Operative Treatment of Elbow Stiffness

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Based on an original article: *J Bone Joint Surg Am.* 2010;92:2187-95.

Introduction

Open elbow contracture release is the mainstay for the operative treatment of posttraumatic elbow stiffness.

The elbow is notorious for stiffness after trauma. Stiffness can be due to a thickened and contracted capsule, heterotopic ossification, articular and extra-articular deformity, arthrosis, or ulnar neuropathy (Figs. 1-A and 1-B). Elbow motion is important for placing the hand in space, and even small impairments of elbow motion can affect function¹.

An exercise program can usually stretch a thickened and contracted capsule, although it can take months for patients to master stretching exercises and change their mindset from feeling protective to feeling healthy and proactive in response to the discomfort associated with a stretch. Patience is warranted. The timing and indications for operative resection of a contracted and thickened capsule remain uncertain and debatable.

Clear targets for operative intervention include heterotopic ossification², osseous deformity such as a malunited capitellar fracture, impinging or improperly placed implants, and compression of the ulnar nerve. In addition to exacerbation of elbow stiffness, compression of the ulnar nerve may lead to progressive nerve damage without treatment. Heterotopic ossification and osseous deformity are appealing operative targets when the bone is causing an obvious and substantial hindrance of elbow motion and the bone is expendable and can be easily and safely removed.

In our experience, most posttraumatic elbow stiffness severe enough to warrant consideration of surgical treatment has elements that would be better treated with open rather than an arthroscopic contracture release. These elements include heterotopic ossification, implants that need to be removed, ulnar neuropathy often involving extensive scarring, and malunion or nonunion. The specific operative technique is based on the location of prior incisions, the bone and implants to be removed, and whether there is ulnar nerve compression. For capsular contracture alone or lateral heterotopic ossification with no ulnar

neuropathy, a lateral release with or without an in situ ulnar nerve release can be performed. A medial approach alone is sufficient when the surgeon plans to address the ulnar nerve in the absence of bone or implants hindering motion on the lateral side. For more complex contractures, both medial and lateral surgical approaches can be helpful.

Three-dimensional computed tomography can help to determine the exact position of bone and implants that are blocking motion. It can also demonstrate bone encasing the ulnar or radial nerve. We use computed tomography when the situation is unclear on the basis of radiographs alone.

If symptoms, physical examination, and electrodiagnostic tests suggest a new and likely progressive ulnar neuropathy and the patient has <90° of flexion, we release the ulnar nerve. When heterotopic ossification is to be removed, we recommend a single radiation treatment of the area immediately prior to surgery. Postoperative nonsteroidal anti-inflammatory medication can also be considered.

Open elbow contracture release is done in eight stages:

1. Skin incision
2. Protect or release peripheral nerves
3. Develop muscle intervals for exposure of the joint
4. Resect bone, contracted capsule, and implants restricting motion
5. Tenolysis/muscle elevation
6. Manipulate the elbow; consider implant removal
7. Wound closure
8. Postoperative management

Step 1: Skin Incision

Use either a posterior skin incision and raise medial and lateral skin flaps or use more direct individual medial and lateral skin incisions.

- Place the patient supine with the arm supported on a table for optimal surgical access to both the anterior and the posterior aspect of the elbow. Use a sterile pneumatic tourniquet

for greater access to the elbow and upper arm and to limit bleeding and improve visualization.

- There is flexibility in the choice of skin incision. The skin around the elbow has a relatively good blood supply with longitudinal collateral circulation. Use either a posterior skin incision and raise medial and lateral skin flaps or use more direct individual medial and lateral skin incisions. The advantages of a posterior skin incision are that it avoids major cutaneous nerves, is relatively inconspicuous, and allows access to almost the entire elbow through a single incision. The disadvantages are that it requires a longer incision, it can be difficult to work with thick skin flaps in obese patients, and it may be more prone to seroma or hematoma formation than separate lateral and medial incisions.

Step 2: Protect or Release Peripheral Nerves

- Release the ulnar nerve using a small incision and in situ release when a lateral muscle interval (between the extensor carpi radialis brevis and extensor digitorum communis muscles) is preferred for the contracture release; use a larger incision with subcutaneous anterior transposition when a medial muscle interval (50:50 split of the flexor pronator mass) is used.
- Protect the median and radial nerves by ensuring that all muscle fibers are elevated from the anterior aspect of the humerus and remain superior to the retractors. Ensure that the radial and ulnar nerves are not encased in heterotopic ossification. If you suspect that they are, identify the nerves and carefully release them from the ectopic bone.

