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Post-traumatic stiff elbow

Lars Adolfsson

- Post-traumatic and post-operative stiffness of the elbow joint is relatively common and may in pronounced cases markedly interfere with normal upper extremity function.
- Soft-tissue contractures and heterotopic bone formation are two major causes of limited movement.
- Extensive recent research has elucidated many of the pathways contributing to these conditions, but the exact mechanisms are still unknown.
- In the early phase of soft-tissue contractures conservative treatment may be valuable, but in longstanding cases operative treatment is often necessary.
- Several different options are available depending on the severity of the condition and the underlying offending structures. Surgical treatment may allow significant gains in movement but rarely complete restoration, and complications are not uncommon.
- The following presentation reviews the recent literature on pathomechanisms and treatment alternatives.

Keywords: stiff elbow; post-traumatic contracture; heterotopic bone formation; treatment; contracture release

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Introduction

Stability, mobility and alignment are essential prerequisites for elbow function. The elbow is one of the most mobile joints of the body and unrestricted movement is necessary to allow free positioning of the hand in space. Average normal range of movement is approximately 0° to 145° of flexion and extension but individual variations may be quite considerable. The proximal forearm joint is also an integral part of the elbow and normal rotation of the radius is on average close to 160°. A minimal range of movement for unlimited use of the arm in everyday activities has been described as 30° – 130° of flexion and extension and a minimum of forearm rotation of 50° + 50° of pro- and supination. Certain activities may, however, call for larger ranges of movement and the limitations that a patient will perceive as a functional deficit will vary depending on the level of activity.

Unfortunately, the elbow joint is particularly prone to post-traumatic and post-operative stiffness. To some extent this is probably due to the highly congruent construction that is necessary for stability and the ability to sustain loads via the long lever arm that is constituted by the forearm. The skeletal anatomy of the humero-ulnar joint in combination with the collateral ligaments allows very little laxity under normal circumstances and the proximal radio-ulnar joint is tightly stabilized by the lateral collateral ligament complex. The relatively confined joint space provided by the capsule and the close relationship of the muscles, working as secondary stabilizers, makes the elbow susceptible to contracture and stiffness following a trauma, be it accidental or surgical.

Loss of elbow movement may also ensue after, for example, neurological or congenital conditions, but this is not within the scope of this presentation.

Pathomechanisms of joint stiffness

Following an injury, bleeding and release of inflammatory agents involved in the repair process will induce activation of several pathways necessary for bone and soft-tissue healing. For unknown reasons the response to the trauma may, however, result in excessive scar formation and contracture of the joint capsule or formation of bone in the capsule or adjacent musculature. Heterotopic bone formation (HO) is induced by activated stem cells producing osteoid which matures into lamellar bone without a periosteal envelope.[1] This is believed to be caused by a combination of the inflammatory response to the trauma including an upregulated expression of bone morphogenetic protein (BMP).[2] Some evidence suggests a genetic predisposition.[3] Recent studies have also indicated the role of peripheral nerve injury in inducing neuro-inflammatory mechanisms that seem to be involved both in fibrogenesis and heterotopic ossification.[4,5] Increased risk of HO formation is reported in conjunction with burns, head trauma, delay of surgery and prolonged post-operative immobilization.[6-8] The risk of developing HO which interferes with joint movement was approximately 20% according to a study by Foruria

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et al[9] on fracture dislocations involving the proximal radius and ulna.

Capsular contractures have been shown to develop due to a markedly increased number of myofibroblasts, a cell type with contractile and synthetic properties. Based on the studies by Mattyasovszky et al,[10] Hildebrand et al,[11,12] and Kopka et al[13] among others, it appears that an increased number of activated mast cells can be found in the development of a capsular contracture and that this in turn activates the myofibroblasts and alters the balance of the matrix metalloproteinase system and collagen synthesis leading to collagen hyperplasia and fibrosis. Several growth factors and cytokines have been identified as involved in this process, transforming growth factor-beta 1 being the most investigated – this has been shown to be an important regulator of connective tissue homeostasis.[14-16]

The exact mechanisms are, however, still to be elucidated.[13] According to a recent report by Doornberg et al,[17] excessive numbers of myofibroblasts are not present in long-standing contractures and were not seen later than five months after the trauma. This may prove to have implications for treatment since any procedure triggering an upregulation of myofibroblast activity in the early phase may aggravate fibrosis and contracture while similar measures in the late stage may be well tolerated.

