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A DYNAMIC PLASTIC ELBOW-EXTENSION ORTHOSIS FOR REDUCTION OF FLEXION CONTRACTURES

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The function of the elbow is to be subservient to the hand in the sense that the elbow enables the hand and fingers to be placed at desired distances from the body. Two types of motion are required to position the hand. The first, and principal one, is the shortening and lengthening of the distance the hand is positioned from the body. The hand may be brought out at full arm's length, as when the elbow is in full extension, or it may be brought up against the shoulder, as it is when the elbow is fully flexed. The second motion of the elbow adjusts the position of the hand in relation to the transverse plane by either pronation or supination.

The ulnar-humeral joint, a pure hinge-type joint, allows extension and flexion motions of the elbow. Extension of the elbow is supplied by the three heads of the triceps, and some slight effort is attributed to the anconeus. The brachialis and the biceps are the two principle flexors, with the brachioradialis considered an auxiliary flexor.

Spinal cord trauma, as well as a variety of neuromuscular diseases, may cause paralysis of the elbow extensors. Although gravity does assist in elbow extension, the patient that has normal or near-normal elbow flexor strength frequently suffers elbow flexion contractures owing to a lack of active elbow extension. This happens usually in quadriplegics with a lesion at the C5-6 neurological level, in which the elbow flexion is in the range of good to normal strength and the elbow extensors are absent. A well-planned program of daily exercise is required to prevent the formation of progressive contractural deformities that frequently occur when the patient no longer has physical therapy after discharge from the hospital.

Various techniques and methods are used for the post-contracture treatment. Several surgical techniques which transpose muscles to improve the extensor power of the elbow may be performed. Serial plaster splinting of the elbow with forced extension while casting is a simple orthotic approach. Various orthotic appliances made of metal, leather and fabric are described in the literature. These appliances have extension moment supplied by metal springs, elastic fabric, or a machine screw. A slow steady pressure is desired so that the fibrous tissue atrophies, stretches, and, in effect, grows longer. Those designs that cause an intermittent pressure such as from a sudden passive manipulation may cause the fibrous tissue to hypertrophy if the extension is applied inexpertly.

Current research at certain Rehabilitation Engineering Centers gives consideration to the elbow flexion contracture. The Annual Progress Reports of Rancho Los Amigos briefly describe research on powered orthoses that are used to extend the contracted elbow periodically. Electrical stimulation of the patient's extensor muscles to overcome the contracture is also receiving their attention.

DESIGN OF THE ORTHOSIS

A review of the existing orthotic designs for elbow extension indicated that a new improved design was needed. It was felt that the use of modern plastics, with their inherent advantages such as lightweight, ease of fabrication, and appearance, should be tried.

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A biomechanical analysis of the problem indicates that the simplest force system that will produce the required extension moment about the elbow joint is that shown in Figure 1. This resultant force system is that of two couples, one proximal and the other distal to the elbow joint.

By positioning a single thermoplastic band into the shape shown in Figure 2, the force system described in the previous paragraph may be implemented. The band is formed into an elbow extension position that exceeds the contracted angular position of the anatomical elbow. When positioned on the elbow with contracted elbow flexors, the result is an extension moment force system.

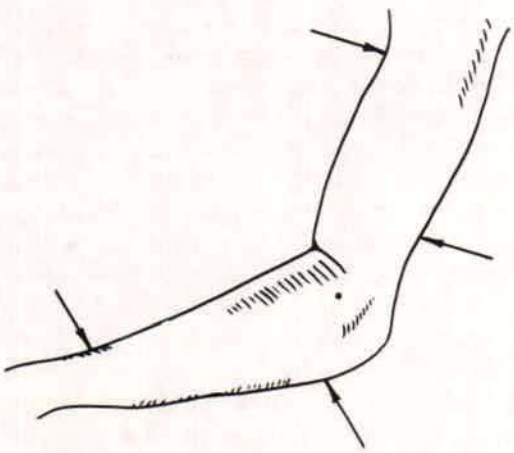

Fig. 1. The simplest force system that will provide an extension moment about the elbow. Note that two couples are provided: one distal to the joint; the other, proximal.