Step 3: Develop Muscle Intervals for Exposure of the Joint

Choose a lateral (*extensor carpi radialis brevis/extensor digitorum communis*) or medial (50:50 split of the flexor pronator mass) muscle interval to expose the elbow capsule.

- On the lateral side, the muscle intervals are between the extensor carpi radialis brevis muscle and extensor digitorum communis muscle anteriorly and under the triceps muscle and the anconeus muscle posteriorly^{3,4}. Develop the anterior interval by identifying the supracondylar ridge of the lateral aspect of the distal part of the humerus (Fig. 2). Elevate the

origins of the radial wrist extensor muscles off the humerus anteriorly and the triceps posteriorly. Continue to release the anterior muscle origins distally, bit by bit, directly off bone, until you encounter synovial fluid by incising capsule or until you see the articular cartilage of the capitellum or radial head (Fig. 3).

- Split the common extensor muscles at the junction of the anterior and posterior halves of the capitellum and the radial head (roughly the extensor carpi radialis brevis/extensor digitorum communis interval) to protect the underlying lateral collateral ligament complex (Figs. 4-A and 4-B). Continue this split distally over the radial neck as necessary. The supinator can be safely split for a centimeter or two, but if you need to go more distally consider identifying the posterior interosseous branch of the radial nerve and protecting it (Figs. 5-A, 5-B, and 6).
- Elevate the triceps and anconeus muscles off the posterior part of the humerus, the elbow capsule, and the tip of the olecranon (Figs. 7 through 10). As you continue distally, elevate the anconeus intact in the interval between the anconeus and extensor carpi ulnaris muscles; in some cases you will need to divide part of the anconeus muscle. Stay posterior to the radiocapitellar articulation to protect the lateral collateral ligament complex.
- On the medial side, identify, release, and protect the ulnar nerve. Define the flexor pronator muscle mass anterior to the ulnar nerve. Split this muscle mass 50:50 anterior:posterior⁵ (Figs. 11-A and 11-B). Elevate the brachialis and the anterior half of the flexor pronator muscle mass off the distal part of the humerus, the elbow capsule, and the coronoid process (Fig. 12).
- Move the ulnar nerve into the anterior subcutaneous tissues. Elevate the triceps off the posterior part of the humerus, the elbow capsule, and the olecranon (Fig. 13). Stay posterior to the medial epicondyle to preserve the medial collateral ligament.

Step 4: Resect Bone, Contracted Capsule, and Implants Restricting Motion

Remove the structures that hinder motion: implants, heterotopic bone, and contracted capsule.

- Remove only those screws or plates that are definitely restricting motion. Removal of implants and bone creates stress risers that increase the risk of fracture with manipulation or

during the postoperative recovery period. Depending on the amount of bone removed, it may be safer to leave the implants in place. If you feel that you can safely remove the implants, then do so after you have manipulated the elbow.

- Isolate the bone to be removed safely from neurovascular structures and remove it piecemeal (Figs. 6, 7, 9, 10, and 14). Use areas proximal or distal to the bone to help define the junction between normal and heterotopic bone. The heterotopic bone usually looks different (more amorphous with many holes or vascular channels) and feels different when you are handling it with osteotomes and rongeurs. Try to restore the coronoid, radial, and olecranon fossae of the distal part of the humerus. Consider removing the tips of the coronoid and olecranon processes.
- The capsule is not very thick when heterotopic ossification or osseous deformity is the primary cause of stiffness, but consider resecting it. When the capsule is thick and contracted, try to remove part of it (capsulectomy) rather than just cutting it or releasing its attachment to the humerus (capsulotomy).

Step 5: Tenolysis/Muscle Elevation

When the triceps and the brachialis muscles are adherent to the distal third of the humerus, release them using an elevator.

Step 6: Manipulate Elbow; Consider Implant Removal

Take care not to push so hard that you fracture the bone at a stress riser created by removal of bone or implants.

