Review Article

Posttraumatic stiff elbow

Ravi Mittal

Abstract

Posttraumatic stiff elbow is a frequent and disabling complication and poses serious challenges for its management. In this review forty studies were included to know about the magnitude of the problem, causes, pathology, prevention, and treatment of posttraumatic stiff elbow. These studies show that simple measures such as internal fixation, immobilization in extension, and early motion of elbow joint are the most important steps that can prevent elbow stiffness. It also supports conservative treatment in selected cases. There are no clear guidelines about the choice between the numerous procedures described in literature. However, this review article disproves two major beliefs-heterotopic ossification is a bad prognostic feature, and passive mobilization of elbow causes elbow stiffness.

Key words: Elbow, myositis ossificans, stiffness, trauma
MeSH terms: Elbow joint, myositis, trauma, contracture joint

Introduction

The normal range of flexion extension of elbow is 0°–145°.[1] The functional range of motion required for daily activities is 30°–130° of flexion extension and 50° of supination to 50° of pronation.[1] Flexion of elbow up to 149° may be required for some activities like using a cell phone and typing on a keyboard.[1] Stiffness of elbow is defined as flexion <120° and loss of extension >30°.[2] Stiffness of elbow causes difficulty in placement of hand in space and hence limits the functional capacity. Mechanical blocks to motion either from soft tissues or bone result in elbow stiffness. Trauma is a common cause of stiffness in the elbow joint with rates ranging from 3% to 20%.[1] The exact incidence of posttraumatic elbow stiffness is difficult to estimate because of its multifactorial pathogenesis and variable time of manifestation. Displaced fractures around the elbow joint are usually treated by internal fixation. Hence, the stiffness that results is due to the combined effects of the initial trauma and the surgical trauma. It is difficult to predict the presence/absence and degree of stiffness in the elbow joint after trauma in any given case.

Department of Orthopaedics, All India Institute of Medical Sciences, New Delhi, India

Address for correspondence: Prof. Ravi Mittal,
Department of Orthopaedics, All India Institute of Medical Sciences,
Ansari Nagar, New Delhi - 110 029, India.
E-mail: ravimittal66@hotmail.com

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Material and Methods

A PubMed search was made using the keywords "stiff" and "elbow" to retrieve articles for posttraumatic elbow stiffness. A total of 192 articles were found. We included only full-text human studies, and they were 120 in number. We excluded articles of stiffness of joints other than elbow, articles published in languages other than English, and articles that talked about arthrodesis and joint replacement only. We also excluded elbow stiffness due to causes other than trauma, case reports, and letters to editor. A total of forty articles were included for the review of literature of posttraumatic stiffness [Figure 1]. All the article were reviewed to know about demography, pathology, prevention, evaluation, nonoperative treatment, operative treatment, and postoperative care of a stiff elbow.

Results

Demography

Most of the studies in the literature are small series, and there are very few large population-based studies on

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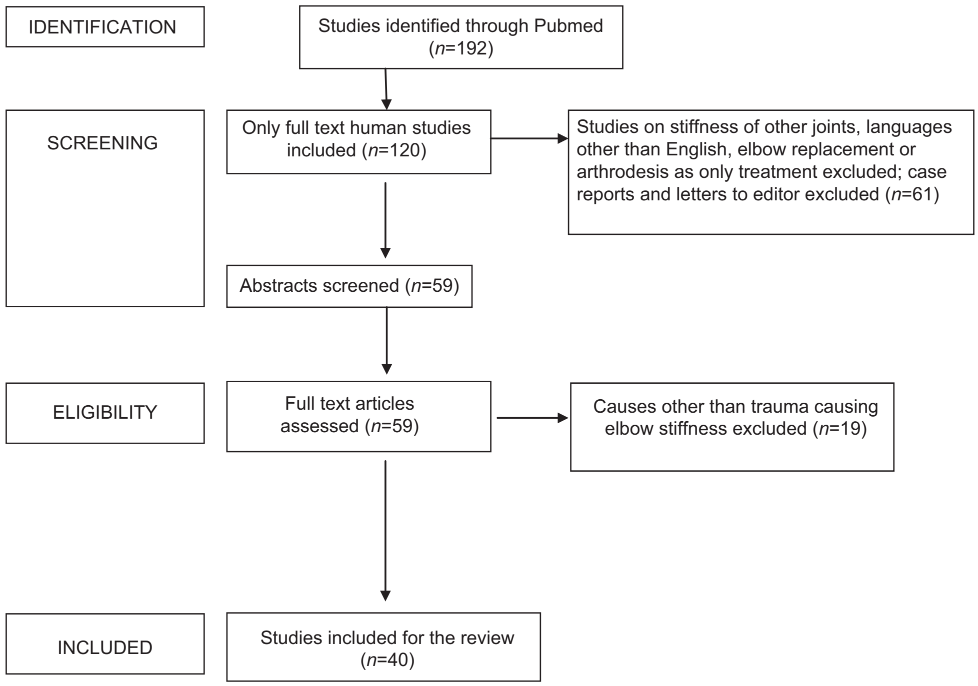

