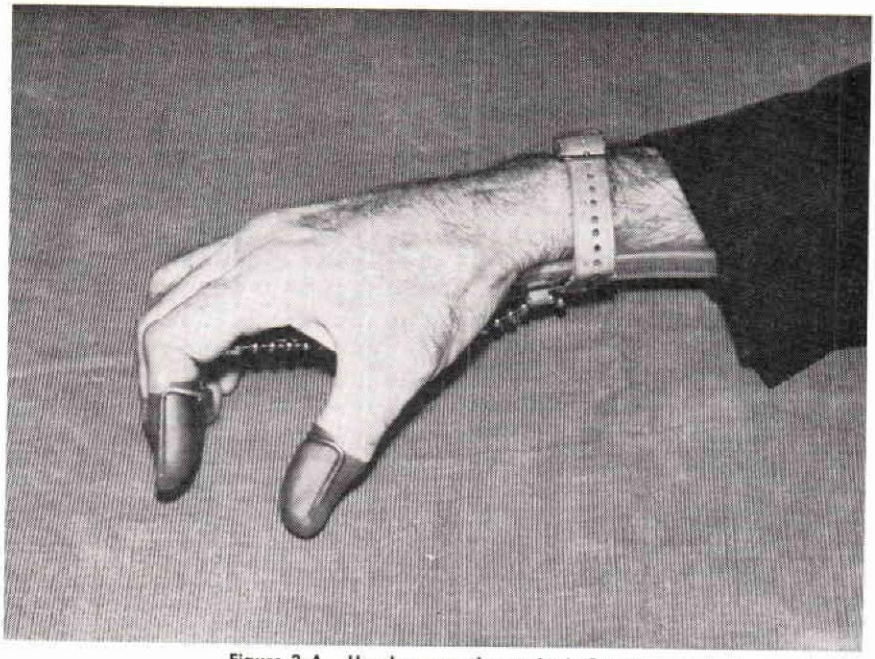

Figure 3-A—Hand opens when wrist is flexed.

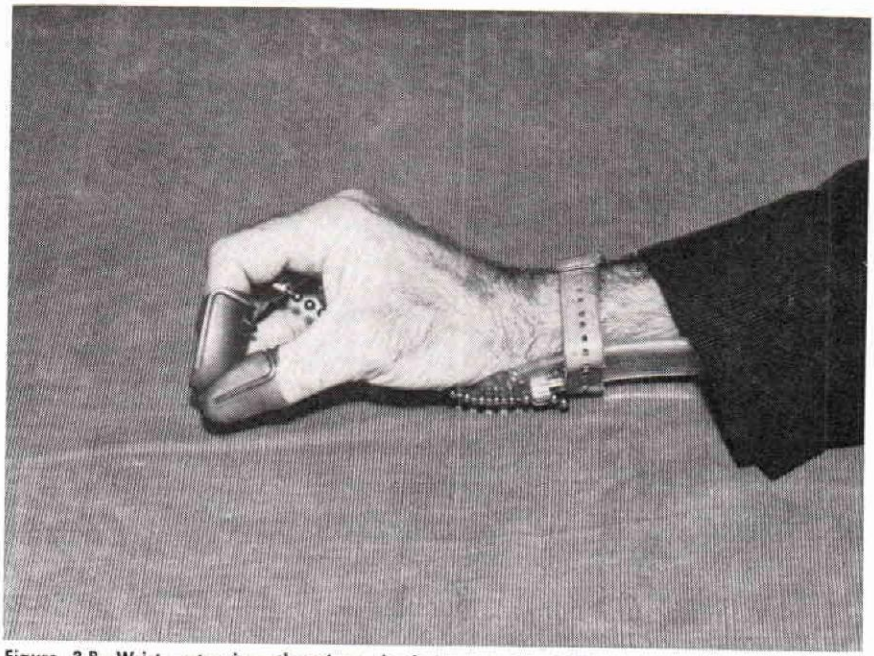

Figure 3-B—Wrist extension—three-jaw chuck type grasp results. Force of grasp depends on degree of wrist extension.