- When bone, implants, and contracted capsule are no longer hindering motion, release the tourniquet and push the elbow into flexion. It will take some force to stretch the remaining capsule and muscle contributing to stiffness, but take care not to push so hard that you fracture the bone at a stress riser created by removal of bone or implants (Fig. 13). A good guideline is to push only as hard as you can with two fingers. Do the same in extension (Fig. 15). If tight areas or residual bone are identified, return to the elbow and make an attempt to release them.
- If the implants are prominent or otherwise problematic, consider removing them at this point, but only if you are certain that the frac-

ture is healed and you have not created important stress risers. In general, err toward leaving at least some of the implants in place after contracture release in the elbow.

Step 7: Wound Closure

Close the muscle intervals and skin. Consider using a drain if there is substantial bleeding from osseous surfaces. If you have mobilized the ulnar nerve, leave it in a transposed position in the anterior subcutaneous tissues. We tend to avoid a fascial sling in this circumstance so that it does not contribute to nerve compression

Step 8: Postoperative Management

The key after surgery is frequent, active, patient-assisted elbow flexion, extension, and forearm rotation stretches. It is important for patients to take ownership of the postoperative therapy rather than being passive (thinking that the therapist will get the elbow moving) and to optimize what psychologists call “self-efficacy,” which includes a sense of responsibility, capability, and optimism. Dynamic or static-progressive splints can be useful tools for stretching, but they should be seen as an active rather than a passive aspect of these exercises. One of us (J.B.J.) has used continuous passive motion periodically over the years, and a case-control study based on this experience suggested that continuous passive motion did not improve the result⁶.

Results

A case series of patients with elbow contracture release documented an average improvement in the arc of elbow flexion of between 21° and 66°¹. In our study of twenty-three patients followed prospectively⁷, the average arc of elbow flexion improved from 50° to 105° and the average Disability of the Arm, Shoulder and Hand (DASH) score improved from 40 points to 19 points. There was no correlation between improvement in flexion arc and improvement in DASH scores.

What to Watch For

Indications

- Loss of elbow flexion or extension of >30° compared with the contralateral side.
- Confidence that stretching exercises have failed to stretch the capsular contracture.

- Bone or implants hindering elbow motion.
- The patient understands the risks and benefits of the procedure and requests surgery to attempt to gain more elbow motion.

Contraindications

- Cognitive or physical problems limiting the ability to perform active, self-assisted stretching exercises after surgery.

Pitfalls & Challenges

- In patients with elbow stiffness in the absence of heterotopic bone, ulnar neuropathy, or prominent implants, capsular release alone will not improve motion unless the patient can confidently stretch the elbow. Since confident stretching can be effective even for established contractures, it is wise to be patient with exercises when capsular contracture alone is responsible for impaired motion.
- Be careful with manipulation of the elbow combined with removal of implants, particularly after removal of heterotopic ossification. There is a risk of fracture.

Clinical Comments

- How long do you allow patients to work on stretching a purely capsular contracture (no bone, implants, or ulnar neuropathy hindering motion) prior to offering elbow contracture release?
- When both medial and lateral elbow releases are needed, is it better to employ a single posterior skin incision or separate medial and lateral skin incisions?
- Do you release the ulnar nerve when there is no preoperative dysfunction but flexion is <90°?
- For simple contractures, is it preferable to perform a medial or lateral elbow exposure?
- Are continuous passive motion machines superior to active, self-assisted elbow stretching after contracture release?
- Why doesn't decreased disability correlate with increased motion after contracture release?

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Disclosure: None of the authors received payments or services, either directly or indirectly (i.e., via his or her institution), from a third party in support of any aspect of this work. One or more of the authors, or his or her institution, has had a financial relationship, in the thirty-six months prior to submission of this work, with an entity in the biomedical arena that could be perceived to influence or have the potential to influence what is written in this work. No author has had any other relationships, or has engaged in any other activities, that could be perceived to influence or have the potential to influence what is written in this work. The complete **Disclosures of Potential Conflicts of Interest** submitted by authors are always provided with the online version of the article.

The line drawings in this article are the work of Joanne Haderer Müller of Haderer & Müller (biomedart@haderermuller.com).

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Figures

Fig. 1-A

Fig. 1-B

Figs. 1-A and 1-B A thirty-seven-year-old man with no elbow or forearm motion after a complex elbow injury. **Fig. 1-A** An oblique attempt at a lateral radiograph demonstrates anteromedial heterotopic ossification between the humerus and the ulna. **Fig. 1-B** Another oblique radiograph shows a proximal radioulnar synostosis.