Classification of elbow stiffness

Morrey[18] divided causes of elbow stiffness into intrinsic, extrinsic and mixed, based on the aetiology and location: intrinsic, implying an intra-articular origin such as loose bodies, osteophytes, arthritis, malunion and intra-articular adhesions; extrinsic contractures are typically extra-articular, for example capsular or muscular contracture, HO, extra-articular malunions and burn contractures; and mixed forms may encompass variations of both extrinsic and intrinsic forms.

Another classification proposed by Kay[19] is based on the primarily causative structure: type 1, soft-tissue contracture; type 2, soft-tissue contracture with ossification; type 3, undisplaced articular fracture with soft-tissue contracture; type 4, displaced intra-articular fracture with concomitant soft-tissue contracture; type 5, post-traumatic bony bars.

Clinical assessment

Restrictions of mobility of the elbow joint must be carefully analysed and related to the individual functional requirements of the patient. Pain and instability are poorly tolerated and if a stable joint cannot be ensured, stability usually has priority over mobility. In case a treatment carries a risk of leading to chronic instability some remaining stiffness is to be preferred. The condition of the surrounding soft tissues must be considered, since tightness and scarring of the skin may itself sometimes cause or aggravate loss of movement. If surgical treatment is considered, meticulous planning of approach should be related to skin quality, placement of previous incisions and skin circulation. Severe scarring may call for plastic surgery with the use of local flaps or skin transplantation.

Neurological assessment is imperative and the ulnar nerve is particularly susceptible to injury associated with the initial trauma. In cases with severe scarring, the normal gliding and stretching of the nerve during elbow movements may be disturbed and any procedure increasing elbow mobility may create ulnar nerve symptoms if the nerve is embedded in scar formation. In many instances, an ulnar nerve release is therefore an integral part of the procedure and some even advocate a prophylactic routine anterior transposition to prevent post-operative symptoms.[20] The radial and median nerves are less often disturbed by regaining elbow movement but may also be affected by surrounding scar formation following the initial trauma, and if symptomatic will also need surgical release.

The muscles around the elbow are frequently affected by an elbow injury, and total or partial tears, HO and scar formation with ensuing tightness and shortening are frequently seen. A procedure aimed at regaining movement may be limited by the incapacity of the muscles to stretch out to normal length and ruptures may need repair.

The collateral ligament complexes and the joint capsule should be assessed to identify the major components of restricted movement but also to ascertain competence of the ligaments to ensure stability.

Elbow function must also be related to the general medical condition of the patient and the entire function of the upper extremity since disorders of the shoulder girdle and the hand may add to the demands of the elbow and forearm.

Indications for treatment

As a general rule, the indications for treatment of a stiff elbow are relative and dependent on the patients' appreciation of the functional deficit. Any given restriction measured in degrees may have different implications for different individuals depending on discomfort and the desired level of activity. Whatever treatment is chosen, a severely injured elbow will never be completely normal and reasonable patient expectations are mandatory for a successful outcome. Marked limitation of mobility and conditions causing pain and instability are usually strong indicators for treatment.

Conservative treatment

In the absence of mechanical conflicts causing restricted joint movement, such as malunion, dislocation and HO,

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non-operative treatment may be considered. In long-standing cases the success of conservative treatment is, however, often disappointing and is not often recommended with conditions present for six to 12 months.[21] Within the early phase, splinting, either static or dynamic, has proven helpful.[22-24] Schwartz,[25] in a literature review, and Müller et al,[26] in a recent meta-analysis, both found support for the use of static-progressive splinting when used in the early phase of post-traumatic and post-operative stiffness. Non-operative treatment also usually includes physiotherapy, guided range of movement exercises and passive mobilizations. Continuous passive movement has also been tried and advocated but is controversial, since no beneficial effects have been proven and some have even argued that the method might increase the risk of bleeding, swelling and ulnar nerve problems.[27-30] There is little or no evidence to support the potential contributions of the individual components of the commonly prescribed methods and the ideal conservative treatment for a post-traumatic elbow stiffness is yet to be proven.[31]