Figure 1: Flow chart

posttraumatic elbow stiffness. Schrumpf *et al*. conducted a study on 19,063 patients of surgically treated elbow trauma.[1] Following the surgery for elbow trauma, 1.4% patients underwent surgical release of elbow contracture after a median period of 7 months. The mean age of patients undergoing contracture release was 43 years and was less than of those not requiring elbow contracture release. They were more often male. Head injuries were seen in 4.4% of the contracture release patients. Burns were noted in 4.4% cases and had the highest predictive value for future contracture release. These cases had a higher proportion of severe injuries and open injuries. Use of internal fixation devices in fractures around elbow had a protective effect against a later contracture release. There was a trend towards diabetes in these patients.

Myositis ossificans (MO) is a frequent reason of elbow stiffness after injury or surgery. About 3% of simple elbow dislocations and up to 20% of elbow fracture dislocations are complicated by MO.[2] Around 5%–10% of isolated head injuries develop MO around elbow.[2] Patients who have a head injury and elbow injury develop MO in 76%–89% cases.[2] Burns cause MO in the proportion of their severity. Additional risk factors include elbow arthroscopy, two-incision distal biceps repair, multiple surgeries within 7–14 days of trauma,[2] genetic predisposition, higher severity of trauma, surgical approach, and hematoma formation.[3] Bauer *et al*. audited their cases and found that the clinically relevant heterotopic ossification (HO) occurred in 7% of elbow trauma cases when no prophylaxis against HO was employed at the time of surgery.[3] Clinically relevant means that it was Class II or III (affecting the elbow range of motion) HO. The highest incidence was seen in floating elbow and terrible triad injuries. The lowest incidence was seen in isolated olecranon and combined olecranon and radial head fractures.[3] The other risk factors were delay in the first surgery and delay in mobilization.[3]

The posttraumatic stiffness is variable in magnitude and time of maturation. There is insufficient literature to document the time course of elbow stiffness. This is relevant when one decides to give up nonoperative treatment in favor of operative intervention. It has been suggested that conservative treatment is indicated up to 6 months after the onset of contracture.[4] Animal models studies have shown stabilization of joint contractures at 32 weeks in rabbit knees.[5] Myden and Hildebrand carried out a prospective study to find the rate of stiffness and intervention required for stiffness after elbow injuries in 25 cases.[6] They found that the range of motion improves in all injuries up to 1 year period. Only 12% cases required surgical intervention for elbow stiffness after this period. Flexion was most affected movement in stiffness. They also noted that if there is a failure of improvement of range of motion after 3 months, it suggests impending elbow stiffness requiring surgical intervention.

Pathology

Regan and Reilly postulated three potential factors for an elbow to be so prone for stiffness – complex articular congruity, brachialis muscle covering the elbow and predisposing it to MO, and prolonged immobilization in the presence of unstable fixation.[7] The stiffness of elbow is multifactorial. Intrinsic contractures are due to intraarticular pathology. Extrinsic contractures are extraarticular pathology.

- The intrinsic limits from deep to superficial to joint motion are joint surface incongruity, osteophytes, synovitis and joint capsule, and ligaments contracture
- The extrinsic causes of joint limitation are contractures of muscle-tendon units, fascial/fibrous supporting tissue that are not tendons or ligaments and skin.

Heterotopic bone also limits motion but is a metaplasia of the above-mentioned structures.

There are two classification systems of stiff elbow.[2] Kay's classification is based on the offending structure:

- Type 1 - soft tissue contracture
- Type 2 - soft tissue contracture with ossification
- Type 3 - nondisplaced articular fracture with soft tissue contracture
- Type 4 - displaced articular fracture with soft tissue contracture
- Type 5 - posttraumatic bony bars.