Fig. 2

After a posterior skin incision is made and a lateral skin flap is raised, the lateral muscular interval is initiated by identifying the lateral supracondylar ridge of the distal part of the humerus and elevating the origin of the extensor carpi radialis brevis muscle. The knife handle runs over the supracondylar ridge and the muscle just anterior to the connection of the blade and handle is the extensor carpi radialis brevis.

Fig. 3

The brachioradialis and brachialis muscles are elevated off the anterior aspect of the humerus and anterior aspect of the elbow capsule as well as off any heterotopic ossification.

Fig. 4-A

Fig. 4-B

The origins of the wrist and digit extensor muscles (being cut by the knife blade in the photograph) from the lateral humeral condyle are incised and elevated distally until the capitellum (just under the knife blade) is identified. The dissection ends at the midpoint of the capitellum; no soft tissues are released from the lateral humeral epicondyle distal to this point so that the origin of the lateral collateral ligament is preserved.

Fig. 5-A

Fig. 5-B

The anular ligament (under the hook) is split and the supinator (being spread by the scissors) is split, divided, and elevated distally. When an anterior proximal radioulnar synostosis is addressed, as it was in this patient, the posterior interosseous nerve (at the tip of the scissors in the photograph) is identified and protected with blunt dissection.

Fig. 6

Muscles are carefully elevated from heterotopic bone (all of the bone anterior to the radial head prosthesis and the tip of the olecranon) to ensure that the radial nerve remains protected. The heterotopic bone is removed with use of osteotomes and rongeurs.

Fig. 7

The triceps and anconeus muscles (posterior to the osteotome in this photograph, with the anconeus distal near the apex of the fascial incision) are elevated from the posterior aspect of the humerus to gain access to the posterior heterotopic ossification and joint capsule.

Fig. 8

In this patient, a Boyd exposure (combined elevation of the extensor carpi ulnaris, anconeus, and supinator off the ulna and radius) of the posterior part of the proximal radioulnar synostosis was used. This photograph shows an incision in the fascia, with the surgeon preparing to elevate the extensor carpi ulnaris and the supinator muscle off the ulna, the synostosis, and the radius. The knife blade is distal (toward the wrist) in this photograph.

Fig. 9

After completion of the Boyd exposure, the posterior part of the synostosis (between the two Hohmann retractors) is isolated and is ready to be removed.

Fig. 10

The posterior part of the synostosis is removed piecemeal with use of osteotomes and rongeurs.

Fig. 11-A

Fig. 11-B

On the medial side of the elbow, the ulnar nerve (tagged with the white vessel loop, posterior to the elevator in the photograph) is identified, released from overlying ligament and fascia, and protected as a medial skin flap is developed. The medial over-the-top interval is developed, splitting the flexor pronator mass anterior to the ulnar nerve 50:50 and elevating the anterior 50%

along with the brachioradialis off the anterior aspect of the distal part of the humerus, the elbow capsule, and the heterotopic bone, with care taken to make sure all muscle fibers remain anterior. The elevator is in the interval. The forceps is over the anterior 50%, and the posterior 50% is between the elevator and the ulnar nerve below the elevator.

Fig. 12

The ulnar nerve (isolated by the white vessel loop) is mobilized and is transposed into the anterior subcutaneous tissues, providing access to the posterior part of the humerus, posterior part of the elbow capsule, and posterior heterotopic bone after the triceps is elevated. Posterior and posteromedial heterotopic bone is then removed.

Fig. 13

The tourniquet is released and the elbow is manipulated to regain as much flexion as possible with the heterotopic bone removed.

Fig. 14

The anteromedial heterotopic bone (all bone anterior to the osteotome in this photograph) is removed through the medial over-the-top exposure.

Fig. 15

Manipulation is also performed for elbow extension as well as forearm supination and pronation.

Fig. 1-A

Fig. 1-B

Fig. 2

Fig. 3

Fig. 4-A

Drawing by Joanne Haderer Müller

Fig. 4-B

Fig. 5-A

Drawing by Joanne Haderer Müller

Fig. 5-B

Fig. 6

Fig. 7

Fig. 8

Fig. 9

Fig. 10

Fig. 11-A

Fig. 11-B

Fig. 12

Fig. 13

Fig. 14

Fig. 15