
Managing the Stiff Elbow: Operative, Nonoperative, and Postoperative Techniques

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ABSTRACT: Elbow contracture may be caused by intrinsic or extrinsic limitations or a combination of both. Evaluation of the specific structures guides the development of an effective therapy treatment program. Intrinsic contractures are by definition due to joint/intra-articular incongruency, and therefore therapy and splinting cannot provide increase in joint motion. Nonoperative therapy treatment options include heat modalities, myofascial soft tissue mobilization, joint mobilization, muscle energy techniques, passive range of motion, active range of motion, extensive use of corrective splinting, and strengthening exercise. All operative candidates must participate in a preoperative therapy program of six to eight weeks to reduce extrinsic contractures as feasible and to assess patient compliance with an intensive postoperative therapy program. Corrective splinting may be needed for as long as six months to maintain gains made in surgery. The therapy following manipulation under anesthesia and open contracture release is similar. The therapist must know the details of the procedure. Operative treatment for the stiff elbow progresses in a sequential fashion to progressively release tissue structures limiting motion and reconstruct any structures as needed to provide joint stability. Postoperative therapy consists of continuous passive motion, corrective splinting, modalities, and specific exercise techniques to maintain passive gains achieved in surgery. The therapy is extensive and requires full participation from the patient to maximize motion and function. Complications of elbow contracture release include nerve palsy or nerve injury, seroma, joint instability, heterotopic ossification, and recurrence of elbow contracture.

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There is very little in published literature about the specific therapeutic management of the stiff elbow. Most often, the discussion of therapy is contained in papers on the surgical management for elbow limitation. The information is often global rehabilitation concepts rather than specific evaluation and treatment. Due to the significant limitation in evidence-based treatment, this article serves to introduce therapy treatment concepts that will then require comparative studies to identify the most effective treatment for the stiff elbow. Elbow stiffness after an injury is a most challenging dilemma for the surgeon, the therapist, and the patient. The elbow serves as a link to place the hand in space and act as a stabilizer for lifting, carrying, pushing, pulling, and throwing. It is a load-bearing joint during closed chain activities and positions the

hand for fine motor function. The elbow must have mobility, stability, and strength and be pain free to allow independent function in daily activities including the physical demands of work and recreation. Without a functional, pain-free elbow, hand function is significantly limited. Optimal outcome after elbow injury requires that surgeon and therapist address all aspects of elbow function simultaneously.¹⁻³

The highly congruous articular surfaces of the elbow joint provide static elbow stability with contribution from the anterior and posterior capsule, and the collateral ligaments. The elbow flexor and extensor muscles provide dynamic stability.⁴⁻⁷ Morrey et al.⁸ reported functional range of motion (ROM) for the elbow to be 30° extension, 130° flexion, and 50° pronation and supination. The patient can compensate for the loss of extension by moving closer to the target object, but he cannot flex the neck and wrist enough to reach the face if flexion is less than 105–110°. Extension contractures are less common than flexion contractures but are considerably harder to treat from the surgical point of view. ROM deficit in

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extension tends to be greater than the flexion deficit in most injuries and is more challenging to restore for the therapist and patient.

CAUSES OF CONTRACTURE

Elbow flexion contracture is the most common complication after injury to the elbow. Contracture may develop following traumatic injury such as fractures and/or dislocations or may develop as the result of an acquired condition such as arthritis, head injury, sepsis, or paralysis. Reported reasons for loss of motion include prolonged immobilization, soft tissue trauma, intra-articular trauma, and heterotopic bone formation.⁹

The elbow is inherently predisposed to loss of motion. The stability of the elbow is provided by 1) the highly congruous articular surfaces, 2) the anterior and posterior capsule, and 3) the collateral ligaments. Any change in the articular surfaces can cause impingement and restricted motion. The three articulations of the elbow, ulnotrochlear, radiocapitellar, and proximal radioulnar, are covered in a single joint capsule that is uniformly thin and vulnerable to injury. The collateral ligaments of the elbow are slack between 70° and 100°, which further encourages the elbow flexion contracture.¹⁰

Elbow contracture may be caused by intrinsic or extrinsic limitations or a combination of both. Extrinsic causes include contracture of the joint capsule and ligaments, muscle contracture, adherence, extra-articular osteophytes, and ectopic ossification. Intrinsic causes include intra-articular adhesions, incongruity, osteophytes, loose bodies, and chondral defects. Of course, contracture and stiffness may also be caused by a combination of extra-articular and intra-articular factors.¹¹ Other possible causes for the stiff elbow may include fracture nonunion, malunion, joint instability, or subluxation.

The terms "extrinsic" and "intrinsic" are used to describe types of contracture for purposes of classifying certain types of contracture from another. It is important for a therapist to know how much intra-articular or intrinsic pathology is present. Significant intrinsic pathology cannot be treated effectively with therapy. The therapist's interventions can usually address only extrinsic contracture.

Factors that contribute to the development of elbow flexion contracture have been reported in the literature. They include the severity of the trauma, intra-articular involvement, and the duration of immobilization.¹² Following injury, the capsule can thicken as much as 3–4 mm.^{5,13,14} After injury, capsular thickening and contracture of the capsule develop within days. The biological response to the chemical irritation of blood in the joint and the co-contraction of the brachialis, which is a response to pain, lead

to capsular contracture most commonly in the anterior compartment. If capsular injury occurs, as in dislocation, the posterior capsule generally does not tear. The anterior capsule is almost universally disrupted. The anterior capsule itself is reformed and becomes limited in extension. The co-contraction of the brachialis and other elbow flexors limit the extension of the elbow dynamically during the healing phase.¹⁵ This allows the anterior capsule to scar down in a shortened and thickened fashion. The "anterior capsule often becomes hypertrophic and can both 'tether' extension and 'block' flexion."⁵

The elbow extension contracture is another issue entirely. The posterior joint capsule itself rarely is a source of extension contracture clinically. The triceps, however, can develop adherence to the posterior humerus and the joint capsule and limits flexion in the post-traumatic stiff elbow. From a surgical point of view, patients who have an extension contracture are much more difficult to treat surgically than those patients with a flexion contracture. Elbow extension contractures more commonly occur in the patient who has sustained a head injury or suffered multiple trauma.¹⁶ The arm/elbow positioning may be ignored due to focus on a number of factors including life threatening injuries and long bone fractures. These patients can be comatose or have very limited cortical control and have elbows that are typically splinted in extension. The appropriate treatment for these patients would include passive ROM of all joints, particularly the elbow at least twice daily. It has been our experience that due to limitations in cost and attention to other injuries, maintaining ROM of potentially uninjured or minimally injured joints tends to be at the bottom of the priority list. Fortunately, the incidence of elbow extension contractures has been decreased as a result of the education of trauma surgeons and neurosurgeons in this complication.

