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Use of Elbow Dynasplint for Reduction of Elbow Flexion Contractures: A Case Study

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A severe elbow flexion contracture following a supracondylar fracture in a 13-year-old-male was treated with conventional physical therapy and an adjustable dynamic splint, the elbow Dynasplint.® The Dynasplint was applied primarily at night. The patient achieved complete resolution of his flexion contracture. The Dynasplint incorporates the principles of adjustable, low-intensity force for prolonged durations of time.

Elbow flexion contractures following trauma to and about the elbow present a difficult problem for the orthopaedic surgeon and the physical therapist. The following case study describes the use of the elbow Dynasplint® (Dynasplint Systems, Inc., Baltimore, MD)‡ in successfully reducing a severe flexion contracture in a 13-year-old male who suffered a supracondylar fracture of the left humerus and a fracture of the distal left radius and ulna.

It has been stated by Sapega et al.,[9] that "following trauma or surgery, the connective tissue involved in the body's reparative processes frequently impedes normal function, because it may abnormally limit joint range of motion. Scar tissue, adhesions and fibrotic contractures are common types of pathological connective tissue that must be dealt with therapeutically."

Connective tissue is the most important target of range-of-motion exercise. It is composed of collagen and other fibers embedded in ground substance, a protein-polysaccharide compound. The viscoelastic properties of connective tissue allow for some elongation of the tissue when proper stretching is applied.

Connective tissue has been defined as having two components of stretch which enables elongation of the tissue. The viscous property of connective tissue allows for plastic stretch which refers to the type of elongation where the linear deformation produced by tensile stress remains after the stress is removed. This is described as permanent elongation of the connective tissue. On the other hand, the elastic property of connective tissue allows for elastic stretch, represented by spring-like behavior, where elongation produced by tensile loading is not permanent and results in the connective tissue returning to its previous length once the tensile loading is removed.[8]

When connective tissue is stretched, the relative proportions of elastic and plastic deformation can vary widely depending on how the tissue is stretched. One prime factor influencing this proportion of elastic and plastic deformation is the amount and duration of applied force to the connective tissue. Techniques used to restore normal joint range of motion following loss from trauma or surgery should primarily be designed to produce plastic deformation, since a permanent increase in range of motion is generally the therapeutic goal. With the exception of adhesions, permanent lengthening of the connective tissue must be achieved without tearing the connective tissue since tearing will result in increased pain, instability, and scar formation and ultimately make the patient worse.[8]

Research has documented that high force, short duration stretching of collagen tissue favors

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‡ Dynasplint is the trade name of a specific adjustable dynamic splint for which a U.S. patent is pending.

recoverable, elastic tissue deformation resulting in a temporary lengthening of the tissue. On the other hand, low force applied over longer periods of time results in higher proportions of plastic stretch to elastic stretch, thereby resulting in a permanent lengthening of the tissue.[4,10,11]

Kottke et al.,[3] stated that prolonged stretching at moderate tension resulted in a significantly greater increase in range of motion about a contractured joint than did intense stretching of short duration. Furthermore, the chances of tissue tearing and unbearable pain are not as great with low intensity-prolonged stretching as opposed to high intensity-short-duration stretching.

Temple University's Center for Sports Medicine and Science uses a protocol for stretching contractured knees which incorporates the principle of low intensity-prolonged duration stretching by using a pulley system with between 3 and 15 pounds of force applied at the ankle, perpendicular to the leg, for 20–60 minutes. This system and others[1,2] have been reported to be successful for increasing flexion and extension when applied in a particular setup. Furthermore, it was concluded by the authors that such principles of low intensity-prolonged duration stretching with appropriate techniques are applicable to all scarred, contractured, and/or surgically shortened connective tissue.[8]

Another description of appropriate stretching technique for contractured joints uses as a guide for all therapists the watchwords of "little" and "often" making reference to the force and duration indicating that they should be of low intensity and prolonged duration.[6]

