Triceps Pronation-Supination Orthosis

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INTRODUCTION

The Triceps-Supination Orthosis* was designed for a patient with flexion contractures of the right elbow and limited pronation and supination secondary to a C6 spinal cord injury (Fig. 1). It is also designed to dynamically extend the elbow while still permitting active elbow flexion, pronation, and supination (Fig. 2 and 3).

During rehabilitative hospitalization, emphasis was on increasing right elbow extension and functional use. A series of six inhibitive serial casts* was applied to obtain gradual elbow extension. Active range increased approximately 8–10° with each successive casting, but gains in this area were not maintained following removal of the cast.

The patient's functional activities were impaired due to a soft tissue contracture of the right elbow, and active forearm pronation and supination were nonfunctional. Upon admission, active right elbow extension measured minus 70° with passive extension measuring minus 35°. Spasticity was noted when active pronation and supination were attempted. The left nondominant upper limb, being most functional, had a good tenodesis grasp with passive range of motion being within normal limits.

*a series of plaster casting to release contractures or spasticity through neutral warmth with prolonged stretch in a submaximal range.

INDICATIONS

The utilization of a triceps pronation-supination orthosis should be considered for individuals with elbow contractures or spasticity along with limited active pronation and supination. In addition to spinal cord injured individuals, this orthosis would be beneficial for patients with closed head injuries and Guillain Barre' with long term disabilities. The orthosis is applicable for spasticity that ranges from mild to severe after other therapeutic methods have been attempted to decrease spasticity.

Active elbow extension of minus 45° and passive pronation and supination are prerequisites for fitting. The orthosis will actively extend the elbow to minus 10° depending upon the severity of spasticity, and will permit full range in pronation and supination.

The patient's personality and educational background play a significant role in training the individual in orthotic use, regardless of the success of fitting of the actual orthosis. The individual who lacked motivation before his disability should not be expected to be dynamic and motivated after the onset.

ORTHOSIS DESIGN

The triceps pronation—supination orthosis incorporate adjustments regulating the amount of tension and force applied at the mechanical elbow and radio-ulnar joints. These adjustments enable the orthotist or therapist to balance the orthosis against the active opposing musculature.

The adjustable extension assist elbow

Fig. 1. Flexion contracture with limited pronation-supination.

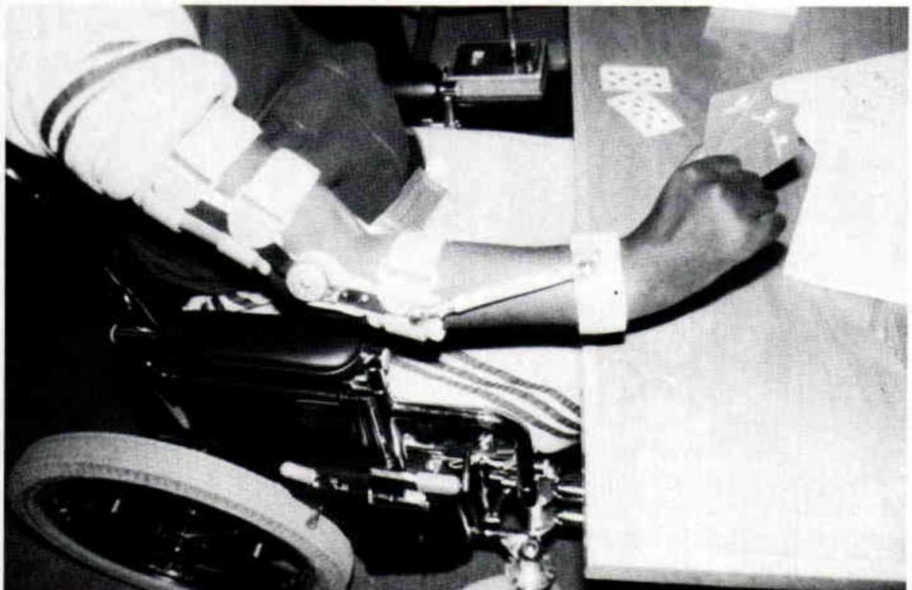

Fig. 2. Triceps Pronation-Supination Orthosis showing dynamic elbow extension and pronation.