Elbow extension contracture is not as prevalent in our experience. Everyone, including the therapist, physician, patient, and family can recognize an elbow flexion contracture. If the elbow is not visually straight, that is abnormal. The degree of normal elbow flexion varies among patients. In the literature, exact degrees of flexion are recorded, generally without comparison to the contralateral side, with 130° being universally accepted as "adequate flexion."³

Generally elbow capsular distension does not contribute to an elbow contracture as often the anterior capsule is disrupted, essentially relieving capsular pressure. However, in isolated radial head fractures without dislocation and in unicondylar fractures without dislocation, the anterior capsule is not disrupted. Intra-articular effusion may distend the intact redundant anterior joint capsule and pull the elbow into flexion.

THERAPISTS' DIFFERENTIAL EVALUATION OF THE STIFF ELBOW

Often the patient is referred to therapy with little more than a diagnosis of a "stiff elbow." The diagnosis of a "stiff elbow" may not be helpful in addressing a patient's problem. Before seeing the patient, the therapist should obtain detailed information regarding the patient's history, injury, surgery, and prior therapy. It is important to review the physician's office report, surgical report, and x-rays. Before initiating therapy, the therapist should know if there is hardware that may impede motion or joint subluxation/instability. Through examination and evaluation, the therapist should determine the nature of the stiffness or limitation. The therapist must thoroughly evaluate the specific intrinsic and extrinsic structures and develop an effective therapy treatment program specific to the problems identified. This is key to developing an effective rehabilitation program focused on maximizing function.

Active and passive ROM measures of the elbow and forearm motions should be made and recorded. It is important to know which motions are limited but also important to assess what specifically is causing the restriction before a realistic and effective therapy program can be developed. ROM may be limited due to a number of factors (Table 1). Compensatory motions at the shoulder can occur with any injury or disease affecting elbow mobility. These injuries and diseases also affect the wrist, forearm rotation, and the hand. Assessment and documentation of shoulder ROM and shoulder co-contraction are important to designing comprehensive, effective therapy treatment. Glenohumeral, scapulo-thoracic motion, and wrist and forearm rotation must also be evaluated for pathology that may contribute to functional limitations.

The stiff elbow is rarely painful at rest or throughout the available range. The patient with the stiff elbow usually complains of pain at the end range. This pain at end ROM may be a limiting factor that delays recovery or limits final outcome. The therapist should assess the source of pain. If pain is present within the available arc of motion, it may be due to intrinsic pathology such as arthrosis, arthritis,

intra-articular incongruity, or damage or developing heterotopic ossification. Pain may also be due to paresthesia from nerve compression or due to a hypersensitive scar. The therapist and referring surgeon will need to communicate their findings regarding pain from intrinsic or nerve problems to determine if therapy can continue.

Edema at the elbow and all other distal structures can be significant after injury and may persist for weeks and even months. The hand can be impressively swollen. Clawing of digits or intrinsic muscle contracture may occur in severe injuries if the hand is not addressed. Initially, swelling is a pitting-type of edema. If it persists, it becomes firm and brawny. Elevating the elbow above heart level can be difficult and cumbersome for the patient and swelling thus tends to pool medially and in the proximal, volar aspect of the forearm. Edema is best measured circumferentially with a tape measure initially comparing it to the uninvolved side and then monitoring it during the course of rehabilitation.

The therapist should evaluate the sensory and motor function of ulnar, median, and radial nerves. Injury to a nerve may have occurred at the time of the injury or at surgery.

The biceps and to a lesser extent the triceps may become tight due to limited use and immobilization. The therapist must identify the specific structures that are tight and/or adaptively shortened. The long head of the biceps originates from the supraglenoid tubercle and the short head from the coracoid process of the scapula. The long head of the triceps originates from the infraglenoid tubercle of the scapula and stabilizes the shoulder joint. The biceps and triceps may be involved as the biceps and the long head of the triceps cross both the glenohumeral and elbow joints. There could also be tightness or contracture of the compartments of the forearm extensors or flexors. The extensor-supinator muscles in the forearm originate from the lateral epicondyle, and the flexor-pronator muscles originate from the medial epicondyle. Except for the supinator, pronator teres, and the brachioradialis, the remaining muscles of the forearm compartments insert in the wrist and hand. The position of the shoulder, forearm, wrist, and digits may affect elbow motion. Elbow extension and flexion should be measured with and without composite stretch of the biceps, triceps, flexor, and extensor compartments and with and without forearm supination and pronation to best identify contributing limitation of the respective muscle groups. To determine whether the biceps is in spasm or shortened, one can perform the differentiating exam described by Bankov.¹⁷ It is a clinical exam and as such specificity and sensitivity have not been determined. At maximum available extension, the biceps will be firm to palpation with supination indicating muscle spasm. The forearm is then passively pronated,

TABLE 1. Factors Limiting Elbow Range of Motion

- Pain
- Edema
- Intrinsic limitations: intra-articular
- Extrinsic limitations: joint capsule, muscle contracture, adhesions of muscle, tendon, nerve
- Nerve compression
- Neuropraxia
- Muscle weakness
- Muscle inhibition
- Muscle co-contraction
- Scar contracture

while maintaining the elbow extension. The biceps is inhibited and relaxed in pronation and will allow further elbow extension. If the biceps is shortened, there will be no further available elbow extension and may further flex as the biceps is stretched across the elbow. The evaluation should be performed while the patient is in the supine position. This position not only provides stabilization of the scapula, but eliminates the force of gravity on the biceps. We have found that the patient with a stiff elbow identifies the pull of gravity on elbow flexors as a painful entity. Evaluation and rehabilitation of the painful elbow with the patient in the supine position can potentially reduce muscle co-contraction and guarding.

To measure the length of the biceps, elbow extension is measured with the shoulder in neutral or slight forward flexion and then in hyperextension. If the biceps is adaptively shortened, elbow extension will be greater with the shoulder in flexion than in hyperextension.

To measure the length of the forearm muscles, the wrist is measured with composite stretch of the forearm compartments. Wrist flexion is measured with the hand fist and the elbow in flexion and then extension. Wrist extension is measured with the digits in full extension and the elbow in flexion and then extension. If there is tightness, wrist flexion and extension will each be greater with the elbow in flexion than with the elbow in extension.

If elbow ROM is limited with the muscles on a slack with the hand/wrist and shoulder in neutral position, then this could indicate a joint capsular contracture.

Forearm supination and pronation should be isolated, measured, and recorded. The authors' preferred method for measuring forearm rotation is with elbow at 90°, the axis of motion of the goniometer at the ulnar aspect of the distal radioulnar joint, the stationary arm vertical and perpendicular to the floor, and the moving arm proximal to the wrist crease, across the distal radio-ulnar joint.