With specific reference to the elbow, there exists considerable opposition to techniques for increasing its range of motion when high intensity-short duration force application is involved. In other words, forceful, passive stretching to any elbow with limited joint range is generally considered taboo. Shands' Handbook of Orthopaedic Surgery[7] states that physical therapy, consisting of vigorous exercises and passive stretching to the elbow, should be avoided since it is believed that such procedures stimulate ossification which may result in traumatic myositis ossificans. O'Donoghue[5] has stated, in reference to various injuries about the elbow, that attempts to forcibly manipulate the elbow by passive stretching tends to encourage calcium deposits. Furthermore, the disabling condition of myositis ossificans may be caused by manipulation and forceful, passive stretching about a fractured bone. In any case, there is no place for passive, forceful stretching to the fracture about the elbow.

In reference to increasing elbow joint range of motion following a fracture, it would appear wise for the practitioner to use techniques of low intensity-prolonged duration force so as to maximize a permanent increase in range of motion without the risk of traumatizing the joints by forceful and vigorous stretching which ultimately may worsen the patient's condition by causing development of myositis ossificans, loss of range of motion, and an increase in pain.

DESCRIPTION OF MATERIALS

The elbow Dynasplint is an adjustable dynamic splint capable of producing low intensity-prolonged duration force acting across the elbow joint.

It is composed of two stainless steel struts placed laterally and medially on the upper extremity and has drill cloth and velcro closures as a means of affixing the unit to the patient (see Figs. 1 and 2).

A compression-coil spring with a screwdriver adjustable means is contained within the distal forearm struts. Mechanically, the Dynasplint has a three-point pressure system classifying it as a first-class lever. Two velcro closure cuffs and a 1-inch wide strap act as the pressure points while the posterior forearm cuff and the posterior upper arm cuff act merely to prevent rotation of the unit on the extremity.

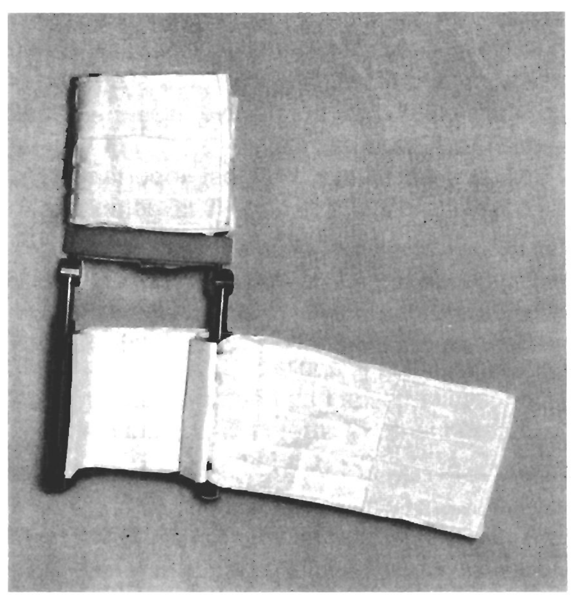

Fig. 1. *Elbow extension Dynasplint.*

CASE STUDY

A 13-year-old male patient was referred to physical therapy September 21, 1981 by an orthopaedic surgeon for hot moist packs, active and resistive exercise, with additional instructions of no passive range of motion to the elbow. It was reported by the patient that he sustained injury to the left elbow and forearm on August 7, 1981 when he fell from a fence. After being taken to a local hospital and diagnosed by the orthopaedic surgeon as having a posteriorly displaced supracondylar fracture of the left humerus and a distal radius fracture with accompanying fracture of the distal ulna, he was placed for 17 days in skeletal traction with a transverse pin through the proximal ulna for purposes of closed reduction of the supracondylar fracture (Fig. 3). The distal radius and ulnar fractures were reduced with closed reduction and temporarily immobilized with a soft cast. Following skeletal traction, a short arm cast was applied for an additional 2 weeks. After the cast was removed, the patient returned to school and was told by the orthopaedic surgeon to actively exercise his elbow and wrist to help improve strength and range of motion. Two weeks following cast removal, he was referred for physical therapy.