Operative treatment

The literature is replete with case series describing generally satisfactory outcomes after surgical release of elbow contractures. There are different methods described to achieve an operative release, ranging from more or less extensive open release, arthroscopic release and open arthrolysis combined with external fixation, with or without concomitant distraction.[32] The different methods have been combined with post-operative regimes of various kinds and the investigated series have included patients of different ages, varying severity of contracture and sometimes with associated HO and other complicating factors. Furthermore, apart from reporting range of movement, various outcome measures have been used and there is no consensus on the definition of complications. All of this makes comparisons difficult and the literature cannot be trusted in finding the ideal treatment in each individual case. In general, the reported results almost unanimously describe gain in elbow movement ranging between approximately 40° and 80°, regardless of the method used. Slightly less total gain may seem to result following arthroscopic release but this is probably influenced by the selection of patients amenable for arthroscopic operation who usually have less pronounced contractures to begin with and rarely have pronounced HOs or skeletal deformities. Reported complications, ranging from minor infection and recurrence of stiffness to severe complications such as permanent nerve damage, fractures and deep infections, vary considerably. In their systematic review Kodde et al[32] found that the rate of complications seemed to increase in relation to the extent of the surgical procedure. More recently another systematic review by Cai et al[33] reported a complication rate of 24% and a re-operation rate of 34%. They also found that less pre-operative range of movement and female gender tended to be associated with an increased complication rate.

Open arthrolysis

Most publications on the surgical management of the stiff elbow have reported the outcome of an open release. Several different approaches have been described and the preferred method must be related to the type of contracture, location of any heterotopic bone, need for skeletal corrections and nerve releases. Previous operations and scarring may limit the options for new incisions. The lateral column procedure as described by Mansat and Morrey,[34] or variants thereof, seems to be the most frequently used.[21,35-37] From a lateral approach, the lateral, anterior and posterior parts may be accessed but not the medial side around the collateral ligament complex and the ulnar nerve. This area frequently needs to be addressed for nerve release and incision of the posterior part of the medial collateral ligament complex, which requires a separate incision or a longer posterior incision from which both the medial and lateral aspects may be approached. Other approaches are more rarely indicated.[21]

Arthroscopic arthrolysis

Patients with soft-tissue contractures, but without marked skeletal deformities needing to be addressed, may be candidates for arthroscopic arthrolysis. Major HOs, malunions requiring correction or indications for other extra-articular procedures call for open surgery, in which case arthroscopy is seldom worthwhile. In such situations the neurovascular anatomy may also be altered, making arthroscopic procedures contraindicated for safety reasons. There may, however, be situations where a combination of an arthroscopic intra-articular procedure can be used together with a limited open approach. Mostly an arthroscopic arthrolysis includes partial synovectomy, debridement of intra-articular adhesions and capsular release or capsulotomy. Loose bodies may be removed and resection of intra-articular osteophytes can be simultaneously performed. The main benefits of the arthroscopic method are the obviously limited surgical trauma, which in turn usually allows for a more rapid course of rehabilitation, and the possibility of detailed examination of intra-articular pathology. Elbow arthroscopy in post-traumatic cases is considered technically demanding and the close proximity of neurovascular structures makes it potentially hazardous.[38,39] Severe complications seem, however, to be rare and, if the above-mentioned indications and contraindications are respected, an arthroscopic elbow arthrolysis is regarded as a safe procedure.[40]

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Fig 1. Iatrogenic coronal shear fracture caused by manipulation under anaesthesia without previous surgical release in a 16-year-old female patient with a capsular contracture following a posterior dislocation.

External fixation

The use of external fixation in the treatment of elbow contractures has been advocated for different reasons. Zhou et al[41] found that after an extensive open release the elbow was unstable, and they protected a ligament repair with a hinged external fixator. A good outcome and stable joints were reported. Pennig et al[42] and Wang et al[43] used external fixation either as a stand-alone procedure or in conjunction with an open arthrolysis, with the purpose of distraction of the soft tissues, and reported results quite similar to most other publications. In cases with post-traumatic arthritic changes the combination of open release, capsulectomy and interposition arthroplasty either with biological tissue or allografts, protected by a hinged external fixator, has reportedly produced reasonable results.[44-46] This procedure has been recommended in younger, high-demand patients as an alternative to prosthetic replacement.