Muscle guarding or co-contraction of the antagonistic muscles and muscle spasm limit active and passive ROM. The therapist should determine whether co-contraction is occurring. Bankov¹⁷ reported that the biceps brachii reacts with active muscle contraction and spasm after elbow injury. Page et al.¹⁵ studied electromyogram (EMG) activity in stiff and normal elbows during elbow flexion and extension. In patients with elbow stiffness, the biceps brachii co-contracted during active elbow extension and during prolonged passive elbow extension positioning. The addition of a 3-lb weight to the distal forearm with elbow extension resulted in greater EMG activity in all three elbow flexor muscles (biceps brachii, brachialis, and brachioradialis).¹⁵

Muscle inhibition may limit active ROM. It is the authors' observation that the triceps is often inhibited

and difficult for the patient to isolate. With the hyperactivity of the biceps co-contracting, there may be reciprocal inhibition of the triceps. During attempts to extend the elbow in the sitting or standing position, the elbow extends with an eccentric or lengthening contraction of the biceps and the assistance of gravity rather than by active concentric, shortening contraction of the triceps. During the early, protective phases of injury healing, the patient tends to carry the arm in a protected adducted position with the elbow flexed. The triceps is relatively inactive and with non-use, the muscle tends to become progressively weak. Over time, the triceps also seems to lose its proprioceptive feedback and then the patient has difficulty isolating elbow extension. Triceps function, therefore, should be tested against gravity with the patient supine and the forearm overhead, or the elbow may be positioned so that the pull of gravity on the triceps is eliminated. The influence of injury on triceps function is significant. This is yet another reason for elbow evaluation and rehabilitation to occur in part with the patient in a supine position.

Scar contracture and hypersensitivity can also significantly limit elbow motion and function. The therapist should evaluate the scar for hypertrophy, adherence, pliability, and sensitivity. The scar quality, location, and size should be documented. Signs of skin blanching and tucking with stretch indicate restriction of motion. Testing for Tinel's sign is also helpful in assessment of the source of postoperative pain, and a positive test could imply cutaneous or peripheral nerve injury. The therapist should communicate any and all findings to the surgeon so that pain relieving strategies such as electrical stimulation for pain control or medications can be prescribed to facilitate rehabilitation.

NONOPERATIVE REHABILITATION OF THE STIFF ELBOW

Physical Agents

The goal of contracture management is to increase tissue extensibility with plastic elongation or growth of the contracted soft tissue structures.¹⁸ Therapeutic heat can be used to prepare the involved tissue for effective stretching. The biophysiologic effects of heat include increases in blood flow and tissue extensibility, and decreases in joint stiffness, pain, and muscle spasm.

Superficial heat can be applied to the elbow in the form of hot packs, electric heating pad, or fluidotherapy. Heat can be very beneficial in achieving increased plastic elongation of connective tissue when applied in combination with prolonged, low load, steady stretch. To provide flexion stretch with heat, the elbow can be wrapped with an elastic

bandage in tolerable flexion in a gravity eliminated or gravity assisted position to minimize co-contraction of the triceps. The therapist should monitor the patient for ulnar nerve paresthesias and position the elbow in the angle of flexion that does not provoke the paresthesias. As the patient improves, more flexion without paresthesias should be tolerated. To provide elbow extension stretch with heat, the elbow is positioned in maximum tolerable extension in pronation with gravity eliminated to prevent co-contraction of the biceps. The patient may also be asked to progressively extend the elbow actively during the heat application.

Fluidotherapy is another heat modality option. The dry heat provided by fluidotherapy is more vigorous, and the elbow is exposed to the therapeutic temperature for the entire 20-minute duration. If the patient's arm is not too long for the inside dimensions of the machine, the elbow can be positioned in extension during the treatment.

Ultrasound provides deep heat reaching tissue depths of 3 cm. Ultrasound can selectively heat deeper muscle and joint capsular tissue increasing extensibility temporarily. Ultrasound is most effective when followed by manual tension applied to the restricted structure(s).

Myofascial Soft Tissue Mobilization and Joint Mobilization

Soft tissue mobilization and myofascial release techniques applied to the skin, fascia, muscles, and tendons can help increase tissue flexibility. Specific techniques include massage, pressure, skin rolling, twisting, and wringing. Applying pressure and stretch in the direction of the tissue restriction, reportedly causes myofascial lengthening and decreased muscle tension. The patient participates and assists with the soft tissue mobilization through positioning, breathing, and resistive movements to help localize the pressure and directional force applied by the therapist.¹⁹ Manual therapy/joint mobilization techniques as described by Kaltenborn and Maitland can be beneficial in increasing ROM in the stiff elbow. Joint distraction and grade III and IV mobilization at end range can be effective especially if it is followed with active and passive stretching. The reader is referred to therapy literature and course work in manual therapy including soft tissue mobilization and joint mobilization for more details.^{20,21}

Range of Motion

Passive ROM should immediately follow the application of heat when the tissues are more responsive to stretch. The goal of progressive ROM (PROM) is to increase ROM by lengthening tissue, not by tearing tissue. Plastic tissue elongation/growth

occurs with moderate constant tension. Passive manual force should be specifically applied to each extrinsic structure previously identified as being involved and contributing to the elbow stiffness and contracture. PROM should be applied with a low load and within tissue tolerance. The patient must be relaxed and avoid co-contracting and resisting the stretching force. The patient may feel discomfort from stretch but should not feel pain. Painful stretching elicits the protective stretch reflex, muscle guarding, and co-contraction. The manual force should be steady, prolonged and as the motion increases, the force and angle of the manual pressure should be adjusted. Passive stretching should also be of prolonged duration. Sustained stretch allows time-dependent stress relaxation to reduce muscle tension and to increase length. Twenty seconds of constant steady stress has been recommended to minimize or avoid the stretch reflex and may be repeated four to five times.²²⁻²⁵

Hold-relax and contract-relax are relaxation techniques based on proprioceptive neuromuscular facilitation (PNF) and can be effective in increasing elbow ROM limited by co-contraction and muscle hypertonicity.²⁶ Contract-relax and hold-relax techniques require maximum contraction facilitating voluntary relaxation. These techniques are beneficial where muscle spasm and pain inhibit motion by avoiding the strain and painful reactions to passive stretch. Contract-relax involves an isotonic contraction of the antagonist followed by a period of relaxation. Movement is then increased in the opposite direction. Hold-relax uses maximal resistance to produce an isometric contraction to achieve relaxation.^{25,27} For example, elbow extension may be inhibited by pain and muscle spasm of the biceps. By applying isometric resistance to the triceps, relaxation of the biceps is achieved, resulting in facilitation of the triceps and increased elbow extension. For detailed description and instruction in relaxation based on the techniques of proprioceptive neuromuscular facilitation (PNF) the reader is referred to the work described by Voss.²⁷

PROM should be followed by active ROM (AROM) recruiting the agonists, facilitating and reinforcing proprioception, and muscle re-education. Elbow extension should be emphasized because it is more difficult to obtain. The greatest challenges are isolating the triceps and preventing shoulder substitution. With elbow trauma, the posterior capsule, triceps muscle, and musculotendinous junction can be torn and injured but are rarely completely disrupted. If the patient does not engage the triceps early in the postinjury period, scarring to the posterior capsule and humerus is inevitable. In one of the author's (KJJ) experience, patients who have had surgical treatment for elbow injuries or have not had instruction in how to isolate and engage their triceps, it is a universal finding that when surgical release is necessary to

increase flexion, there is dense scarring of the triceps to the posterior cortex of the humerus and posterior capsule of the elbow.