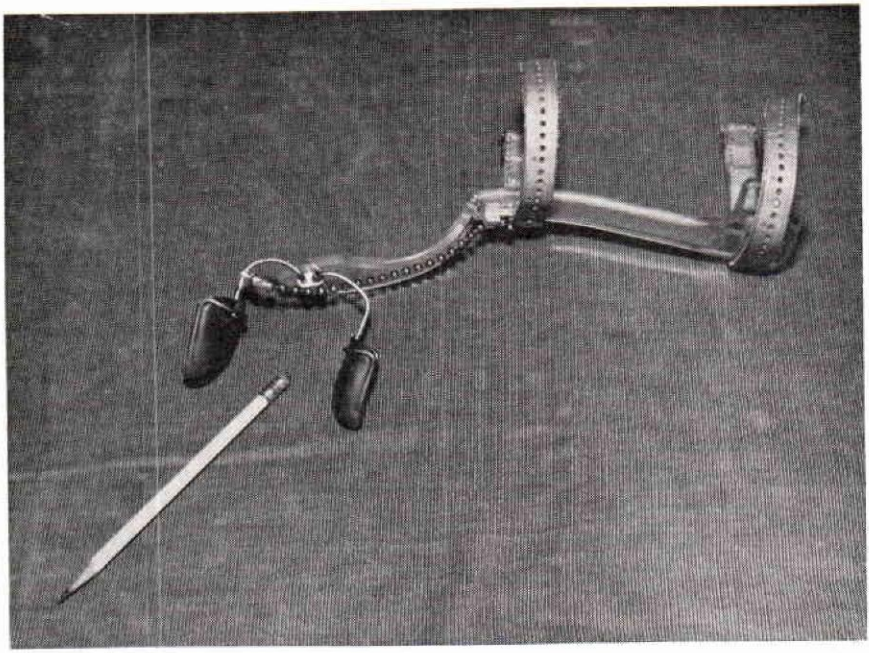

Figure 4-A—Construction details and method of operation (wrist flexion) are illustrated.

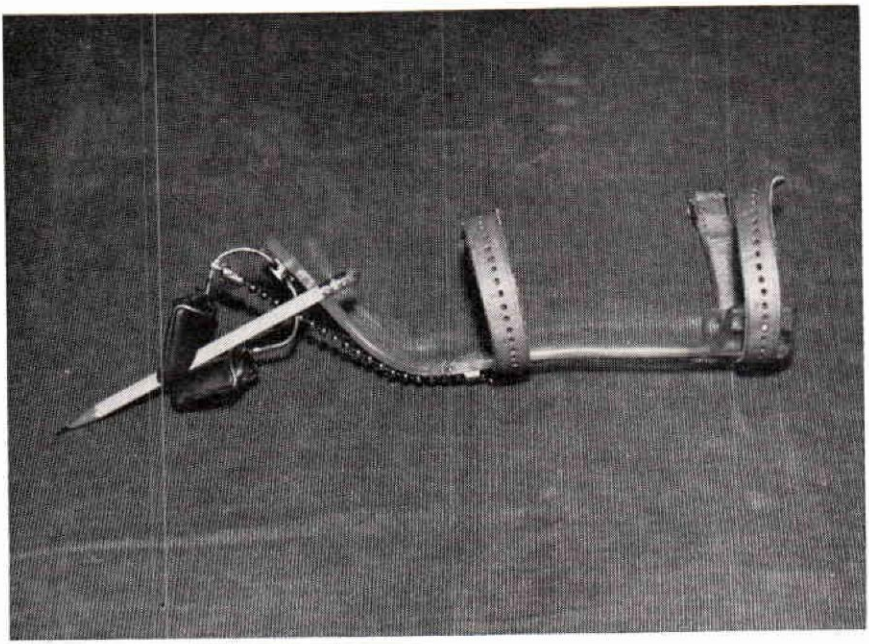

Figure 4-B—Grasp or pinch position resulting from wrist extension.

boots that are used in the hydraulic hand. However, the split is hinged at a point corresponding to the volar crease of the wrist. The hinge contains oilite bushings to assure long life. The spring also differs from the standard C-spring in that it is in two sections and is spring loaded to aid in opening the hand as the wrist flexes. The strength of this spring is varied to overcome any resistance the finger flexors may offer as the wrist is flexed. There is available a light weight snap-on yoke which holds the index and middle fingers in position, should they tend to slide from the latex finger grips as the fingers move during use of the orthesis.

The anterior half of the spring lies between the index and middle fingers and has attached to it a bead chain which is adjustable in length. The other end of the chain is attached to the splint by means of a standard receptacle which is located just proximal to the hinge joint. When the bead chain is shortened, little wrist extension is necessary to produce the three-jaw chuck grip. Conversely, lengthening the chain delays finger closing until the wrist is extended to a much greater degree. The force of grasp is governed by the degree of wrist extension.

The spring mounting mechanism and ball chain assembly are so located that there is no interference with function of the hand. The acrylic splint is contoured to leave the thenar area of the hand free so that it may be used to push the wheel chair. Figure 3 A and B shows the tenodesis splint in use by a patient. In (A) the hand is seen opened by wrist flexion and closed (B) when the wrist is extended. Figure 4 A and B further illustrates the method of action of the orthesis to provide grasp and release by wrist movement.

SUMMARY

A simple, light weight, wrist extension orthesis is described. The unit provides a three-jaw chuck type grasp for the patient with hand paralysis and permits many activities otherwise impossible.

The new tenosesis splint is superior to those now available in that fitting and fabrication have been simplified, and cosmesis and function have been improved.

HENRY BATES

Henry Bates Represents Pope Brace Division

Henry ("Hank") Bates has joined the field staff of the Pope Brace Division and will travel extensively for them, especially in the Middle West. Hank was for many years on the staff of Tru-Form Supports and is deservedly popular throughout the United States. the *Journal* especially appreciates Hank for the excellent pictures he supplies us with. A number of them have appeared in both the *Journal* and the *Almanac*.