Manipulation under anaesthesia

There are few reports describing results after this procedure and we have seen referred cases with iatrogenic fractures caused by aggressive manipulation under anaesthesia without previous surgical release (Fig. 1). If, however, the causes of a contracture are surgically removed, passive mobilization with gentle force is often beneficial at the end of the procedure. Araghi et al[47] reported the outcome of series of 51 patients that had a mobilization under anaesthesia performed at a mean of 40 days after a previous open release and found the procedure valuable. Ek et al[48] reported the same experience having used the same procedure in a series of 12 paediatric patients.

Total or partial elbow arthroplasty

In elderly and low-demand patients with an elbow contracture associated with severe arthritic changes of the joint surfaces, a prosthetic replacement may be considered.[49-51] In such situations a complete soft-tissue release, ulnar nerve transposition and resection of joint surfaces as well as any impinging heterotopic bone is needed and a semi-constrained prosthesis is usually recommended. Anecdotal cases with hemiarthroplasty have been reported in younger patients with stable joints and relatively preserved joint architecture but clinical results have to date been sparse.

Adjuvant therapies

Non-steroidal anti-inflammatory drugs such as celecoxib and indomethacin have been sparsely investigated in their role of preventing HO around the elbow. In a recent retrospective study Sun et al[52] found that administration of celecoxib for 28 days after open arthrolysis significantly reduced formation of HO. Costopoulos et al,[53] also in a retrospective study on distal biceps repairs, found a significant reduction of HO in patients treated with indomethacin post-operatively for ten to 42 days. Also, single-dose radiation therapy has been suggested and used both as prophylaxis following a trauma and after excision of manifest HO. The only randomized controlled study on acute injuries, by Hamid et al,[54] was terminated before completion due to a high number of nonunions in patients receiving radiation therapy. The role of radiation as a post-operative adjunct following HO resection is controversial and although often recommended, there is a lack of evidence supporting its use.[55]

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Table 1. Summary of most commonly reported treatments for elbow stiffness and the respective outcomes when applicable

Procedure	Preferred indication (as reported)	Reported gain	Comment
Splinting	Soft-tissue contractures in early stage (6 mths)	up to 40°	
Arthroscopic release	Intrinsic contractures; capsular contracture, arthrofibrosis, osteophytes and loose bodies	30° to 60°	Not for extra-articular bony procedures but may be combined. Not in case of altered neurovascular anatomy
Open release	Extrinsic and mixed contractures, heterotopic bone formation excision	35° to 85°	In late stages and when osteotomies or extra-articular procedures needed. Increased safety of neuro-vascular structures
Open release and external fixator	When release of collateral ligaments has been performed. Complete ankylosis	30° to 85° (116°)	To ensure reduction and to protect ligament healing
Distraction arthroplasty	In combination with open release or isolated for arthrofibrosis	30° to 90°	
Continuous passive movement	Post-operative management after surgical release		Efficacy controversial
Manipulation under anaesthesia	Peri-operative following surgical release		Not recommended as a stand-alone procedure. Iatrogenous injuries reported
Interposition arthroplasty	Pain relief in younger patients with secondary osteoarthritis	Up to 55°	Primarily for pain reduction
Total elbow arthroplasty	For severe post-traumatic osteoarthritis in low-demand patients	Up to 90°	Pain reduction and increased range of movement

Summary

Post-traumatic and post-operative stiffness of the elbow joint constitutes a significant problem since the elbow is prone to develop soft-tissue contractures and HO. Recent research has increased the knowledge of the biomechanical and biochemical processes causing post-traumatic elbow stiffness but the exact mechanisms are still largely unknown. A large range of movement is essential for upper extremity function and restrictions may cause severe functional limitations. In patients with a pronounced limitation of movement, treatment may consist of physiotherapy and splinting in the early phase, while manifest contractures may require surgery. With soft-tissue contractures without extra-articular deformities or HO, arthroscopic release is often amenable but the technique is demanding. Combinations of intrinsic and extrinsic injuries such as bony abnormalities and associated injuries affecting nerves or skin are usually best addressed by an open approach, with or without adjunctive external fixation, and in general improvements of at least 50% of the movement loss can be expected (Table 1). The potential effect of adjuvant therapies such as non-steroidal anti-inflammatory drugs and radiation are yet to be proven.

AUTHOR INFORMATION

Department of Orthopaedics, University Hospital of Linköping, Sweden.

Correspondence should be sent to: L. Adolfsson, Department of Orthopaedics, University Hospital of Linköping, S-581 85 Linköping, Sweden.
Email: lars.adolfsson@regionostergotland.se

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