The triceps can best be isolated in the supine position with the shoulder flexed to 90° and the elbow pointing to the ceiling. The shoulder is unloaded and the scapula is stabilized in supine. The patient extends the elbow with a concentric contraction of the triceps against gravity and reciprocal inhibition of the biceps. The patient then flexes the elbow with an eccentric contraction of the triceps. The authors' preferred method is active muscle contraction of the agonist reaching maximum available range, holding the end range for 5 seconds without co-contracting the antagonist for 15 repetitions for elbow extension/flexion and supination/pronation. Once the patient can isolate motor control with active elbow muscle contraction and reciprocal relaxation, AROM with functional activities should be emphasized.

Muscle Energy Techniques

Muscle energy techniques involve the patient actively contracting the involved muscle in a precisely controlled angle and direction with varying intensity of force, against a counterforce applied by the therapist.¹⁹ The patient contributes to the corrective force and therefore may control the force. The patient's active force can be in the form of isometric, concentric, and eccentric muscle contraction, and the patient's voluntary muscle contraction can range from a minimal muscle twitch to a maximal isometric contraction. The duration of the contraction can be from a fraction of a second to sustained effort lasting several seconds. The potential effects are inhibition of a hypertonic antagonist, relaxation of a hypertonic agonist, increased muscle tone, and lengthening of shortened muscle to mobilize a joint with extrinsic tightness.²⁶

Applied with appropriate intensity, muscle energy techniques can be physiologically and anatomically safe and can be valuable in treatment of the elbow contracture. The reader is referred to Greenman¹⁹ for more detailed description of the various muscle energy techniques.

Corrective Splinting

Once the elbow has become stiff with contracture of extrinsic structures, splinting may successfully resolve ROM deficits. Before beginning a corrective splinting program, the therapist must thoroughly evaluate the patient to identify the specific structure or structures contributing to the contracture: intrinsic, extrinsic, or combination. Splinting cannot increase motion limited by intra-articular or intrinsic causes.²⁸ Splinting the elbow with intrinsic pathology may provoke significant pain and inflammation and

further limit the patient's functional use of the involved arm.

There are various commercial and custom-fabricated corrective splint designs described in the literature. The reader is referred to the thoroughly detailed work on elbow splinting published by Griffith²⁹ and Blackmore.³⁰ To date there are no double-blind, prospective, randomized studies comparing the effectiveness of the various elbow splint types. Corrective splints are designed to apply low load, prolonged tension to produce plastic elongation of contracted tissue in the fibroplastic and remodeling phases of healing. In one of the author's (SD) experience, custom-fabricated serial static and static progressive splints are most effective in producing permanent ROM gains. The custom-fabricated splint is molded to the patient and therefore provides optimal contoured fit, which allows optimal alignment for well isolated corrective force and can be more comfortable for the patient. We find that the custom splint is better tolerated, minimizing or preventing an inflammatory response and maximizing elbow motion.

Flexion Contracture Splinting

For elbow flexion contractures, one of the authors (SD) has found the static progressive hinged extension turnbuckle splint to be most effective (Figures 1A and 1B). In our experience, the turnbuckle splint has been used to reduce flexion contractures of as much as 90° or more, successfully reaching 0°. The patient controls the extension force and position by turning the housing of the turnbuckle to separate the proximal and distal components to incrementally increase extension. The patient is instructed to increase the degree of extension until discomfort from stretch is felt but to avoid pain from potential tearing of soft tissue structures and provoking an inflammatory response. With the patient able to control the position to tolerance, total end range time can be maximized.

Green and McCoy²⁸ reported an average increase of 43° of elbow motion with extension turnbuckle splinting over 20 weeks in elbow flexion contractures of greater than 30° due to soft tissue contracture. Ideally, the forearm should be in supination to apply optimal tension of the anterior capsule and elbow flexors. Practically, the patient prefers to place the forearm in pronation to allow functional use of the hand while wearing the splint.

When flexion contractures are 30° or less, serial static extension splints may be considered. The splint is molded over that anterior arm and is progressively remolded in greater extension as motion increases. Blackmore describes the belly gutter splint for elbow flexion contractures based on the principles described by Wu³¹ for the proximal interphalangeal (PIP) belly gutter. The splint provides for three points



FIGURE 1. (A) Extension turnbuckle splint, medial view. (B) Extension turnbuckle splint, anterior view.

of pressure. The belly is molded over the antecubital fossa and the posterior elbow strap applies progressive force into extension.³⁰

Extension Contracture Splinting

A hinged elbow turnbuckle splint may also apply force into flexion for elbow extension contractures less than 95°. The turnbuckle is opened to maximum length before attaching it to the thermoplastic. As the housing is turned, it brings the proximal and distal components together to position the elbow in progressively increased flexion. A hinge is not required for static progressive flexion splinting for elbow extension contractures of 95–100° or more. The authors have found the cuff and collar design to be very effective (Figures 2A and 2B). The proximal component is a collar around the shoulder, secured with straps under the contralateral axilla and the distal component is a dorsal wrist/forearm cuff with a volar bar. Nonelastic tension is applied via a monofilament that is progressively shortened to position the elbow in greater degrees of flexion.

Supination/Pronation Contracture Splinting

Forearm rotation contractures are common after elbow injury with pronation contractures more common than supination contractures. The forearm tends to rest in pronation after an elbow injury with the wrist in flexion. A soft tissue, extrinsic pronation contracture develops as the three elbow flexors (brachialis, biceps, and brachioradialis) and the accessory lateral collateral ligament are in a lengthened position in pronation. The proximal radio-ulnar joint may also develop an intrinsic contracture due to