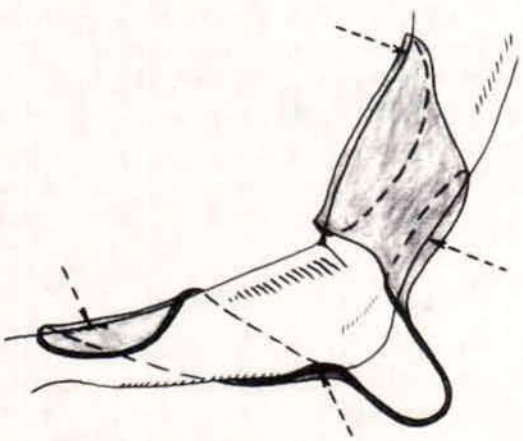

Fig. 2. A single plastic band shaped to provide the force system shown in Figure 1 and thus produce an extension moment about the elbow.

The plastic used in the construction of the orthosis is Plexidur,[2] a thermoplastic that offers the desired mechanical and physical properties. Its amber color offers cosmetic appeal.

The bow shape of the orthosis over the olecranon process of the elbow serves three purposes. First, it insures that no contact is made over the pressure sensitive region of the olecranon process and the lateral and medial epicondyles. Second, it serves to reduce the stress concentration that would be present if a sharp change in direction of the plastic were formed over the relatively prominent olecranon process. Third, the bow shape is used to adjust the pre-extended position built into the orthosis. Localized heating of the bow with a heat gun allows angular adjustment to be made easily. This permits the orthotist to adjust the extension moment as the flexion contracture is gradually reduced over a period of time.

Assistance is needed in donning the orthosis, which must be forced into a flexed position but put on the patient's arm with a twisting motion. Donning and removal of the orthosis is a relatively simple procedure after one or two trials. The unwinding action of the spiral and also the fit of the shell over the anterior aspects of the arm and forearm keep the orthosis stable and properly positioned.

FABRICATION

The initial step in fabrication is to obtain a plaster cast of the patient's arm with the elbow extended to the limit of the contracture. The arm is positioned with the forearm supinated, and prominences and landmarks are marked with an indelible pencil. The cast is removed carefully and filled with plaster of Paris to provide a positive model.

[2]Rohm & Haas Company, Darmstadt, Germany

The positive model is smoothed and undercuts and buildups added for flares at the location of trim lines. As shown in Figure 3, a cylindrically shaped piece of plaster of about five centimeters diameter is added over the olecranon process for formation of the bow shape. A paper pattern is cut and fitted on the cast, and then used to lay out the thermoplastic from 4 mm.-thick sheet stock, as shown in Figure 4. The edges of the thermoplastic are sanded and polished.

The thermoplastic is heated in an oven to a temperature of 140 deg. Celsius for approximately ten minutes. The plastic is removed and wrapped over the positive model and held in place with an elastic bandage. After the plastic has cooled to room temperature, it may be removed from the mold, as shown in Figure 5.

The orthosis is extended prior to fitting by locally heating the 5 cm. diameter bow with a heat gun, and carefully extending the orthosis to the desired angular displacement. The amount

Fig. 3. The cast has been modified by building up a five-centimeter diameter piece over the olecranon to provide for formation of the connecting bow. A paper pattern for the orthosis is developed over the model.

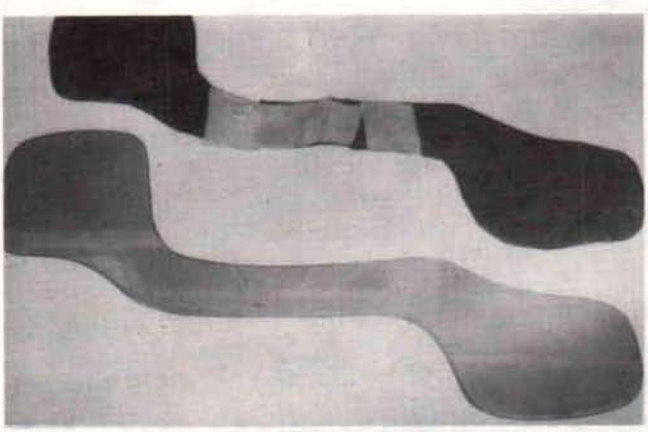

Fig. 4. The paper pattern is used as a guide for cutting the Plexidur flat stock.