Fig. 2. *Dynasplint applied to patient.*

On arrival at the physical therapy clinic September 23, 1981, the patient did not report any pain at rest, but had some tenderness around the elbow region particularly in the antecubital fossa. He occasionally noted a "shocking" sensation into the ulnar side of the hand when he clapped his hands. He was using his arm somewhat but was concerned with the extreme stiffness of the elbow.

He was an eighth grade student attending school full-time. The past history, not specifically related to his present injury and sequelae to it, was unremarkable. His chief complaint was stiffness in the elbow and wrist.

Fig. 3. *Posteriorly displaced supracondylar elbow fracture.*

Fig. 4. *Elbow flexion contracture of 53°.*

EXAMINATION

The initial examination was performed on September 23, 1981. The general appearance of the elbow was marked by apparent, hard tissue swelling at the supracondylar region of the humerus. There was marked atrophy of the thenar and hypothenar muscles in the hand. The forearm muscles were also atrophied. The elbow, forearm, and wrist range of motion were limited in varying degrees. The greatest limitations were noted in elbow extension, wrist extension, and forearm supination (see Fig. 4 and Table 1). Strength of the elbow was significantly diminished although thorough, manual muscle testing was not administered at the time of the initial evaluation. On October 7, 1981 an individual manual muscle test was performed on muscles of the forearm, wrist and hand, especially the dorsal and palmar interosseous muscles, both groups of which were graded between 20 and 30% of normal. The wrist flexors and extensors tested at 70–75% of normal strength. Other muscles tested not only indicated a pattern of general disuse weakness about the elbow, wrist, and forearm, but also a specific pattern of ulnar nerve distribution weakness extending into the hand. It was believed that there was some ulnar nerve compression in the ulnar notch at the elbow during the initial stage of fracture reduction and healing. However, surgical intervention for relief of this compression was not necessary. Additionally, there was a positive Tinel sign at the ulnar notch.

TREATMENT PROGRAM

The initial treatment had consisted of moist heat and active exercise to the left elbow, wrist, and forearm regions. The patient attended the physical therapy clinic two times per week for 4 weeks, once per week for 8 weeks, then once every 2

TABLE 1
Range of motion

	1981						1982		
	9/23	10/2*	10/16†	11/9	11/30	12/14	1/5	2/1	3/1
Left wrist flexion	50	65	75	76	82	88	90	90	90
Extension	20	50	58	62	65	75	78	77	78
Forearm supination	15	20	30	38	42	47	55	57	62
Pronation	40	45	47	56	57	58	60	60	60
Elbow flexion	98	107	112	110	112	117	120	118	120
Extension	−53	−43*	−28	−24	−18	−14	−10	−6	0

* Elbow Dynasplint daytime application begins.

† On October 19, 1981, the elbow Dynasplint was worn through the night for the first time and was no longer worn during daytime.

weeks for an additional month, followed by a final 1 month follow-up. Observation in the physical therapy clinic spanned approximately 5½ months.

Initially, the active exercise program in physical therapy consisted of forearm supination, elbow extension, elbow flexion, and wrist extension. He tolerated these well. Several days later, he was given a progressive resistive exercise program for the arm, forearm, and hand muscles. Because the patient had already been performing some active exercises on his own for approximately 2 weeks before attending physical therapy, he was permitted to start on the elbow Dynasplint 10 days after the initial visit in the physical therapy clinic (see Table 2 for elbow extension Dynasplint protocol).

The patient wore the elbow Dynasplint ½-hour each visit on the setting of one in the physical therapy department starting October 7, 1981. After four visits, he used the Dynasplint at home during the day for up to 1-½ hours twice per day until 2 weeks later when he began sleeping with it at night. Other active and resistive exercises were continued during the months the Dynasplint was used.