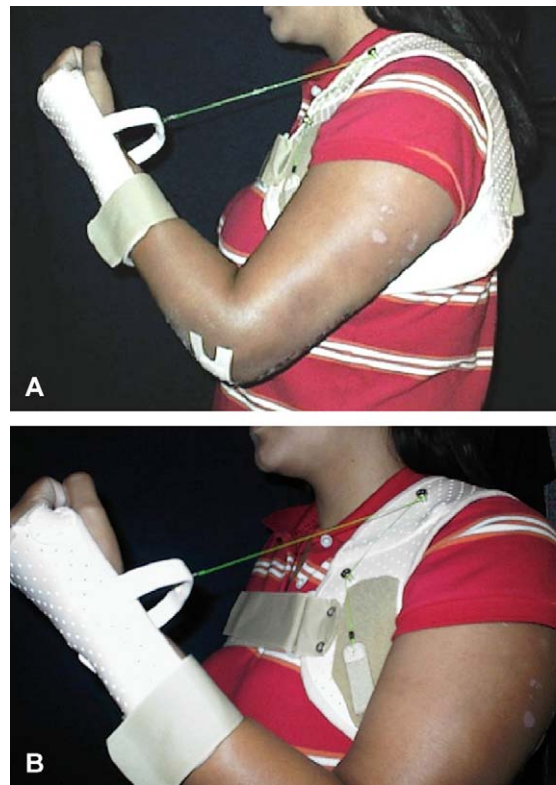


FIGURE 2. (A) Static progressive elbow flexion splint, lateral view. (B) Static progressive elbow flexion splint, anterior view.

intra-articular damage from a fracture dislocation.²⁹ The authors have had success in correcting forearm rotation contractures with a custom-fabricated static progressive splint (Figures 3A and 3B). Both supination and pronation can be corrected with one splint. The corrective force is applied with one outrigger attached to a distal forearm based wrist gutter component, and another outrigger attached to a proximal component holding the elbow at 90°. The inelastic corrective force is applied via a monofilament or Velcro™ strap. As the filament/Velcro™ strap is shortened, the forearm is rotated and held at maximum available end range.

A corrective splint may be needed to correct elbow contracture in each direction: extension, flexion, supination, and pronation. It is neither practical nor effective for a patient to use splints to correct more than two directions during waking hours. If all four directions require splinting, it may be more effective to prioritize two motions during the day initially to provide enough end range time to improve ROM. If splints are used for all four directions during the day, there may not be enough end range time in each splint to create changes in ROM. It has been the authors' experience that therapy and functional activities tend to be more effective in improving elbow flexion and pronation. Elbow extension and supination deficits tend to be greater, more difficult to regain, and are therefore usually the priority for



FIGURE 3. (A) *Static progressive forearm supination splint, lateral view.* (B) *Static progressive forearm supination splint. View of outrigger.*

corrective splinting. At night, elbow extension splints may be more easily worn allowing the patient to alternate between supination and elbow flexion splints during the day if needed. In this therapist's (SD) experience, six hours or more of total end range time in each splint is effective in correcting contractures.^{32,33} Corrective splinting may be necessary for six months before gains in motion can be maintained without splinting.

In order for corrective splinting to be effective, the therapist should monitor and adjust the fit of the splint as needed for comfort and as the patient improves. The therapist must also be aware of potential problems from splinting. As elbow flexion increases, the patient may experience ulnar nerve symptoms. Pressure from the splint over the dorsal sensory branch of the radial nerve may cause paresthesias and hypersensitivity. The splint schedule may need to be modified to shorter, more frequent periods, and/or splint adjustments may be necessary to increase wearing tolerance.

Strengthening Exercise

Strengthening exercise should be included in the elbow rehabilitation program to increase and maintain function as ROM improves. The strengthening program should address elbow flexors and extensors, wrist flexion and extension, and supination and pronation using isotonic, concentric, and eccentric exercises. The patient may begin with low weight, submaximal effort, and high repetitions to include the biceps and triceps, and wrist curls with the forearm in pronation and supination. A weighted bar can be used for supination and pronation

strengthening. Isotonic exercise can be performed with free weights, wall pulleys, and elastic bands to isolate specific muscle groups or motions, using straight planes or diagonal patterns, emphasizing concentric or eccentric muscle contraction. Instrumented dynamometers such as the BTE (Baltimore Therapeutic Equipment, Hanover, MD) and its various tools can be used for exercise routines emphasizing functional tasks specific for work or sport. Exercises to promote proximal stabilization rotator cuff musculature should also be included with any strengthening program for the elbow as should grip strengthening.³⁴

Early strengthening should include progressive resistive exercise to help incorporate motion and strength into activities of daily living (ADLs) and functional activities for home and work. The strengthening program should then progress to job or sport specific exercise and activities that focus on appropriate muscle strength, power, speed, endurance, and coordination. Weight-bearing, closed chain, and open chain exercise should be considered to maximize potential task-specific function for return to work or sport. A work hardening program may be indicated or the patient may need to progress to a sport training/conditioning program. Wilk et al.³⁵ describe an excellent progressive strengthening and functional retraining program for baseball pitchers.

SURGEON'S EVALUATION OF THE STIFF ELBOW

The surgeon's initial evaluation of the patient with a stiff elbow includes a detailed history regarding any and all injuries (including head trauma and peripheral nerve lesions), injuries to other areas of the body that affect ambulation, posture and use of the involved extremity. Details of all previous surgical procedures, treatments, and/or testing must all be reviewed and assessed prior to establishing a treatment plan. Assessment of the patient's current medical status is imperative. Not all patients with stiff elbows are candidates for surgery. All organ systems must be assessed. Consider that an otherwise young, physically healthy patient with a central nervous system injury leading to limb neglect, spasticity or paralysis, or cognitive problem could certainly undergo a surgical release without concern of anesthetic risk, however, would likely not be able to comply with any or all of the postsurgical therapy. Such a patient would be a poor surgical candidate.

Further current history is also imperative. What is it that bothers the patient about his or her elbow or extremity? Is the pain activity related or present at all hours of the day and night? Activity-related pain and pain at extremes of motion are typical. In general, a stiff elbow secondary to arthritis typically is not

painful at rest. If pain is present and problematic, the pain must be localized, assessed, and documented. Pain and ROM in adjacent joints or other areas of the limb need to be documented. Symptoms suggestive of peripheral nerve injury or compression should be investigated and recorded. The ulnar nerve is universally affected to some degree in patients with stiff elbows. Symptoms may be medial elbow pain, weakness, or hand cramping rather than sensory loss in the typical ulnar nerve distribution. Nocturnal symptoms are common, as are symptoms that occur at the extremes of elbow flexion and extension. The detailed physical examination to follow the history will help in diagnosis.

The physical examination is key to designing an individualized treatment for any given patient. The status of the soft tissue envelope about the elbow, including location of scar(s), skin hypersensitivity, swelling, or atrophy, is assessed first. Generally, the patient's resting position is assessed during the history, as are behaviors, adaptive or otherwise, as to how the patient's arm functions in its current status. This can be observed by how/if the patient gestures with the extremity, hikes up the shoulder during movement, continuously rubs the arm, or keeps it covered and warm.

Unless the patient's clothing allows access to the entire extremity, including the shoulder girdle and cervical spine, clothing must be removed and women should don a gown. The exam begins with examination of joints and body parts relatively remote to the elbow. Examination of the cervical spine is first, then the shoulder, hand, and wrist should also be examined. In addition to a detailed musculoskeletal examination, peripheral nerve and vascular examination are imperative, especially in the patient who has had multiple procedures and/or significant trauma. Skin temperature, erythema, sweat patterns, hair growth, and atrophy are all important.