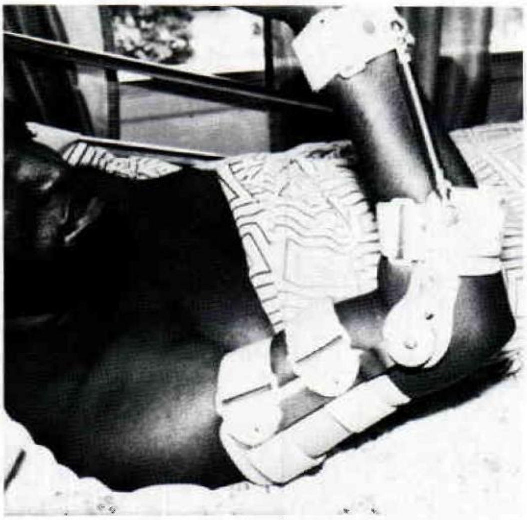

Fig. 3. Patient actively flexing the elbow and supinating the hand.

joint (Fig. 4) was originally designed as a flexion assist, but a modification to the coiled spring was made to obtain the extension forces used to simulate the triceps. Clockwise-counterclockwise rotation of the spring's mounting allows adjustment of tension forces, either increasing the amount of force by rotating the spring clockwise, or decreasing it with counterclockwise rotation. Adequate elbow extension can be achieved only when functional passive range of motion has been established.

The forearm is composed of the radius and ulna and its articulating surfaces which consists of the proximal radio-ulnar joint and the distal radio-ulnar joint, both classified as pivot joints. The primary movement permitted is rotation, and the joint is therefore monoaxial. The pivot axis extends diagonally from the proximal head of the radius to the distal head of the ulna, the forearm rotates around this axis, which results in supination and pronation.

During pronation, the radius crosses the ulna diagonally (Fig. 5).

In order to simulate supination-pronation of the hand with an orthosis, similar characteristics must prevail. Rod end bearings are used to mimic the radio-ulnar joints. Proximally, the rod end bearings are riveted to the forearm band (Fig. 6) and distally to the polypropylene wrist cuff (Fig. 7). Stainless steel linkage rods simulating the radius and ulna are threaded and rotate in the sleeve of the proximal rod-end bearing. This rotation, coupled with the intrinsic pivot action of the bearing, enables the orthosis to imitate pronation and supination. Distally, the

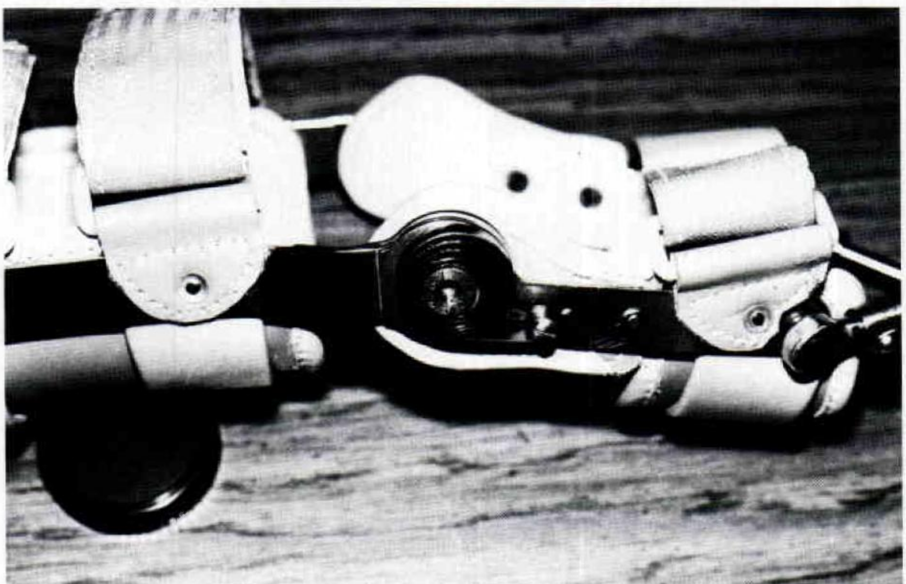

Fig. 4. Dynamic elbow extension joint (cover removed).