On March 1, 1982, the Dynasplint was discontinued as his elbow extension reached 0° with virtually no limitation toward extension (see Fig. 5).

DISCUSSION

It should be noted that there existed anterior blockage from a fracture fragment to the elbow region. The orthopaedic surgeon expected this to give him some prolonged limitation for achieving maximum elbow flexion. With 120° elbow flexion

TABLE 2
Elbow extension Dynasplint protocol

1. The first couple days the Dynasplint is worn, have the setting on the scale register between 1 and 2 and have the patient wear it between 1 and 2 hours each day. Generally, a setting of 1 on the scale is recommended but, in cases where the flexion contracture is less than 20°, a setting closer to 2 on the scale may be desirable.
2. The patient should not feel much, if any, tension from the spring in the first 5–10 minutes. If he does feel a stretching tension in the elbow in this first 5–10 minutes, it is likely that there is far too great a beginning tension in the spring.
3. After the patient tolerates wearing the Dynasplint 1–2 hours in the daytime, encourage the patient to sleep with it at night, keeping the tension on the spring on the same scale of 1 to 2.
4. It is likely that the patient will have difficulty sleeping through the whole night for several nights. When they awaken have them take the Dynasplint off the remainder of the night.
5. After three to seven nights they should start adapting to being able to wear the Dynasplint through the entire night without awakening. When they awaken in the morning, they should experience discomfort in the elbow for up to, but not exceeding, 1 hour after its removal. If they are experiencing discomfort in the elbow beyond an hour, then the tension level is too high; therefore, decrease it by ½ of a mark. If they experience no discomfort in the elbow after its removal in the morning, then increase the tension level on the scale by ½ of a mark.
6. If after 7 nights they are still awakening with the Dynasplint in the middle of the night and complaining of discomfort in the elbow, then decrease the tension on the spring by ½ of a mark, since it is very desirable to get them to be able to sleep through the entire night with the Dynasplint on. If they are complaining of some other discomfort, perhaps from pressure from the counter-strap or from numbness or tingling in the hand, then adjusting the counter-strap or one of the cuffs may be necessary. However, when making adjustments of the cuffs or the strap please note that ever so slight an adjustment will make the difference between success and failure.
7. With the above steps taken to encourage the patient to sleep with it at night, and the patient still is unable to sleep through the entire night, then resign use of the Dynasplint to daytime applications. Wearing the Dynasplint 2 hours or more will be effective at the low tension level setting of 1 to 3. Consideration should be given in these cases for applying the Dynasplint twice per day for 2–4 hours each. If they are wearing it during the day, make sure they are not keeping their arm flexed beyond the point of the contracture all the time. Flexing the elbow joint periodically is permissible in order to relieve some of the stretching tension in the elbow.
8. The older the contracture and the more severe the patient's condition, the longer the length of time necessary for using the Dynasplint. A range of 2 months to a year can be expected for resolution of the contracture with 2–5 months necessary for newer contractures and 6–12 months being necessary for old contractures. The older the patient, the slower the progress.
9. While increasing both the Dynasplint wearing time and tension level of the spring is generaly desirable, the most important consideration should be given to increasing wearing time to its maximum (in most cases overnight application) before advancing the tension on the spring beyond 1 to 3. Once the optimal wearing time is achieved, gradually advancing the spring tension can take place but only if the patient's tolerance permits it (see paragraph 5 for expected reactions). Advance the spring by no more than ½ notch on the gauge at a time. In time, a tension level will be reached beyond which further advances will not be necessary in order to reduce the contracture but would actually make the patient too sore for the patient to tolerate it. Therefore, keeping a lower level of spring tension for a greater number of weeks will result in greater success at reducing the contracture than trying a higher level of force in a fewer number of weeks.