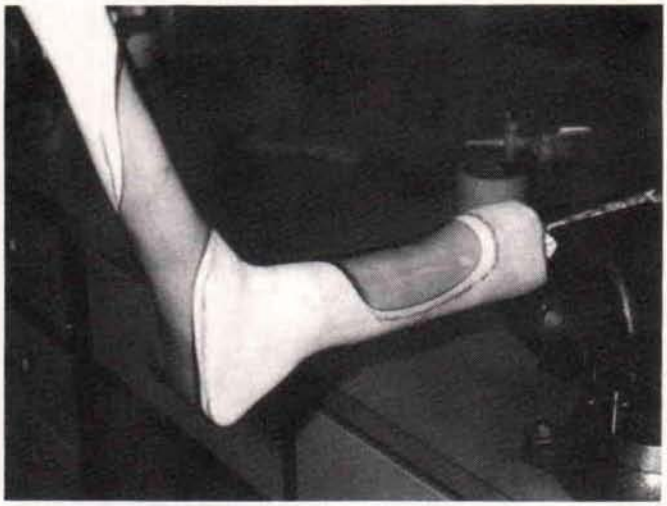

Fig. 5. The orthosis just before removal from the model.

of extension will depend on the patient and the severity of the contracture but an initial extension of approximately twenty degrees beyond the contracted position has been found to be satisfactory. The orthosis is shown on a patient's arm in Figure 6.

DISCUSSION AND RESULTS

A total of five plastic elbow extension orthoses have been fitted to patients. The overall acceptance of this device by the patients has been good.

The functional performance of the orthosis to stretch out the elbow flexion contracture is shown in Figure 7, which graphically illustrates the gonimetric record of the elbow joint extension over the first five months of treatment. The slopes of the curves indicate that a reduction of approximately two degrees of contracture per week can be obtained with the orthosis during the early months of treatment.

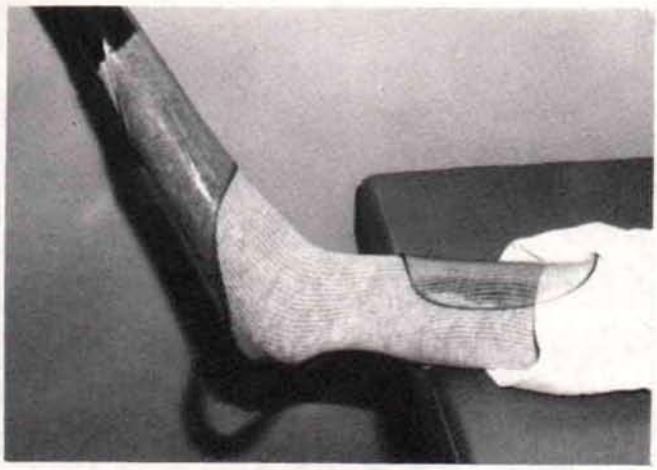

Fig. 6. The orthosis on the patient.

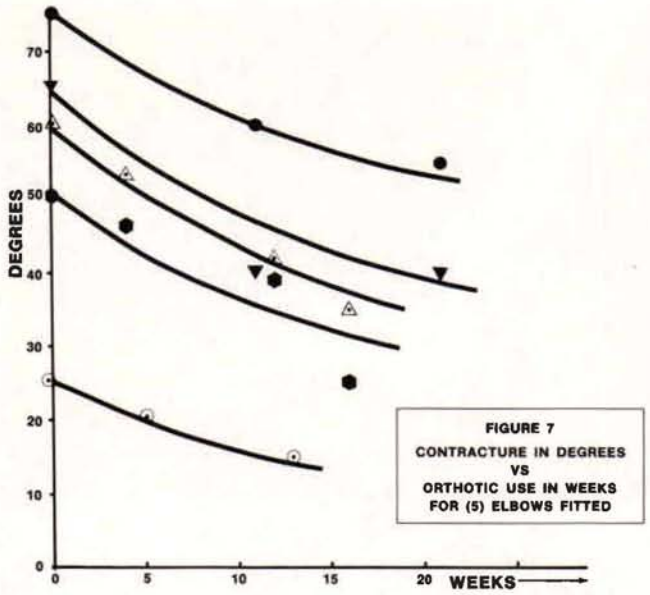

FIGURE 7
CONTRACTURE IN DEGREES
VS
ORTHOTIC USE IN WEEKS
FOR (5) ELBOWS FITTED

Some of the advantages of the new plastic orthosis described in this paper over the conventional designs are improved cosmesis, lighter weight and less bulkiness. The plastic orthosis also offers the advantage of being relatively easily removed for bathing. The appliance is also easily maintained in a clean and appealing condition.

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