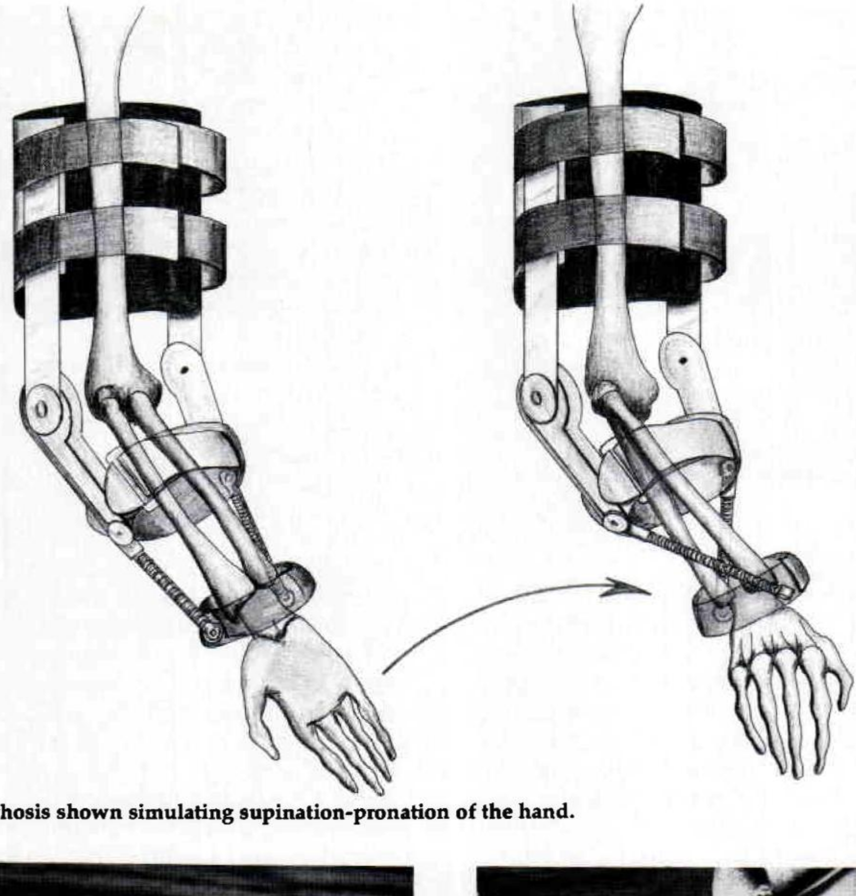

Fig. 5. Orthosis shown simulating supination-pronation of the hand.

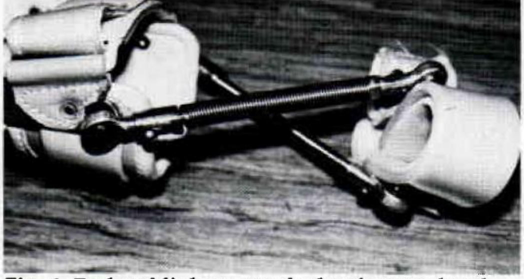

Fig. 6. Rod end linkage attached to forearm band.

Fig. 7. Distal rod end bearing attached to polypropylene wrist cuff.

steel rods are statically attached to the rod end bearings.

In order to dynamically assist the hand into pronation, a torsion spring was incorporated over the radial stainless steel rod (Fig. 8). The torsion spring is wound in a counterclockwise direction for right hand pronation, and clockwise for left hand pronation. The torsion spring provided the necessary force to passively advance the hand into pronation. Proximally, the spring is attached to an outer adjustment sleeve. This sleeve allows the orthotist or therapist to vary the amount of force transmitted to pronating the hand. An additional spring can be added to the ulnar stainless steel linkage rod if more force is required to pronate the hand.

Fig. 8. Torsion spring assisting hand into pronation.

Fig. 9. Triceps Pronation-Supination Orthosis increases patient's ability to self-propel a manual wheelchair.

Functional Benefits

The following functional activities can usually be carried out with the triceps pronation—supination orthosis after training and practice.

- **Increased Range of Motion.** The orthosis dynamically extends the elbow and permits active elbow flexion while assisting with active pronation—supination.
- **Increases Active Functional Forearm Rotation.** The orthosis assists with writing skills, card playing, and ability to pick up objects.
- **Wheelchair Mobility.** The orthosis increases the ability to reach wheel rims for self-propelling a manual chair (Fig. 9) and provides the range of motion for reaching the control on an electric wheelchair.
- **Feeding Skills.** Utilizing quad cuff utensils, patients can actively and functionally feed themselves, pick up a cup, and cut food with a rocker knife.
- **Light Hygiene.** The orthosis increases the ability to comb hair, brush teeth and apply deodorant.

ACKNOWLEGMENTS

The authors would like to thank Bob Wilson for the technical illustrations.

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*U.S. patent pending