The final step in the initial assessment of the stiff elbow is imaging and other indicated testing based on the history and physical examination. One of the authors (KJJ) believes that computerized tomography (CT) and electrodiagnostic testing with electromyography are helpful in most all cases. CT provides the best combination of information regarding fracture healing, joint congruency, and the presence and location of heterotopic bone, if present. Aspiration arthrogram followed by CT is occasionally preferable to CT alone if there is a history of septic arthritis, inflammatory arthritis, or other pathology in which joint fluid analysis and culture are needed.

PATIENT SELECTION

Not all patients with limited elbow mobility are operative candidates. It is one of the author's (KJJ)

practice to interact with the patient and his family and confer with the therapist on several occasions before considering operative intervention. After the initial office visit, patients are typically referred for additional imaging and testing and referred simultaneously to the therapist for soft tissue mobilization, nerve and tendon gliding, and corrective splinting. Although many patients present with a history of previously having "failed treatment with physical or occupational therapy," at least in our environment, it is a rare therapist who has the training or experience to treat complex elbow disorders. Unless the surgeon knows the therapist, or has adequate documentation of the appropriate therapy that took place, it is assumed that adequate nonoperative treatment has not necessarily been performed.

Generally speaking, the benefit of therapy and splinting will be limited if ROM is limited by intrinsic contracture, with a hard end feel that has been chronic for more than 12 months. Contractures that are in the late fibroplastic or remodeling phase, of less than 12 months duration, that are due to extrinsic causes, and have a softer end feel, have a better prognosis of responding to nonoperative treatment.³⁶ A course of intensive therapy and splinting for at least six weeks should be provided until it is determined that progress is not being made before operative treatment is considered. This is the "litmus test" to see if the patient will comply with postoperative rehabilitation and splinting. This surgeon (KJJ) will not operate on someone who either is noncompliant with his or her therapy preoperatively, or for social/financial reasons will not be able to receive the therapy necessary after surgical release.

Most stiff elbows are limited due to a combination of intrinsic and extrinsic factors.⁵ Intrinsic contractures are by definition due to joint/intra-articular incongruency, and therefore therapy and splinting cannot provide increase in joint motion. However, the soft tissue envelope can be treated effectively with therapy before surgery, and patients who have significant intrinsic contracture do also have some degree of extrinsic contracture that may respond to preoperative therapy and splinting.

It is this surgeon's (KJJ) practice to insist on six to eight weeks of corrective splinting and soft tissue mobilization before considering surgical release. Patients who do not comply with therapy (which may consist of only a home program and corrective splinting protocol) for whatever reason are not surgical candidates. The time spent in therapy while gathering medical records, old operative reports, and completing all preoperative testing allows the surgeon a window in which she can assess the patient's commitment to treatment.

During this trial period of therapy, it is not uncommon for patients with small flexion contractures of 30° or less to select themselves out of the surgical

candidate pool. Flexion contractures less than 30–40° generally are easily compensated for by positioning the body closer to the object or entity being manipulated.³ In our experience, if a patient with such a contracture does not dedicate time and effort during the trial period with day and/or night splinting, then the contracture, while visibly evident, is likely not functionally significant.

Patients with limited flexion are significantly more limited functionally. Although the literature is sparse in defining the amount of flexion one must have for adequate function, Morrey and An³ have identified 30–130° as adequate for a series of activities of daily living. Hotchkiss evaluated the ability of 52 patients to perform 20 elbow dependent tasks. They found that more than a 40° fixed flexion contracture and less than 105° of flexion are functionally significant. Loss of flexion generally cannot be compensated for with the neck, shoulder, or distal joints.⁵

At least one preoperative discussion with the patient and involved significant others is the next step. Realistic expectations are emphasized and commitment to postoperative splinting and therapy is again emphasized. The fact that up to 8% of patients treated operatively do not maintain improved ROM long term should be reviewed.³⁷ The possibility of transient or permanent nerve injury to the ulnar nerve in particular and possibly the radial or median nerve needs to be discussed. The surgical plan, which includes two to three days of hospitalization, the possibility of a compass hinge external fixator, ligament reconstruction with tendon grafts, and postoperative radiation therapy, is discussed. In the physiologically older patient (limited demand, or aged 65 or older), the option of elbow arthroplasty is introduced.

SURGICAL APPROACH

The patient is supine with the entire extremity on the hand table. The preferable anesthetic is endotracheal or laryngeal mask anesthesia with a presurgical incision placement of an axillary, interscalene, or subclavian perivascular marcaine block and catheter for postoperative pain management. One of the authors (KJJ) has compared presurgical block versus postsurgical block. Presurgical block is without question more effective in controlling immediate postoperative pain. The catheter is bloused prior to extubation. With this technique, many patients require minimal to no narcotics acutely postoperatively and the incidence of nausea is decreased. While the patient is in the hospital, the catheter is set to run at 0.25% or 0.125% marcaine continuous infusion. The same catheter is connected to a “pain ball” upon discharge from the hospital, and left in place for up to seven days postoperatively. A sterile

tourniquet is applied and the procedure is performed in a bloodless field.

The surgical approach is determined by preoperative identification of pertinent pathology and scars from previous surgery. Except in the low demand or older patient where elbow arthroplasty is likely, separate medial and lateral approaches are made. The surgeon begins on the side where pathology has been preoperatively identified. In patients with preoperative ulnar nerve symptoms, the medial approach is first.

Medial Approach

The medial approach consists of a very posterior incision (along the medial side of the subcutaneous border of the ulna). This decreases the incidence of injury to the medial antebrachial cutaneous nerve. Once the flexor pronator origin has been exposed anteriorly and the triceps including the ulnar insertion posteriorly, the ulnar nerve is addressed. At the very least, a decompression *in situ* is necessary. The nerve is carefully mobilized under loupe magnification. The superior and inferior branches of the ulnar collateral artery are mobilized with the nerve along with perineural fat. Limited neurolysis of motor branches to the flexor carpi ulnaris is necessary to allow the nerve to be mobilized anteriorly. The surgeon must be cognizant of the ulnar nerve throughout the procedure. The anterior compartment and capsule are usually exposed by dissection along the superior edge of the flexor pronator muscle group where the transverse fibers in the superficial fascia of the pronator muscles meet with the longitudinal fibers overlying the biceps and brachialis. The median nerve and brachial artery are directly observed and palpated lying superficial to the brachialis. Dissection ensues underneath the brachialis beginning at the medial intramuscular septum and staying directly on the anterior cortex of the humerus. Once the capsule is opened, retractors are placed to expose the ulnohumeral joint. The anterior capsule can be safely released from its insertion into the humerus proximally, the location of the brachial artery and median nerve having been previously identified. The capsule can be released laterally to the lateral intramuscular septum through this exposure. Unless there is pathology (heterotopic ossification) adjacent the coronoid, this exposure preserves the entire medial collateral ligament (MCL) complex. Should there be a need to assess the coronoid process, an internervous plane is developed between the flexor carpi ulnaris and the common flexor pronator muscles. As long as the anterior inferior quarter of the articulation between the ulna and humerus (based on the center of rotation of the trochlea) is maintained, the anterior band of the MCL is protected. If it is necessary to detach the complex to address the pathology,

preoperative planning has already prepared for acute MCL reconstruction.