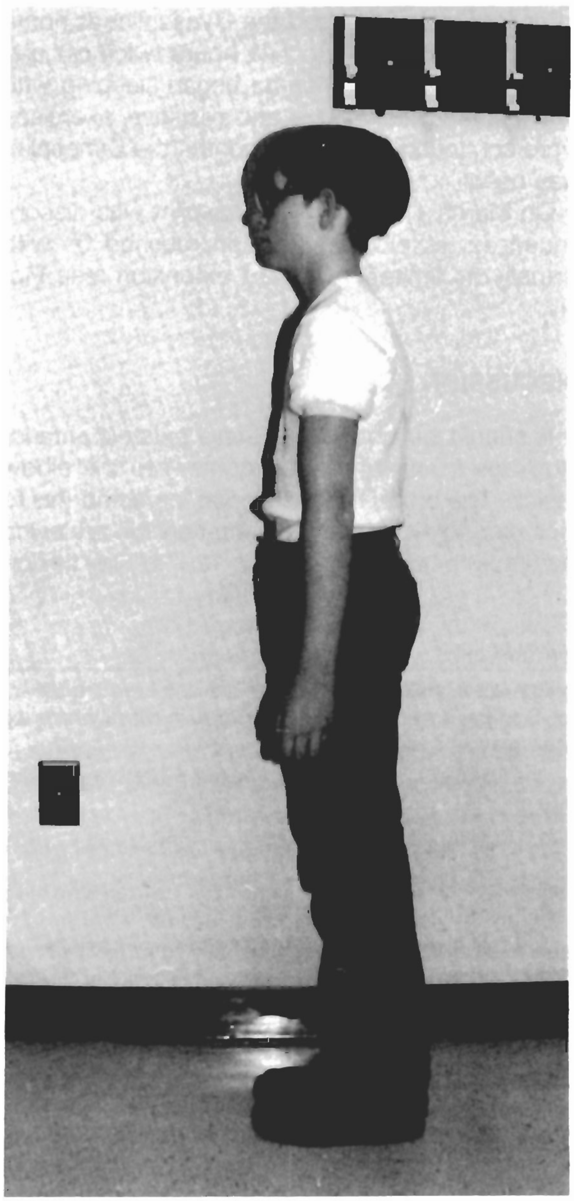

Fig. 5. *Complete elbow extension achieved.*

achieved, the patient was satisfied with the ability to use his hand for all functional activities.

The patient was very pleased with the achievement of full elbow extension. Other joint ranges of forearm supination and pronation, wrist flexion and extension made considerable improvement as well. Strength had improved considerably but there remained some weakness of the intrinsic muscles of the hand. In February 1982, muscle testing revealed that the intrinsic muscles of the hand tested at 75% of normal and therefore were no longer of major concern as it was felt that they would reach 100% of normal with continuation of the home exercise program.

It should be mentioned that although 11° of elbow extension was gained in the first week of formal physical therapy treatment, that 11° represented the "easy" degrees of improvement which is frequently obtained when a patient initially begins a treatment program learning proper exercise methods. At −43° elbow extension, when the Dynasplint was added to the treatment program, the end feel was springy and nearly abrupt (all elbow flexor muscles were palpably relaxed when this determination was made) toward elbow extension. It was felt by the attending physical therapist that this limitation of 43° elbow extension would be very difficult if not impossible to completely eliminate using those conventional physical therapy techniques known to him. However, with use of the elbow Dynasplint, full elbow extension was achieved.

SUMMARY

This case presented a typical and difficult problem encountered by the orthopaedic surgeon and physical therapist following fracture and other trauma about the elbow. That specific problem being gaining satisfactory joint range of motion and in particular, gaining full elbow extension. The use of an adjustable dynamic splint called the elbow Dynasplint was incorporated early into the treatment program and contributed significantly, and probably chiefly, to the achievement of full elbow extension.

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