The posteromedial elbow can also be addressed via this exposure. By limiting the plane of dissection to the cortex of the posterior humerus, injury to the triceps can be avoided. The olecranon is identified (with the image intensifier if necessary), and the proximal end removed with an osteotome or saw. Enough bone should be removed so that full passive extension without a mechanical block is ensured.

The other aspect of the posteromedial compartment that needs to be addressed is the triceps mechanism. Adhesions between the triceps and posterior capsule and humeral shaft can restrict flexion and lysis of the adhesions in this area is important to increasing flexion.

Lateral Approach

If a persistent contracture remains after medial release, or if the primary pathology is lateral, the lateral approach is used. Our institution uses a "Texas Lateral" approach developed by one of us (KJJ). This is a ligament preserving dissection that limits disruption of the native anatomy. A longitudinal incision is made just posterior to the lateral epicondyle. The length of the incision is variable and based on patient size in general. One begins 2 cm above the epicondyle and aims distally toward the distal radialulnar joint (DRUJ) or fifth dorsal compartment. Skin flaps are developed to expose the entire common extensor origin as well as the extensor carpi ulnaris, anconeus muscle, and the triceps.

The location of a longitudinal septum between the common extensor and extensor carpi ulnaris (ECU) can be easily identified by palpation. The overlying fascia is longitudinally divided 1–2 mm radial to the septum. The common extensor is raised off of the supinator distally, and the insertion proximally is sharply released. The posterior interosseous nerve is located at the distal margin of the supinator, adjacent to the septum. The nerve leaves the protective cover of the supinator and branches off at this point to innervate other extensor muscles. The nerve can also be palpated at the antecubital fossa. Fingertip dissection between the supinator and overlying extensor muscles will allow identification of the nerve surrounded by fat at the antecubital level. The nerve can then be followed proximally if necessary.

After the common extensor tendon is released proximally, the radiocapitellar joint can be assessed. Excision of the posterolateral capsule is usually necessary. The proximal edge of the annular ligament is occasionally released and later repaired. If radial head resection or replacement arthroplasty is necessary, it is done through this exposure.

The posterolateral joint may be assessed if necessary through the same exposure. As long as the ECU

remains intact, the anterior lateral collateral ligament is preserved. As on the medial side, this complex is in the anterior inferior quadrant. The area is exposed by palpating and developing the interval between the ECU and anconeus. There is a stripe of fat that we refer to as the "anconeus stripe" that marks the interval. The anconeus is raised off of the posterolateral capsule, thereby exposing the more posterior aspect of the radiocapitellar joint.

As on the medial side, if extension deficit is still present, dissection continues on bone along the posterolateral cortex of the humerus to enter the posterior compartment.

If the patient still does not have adequate flexion at this interval, palpation generally can lead the surgeon to the offending anatomic structure. For severe long-standing contracture, or if it is favorable to weaken flexion (as in spasticity) the biceps can be lengthened. Brachialis release typically ensues in the substance of the muscle during the multiple passive manipulations during the procedure. Theoretically, all structures of the elbow can be lengthened if necessary with the exception of the median and ulnar nerves. If after the previous steps contracture remains, a compass hinge external fixator will be necessary.

Rather than routinely using a hinged external fixator, the authors advocate primary reconstruction of the medial and lateral ligament complexes with tendon grafts. In the extreme case, a compass hinge may still be necessary for six weeks.

POSTOPERATIVE MANAGEMENT

All patients are placed in light dressings after surgery and the incisions are closed over medium sized drains. Ice wraps are applied for swelling. Due to the recognized potential for seroma, the surgeon removes the drains only when there is miniscule drainage output (usually two to three days). With almost no exception, the patients are monitored in recovery to make sure analgesia is achieved to tolerate full range in the device. This has not been a problem in patients operated on by one of the authors (KJJ), presumably due to the indwelling catheter.

Patients with significant heterotopic ossification are treated with a single dose (700 rads) of radiation within 24 hours of surgery.^{5,38} The beam is coned down to the location of the ossification as marked by the surgeon on radiographs that accompany the patient to radiation therapy. Indocin, 75 mg, slow release is another alternative for a patient with open physes or a fracture that is not healed. This must be continued for six weeks postoperatively.

The patient begins therapy on postoperative day one. Patients with a hinged external fixator begin motion. Once a reasonable arc of passive motion is achieved in therapy, the hinged external fixator is

unlocked to allow active extension. Other modalities are introduced with an emphasis on passive ROM followed by active ROM.

When the hinged external fixation is not required, the patient's elbow is fitted with a continuous passive motion (CPM) device in the recovery room. The CPM is not used if ligament reconstruction has been performed.³⁹ CPM following elbow manipulation or open release can be beneficial. The reported benefits of CPM can prevent stiffness, minimize edema and pain, enhance healing of peri-articular connective tissues, minimize adhesion formation, maximize ROM, and prevent ectopic ossification.⁴⁰⁻⁴² It is applied as soon as possible after surgery. The CPM is set at a full range of 0-130°. ^{5,39} The CPM is applied full time, day and night, for the first three days post-op.⁴² At hospital discharge, CPM use is prescribed eight hours/day. The CPM is generally continued for at least two weeks, and not longer than six weeks.

If the patient cannot sleep with her arm in the CPM, a static elbow extension splint is fabricated by the therapist within the first week and is to be used at night. The authors have yet to identify a commercially available splint to use in this fashion. In general, splints are custom fabricated by the therapist for optimal contoured fit. Progressive adjustments are made to increase extension as necessary. Nighttime extension splinting is continued through the recovery period, generally three months, or until the soft tissue envelope has reached equilibrium.

ROM is carefully monitored by the therapist and surgeon. Early intervention (within the first six weeks) is indicated if there is progressive loss of ROM from what was achieved intraoperatively. Patients who lose motion in this way usually are not tolerating therapy or splinting because of pain. Intervention may include reinsertion of a catheter for pain control and a manipulation under anesthesia may be scheduled if necessary. In patients with significant biceps and/or triceps co-contraction, Botox injections may be indicated.

COMPLICATIONS

The most devastating complication of elbow contracture release is that of nerve palsy or nerve injury. Generally it is difficult to determine the status of the nerves due to the axillary catheter. This is one of the reasons why one of the authors (KJJ) advocates at least palpation of all three peripheral nerves during the operative procedure. Fortunately, the catheter rarely gives complete motor block of the three major nerves; therefore, direct examination is used to evaluate peripheral nerve integrity. It is quite common for the multiply operated patient to have at least some degree of ulnar nerve dysfunction. Complete nerve palsy requires operative exploration.

Seroma is relatively common after radical contracture release. This is particularly notable in the patient who has significant heterotopic ossification requiring extensive dissection. Seromas should be aspirated, and the therapist supplies a compression sleeve. Small seromas of 20 cc or less are treated expectantly. Although seromas reoccur, rarely does the surgeon have to take the patient back to the operating room.

Failure to improve ROM fortunately is not common. The patient should be carefully examined and evaluated as previously described and the cause determined to develop an effective corrective plan of care. Interposition arthroplasty can be considered after the soft tissues have reached equilibrium as indicated.

Postoperative instability is also fortunately rare. Primary reconstruction of all ligaments is performed during the procedure as indicated. If necessary, a second procedure is necessary to place a hinged external fixation device.

REHABILITATION AFTER MANIPULATION UNDER ANESTHESIA AND OPEN ELBOW RELEASE

The therapy following manipulation under anesthesia and open contracture release is similar. The therapist's goal is to reach and maintain the passive ROM achieved by the surgeon in the operating room. It is therefore imperative that the therapist know the end ROM obtained. The patient will not be able to achieve more ROM than was obtained intraoperatively. If an open release was performed, the therapist must know the details of the procedure including the structures released or repaired, whether the ulnar nerve was transposed, or whether there was excision or resection of heterotopic ossification.

The postoperative dressing includes a splint with the elbow in maximum extension. The patient is referred to therapy for one to three days following the procedure. The patient is treated as if there is an acute elbow injury in the inflammatory phase of healing. An axillary catheter will provide 48-72 hours of post-op analgesia. Later TENS may be used for pain control. Postoperative edema is controlled initially with ice and then with decongestive or retrograde massage, and compression sleeve and glove are included as soon as possible. Intensive active and passive exercises are performed reaching the new end range of elbow motion. Initially, the ROM exercises are performed supine as previously described to isolate the triceps against gravity and flex the elbow with the assistance of gravity. Care must be taken to avoid or minimize the inflammatory response.

Extension splinting is emphasized immediately post-op. A static or static progressive turnbuckle splint is begun on the first therapy visit. Extension

splinting may be needed to prevent the flexed posture at night for three to six months. Flexion splinting may be added as indicated later. Static progressive flexion splinting for six to eight hours a day may also be needed for three to six months to increase and maintain ROM gained in surgery.

Results of operative treatment for elbow contractures vary. There is limited data in the literature. This is likely related to hesitancy of general orthopedic surgeons and hand surgeons to "take on" the challenge of the stiff elbow. Exposure to the treatment of these patients during a residency training program is unusual. Even the "best" residency programs treat the elbow as somewhat of a "no man's land" and approach complex elbow problems with the hesitancy that was previously prevalent in the operative treatment of zone II flexor tendon injuries.

There are a number of factors that effect outcome. These include the type of contracture (flexion versus extension), surgical technique and approach (open versus arthroscopic), patient factors (compliance and dedication to therapy, smoking, and other medical conditions), and the management of complications. The most commonly encountered problem in patients with a significant flexion contracture is persistent or recurrent contracture. Compliance with postoperative rehabilitation is likely the biggest factor; however, some surgeons do not pursue full extension operatively or limit surgical treatment once the surgeon can obtain full extension with passive force. One of the authors (KJJ) will not leave the operating room until the elbow can fully extend with gravity alone on a stack of towels. Heterotopic ossification can also occur. Another major issue is co-contraction of the elbow flexors and not adequately controlling postoperative pain. The approach suggested previously addresses these issues. Even at several weeks postoperatively, if pain cannot be controlled with normal medication and therapy modalities, the patient can have an axillary catheter inserted and the elbow can be manipulated under anesthesia if necessary at the same time.

Other issues that the surgeon and therapist should address for recurrent contracture include determining if there is underlying instability created by surgery or previously present. These patients universally co-contrast subconsciously to preserve the integrity of the ulnohumeral articulation (rarely the radiocapitellar joint). Peripheral nerve tethering can also add a marked influence on postoperative extension. The ulnar nerve is encountered universally with the medial exposure. One of the authors (KJJ) recommends formal decompression at the initial surgical procedure in any patient who has any preoperative symptoms, patients with extension contractures, and patients with preoperative flexion contracture of greater than 30°. The nerve should always be mobilized with surrounding epineural fat

and the superior and inferior ulnar collateral vessels to preserve the blood supply and assist with nerve gliding. The other peripheral nerves are almost never involved in open release, whereas the radial nerve can be compromised by the anterolateral or lateral portals in arthroscopic release. Significant nerve tethering is addressed with medication (Lyrica, Cymbalta) and decompression is necessary.

Complications with surgical wounds are not common in patients with flexion contractures, but are potentially disastrous in patients with extension contractures. Before contracture release, the use of tissue expanders or distant myocutaneous or fasciocutaneous flaps should always be considered. The preoperative assessment of the soft tissue envelope should address this issue. Seromas can occur and usually resolve with aspiration. Therapy, CPM use, and corrective splinting should not be modified if a seroma occurs.

The most important factor influencing surgical outcome is the preoperative planning. All essential elements of postoperative rehabilitation must be anticipated and addressed. Arrangements are made for CPM use and radiation therapy if necessary. The physician who provides anesthesia for the case must be comfortable with the placement of an axillary catheter. Six weeks of intensive, comprehensive therapy must be scheduled and approved by insurance carriers. The same applies to the need for corrective thermoplastic splints.

Operative treatment for patients with a stiff elbow can be very rewarding for the patient, therapist, and surgeon. The future will hopefully provide additional modalities and surgical approaches to even further optimize results.

SUMMARY

The therapist must be aware of any and all intrinsic and extrinsic factors contributing to the elbow joint contracture. Therapy treatment must address all extrinsic factors contributing to the stiff elbow in an intensive, comprehensive therapy program. Nonoperative therapy for the stiff elbow often requires corrective splinting, which may be necessary for as long as six months to maintain gains in motion. All operative candidates must participate in a preoperative therapy program to reduce extrinsic contractures as feasible and to assess patient compliance with an intensive postoperative therapy program. Operative treatment for the stiff elbow progresses in a sequential fashion to progressively release tissue structures limiting motion and reconstruct any structures as needed to provide joint stability. Postoperative therapy consists of CPM, corrective splinting, modalities, and specific exercise techniques to maintain passive gains achieved in surgery. The

therapy is extensive and requires full participation from the patient to maximize motion and function.

Certainly prospective randomized studies are needed to determine the most effective course of treatment.

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