Morrey's classification is based on etiology and its location and is classified as intrinsic, extrinsic, and mixed.

In any given case, there could be a single or multiple structures contributing to the joint stiffness. Understanding the cellular and molecular pathways of activation and function of myofibroblasts would help to understand the pathology of posttraumatic capsule contracture and to intervene therapeutically. Contracted elbow capsule is much thicker than normal and has collagen disorganization and fibroblast infiltration. The pathology of capsule contracture has been studied by Hildebrand[8] and he described the cascade and mediators of capsule fibrosis after trauma. The author showed that:

- The number of myofibroblast increased 4–5 times in the joint capsule of patients with contractures compared to control capsule. Myofibroblasts are modified fibroblasts which have a function of contraction
- The levels of messenger RNA (mRNA) for Type 1 and Type 3 collagen and matrix metalloproteinases (MMP) 1 and 13 were significantly increased in the contracture joint capsule
- The levels of mRNA of tissue inhibitors of MMP 1 and 2 were significantly decreased in contracture joint capsule
- The levels of mRNA for transforming growth factor (TGF-β1), extra domain A of fibronectin, and connective tissue growth factor are significantly increased in contracture joint capsule. All these factors are upregulators of myofibroblasts.

The number of mast cells is increased in contracture capsules. The mast cells induce a fibrotic response through the involvement of connective tissue fibroblasts and myofibroblasts through the release of intracellular inducing mediators. These mediators are platelet-derived growth factor-A, basic fibroblast growth factor, endothelin-1, and TGF-β1.

The number of nerve fibers containing substance P (SP) and mast cells is also increased in conditions like Dupuytren's contracture which show extensive fibrosis. SP causes degranulation (activation and release of mediators) of mast cells.

Hence, the authors proposed a myofibroblasts-mast cell-neuropeptide axis of fibrosis. The neuropeptides (SP) is produced as a result of the injury. SP activates mast cells. Activation of mast cells in turn activates fibroblasts and myofibroblasts. Myofibroblasts with its contractile and synthetic properties are at fault to produce capsule contracture. This proposed mechanism is consistent with pain (neuropeptide) and inflammation (neuropeptide and mast cells) associated with injury and early healing phase which later gives way to contracture formation (myofibroblasts). To validate this hypothesis, the author evaluated the effect of ketotifen, which is a mast cell stabilizer, on the posttraumatic capsule fibrosis in rabbits. All the biochemical measures of capsule fibrosis were decreased significantly after the administration of ketotifen.

Mattyasovszky *et al.*[9] studied the capsule from normal patients and from the patients with joint contracture. They even carried out *in vitro* cell cultures from these tissue specimens. They found that:

- Normal capsule showed low number of spindle cells that were negative for alpha smooth muscle actin (α-SMA). Specimens of contracted elbow joint capsule showed small spindle cells that were strongly positive for α-SMA. α-SMA is a protein associated with contractile phenotype of myofibroblasts, as well as synthesis of proteins over the course of healing process
- Upon addition of alpha tumor necrosis factor (α-TNF) which is a proinflammatory cytokine, there is an increase in myofibroblasts cell viability and proliferation in cell cultures. This proliferative effect of α-TNF is blocked by addition of its blocker, infliximab. Co-incubation of myofibroblasts with α-TNF and COX2 inhibitor diclofenac resulted in significant inhibition of α-TNF-induced cell proliferation
- Should be debridedα-TNF significantly reduced the collagen gel contraction, indicating reduced contractile forces exhibited by myofibroblasts. This reduction in

collagen gel contraction was blocked by addition of infliximab. Diclofenac exhibited an effect similar to infliximab on collagen gel contraction
- Addition of α-TNF downregulated the gene expression for collagen Type 1 and α-SMA. This downregulatory effect was blocked by addition of infliximab and diclofenac, respectively
- α-SMA positive myofibroblasts secreted enzyme COX2 which is required for synthesis of prostaglandin E2 (PGE2). Addition of α-TNF showed an increase in PGE2. Co-incubation with diclofenac and α-TNF blocked the increase in PGE2 synthesis
- α-TNF inhibits extracellular matrix contraction by downregulation of α-SMA and collagen Type 1 expression in myofibroblasts presumably by promoting PGE2 synthesis.

These results show that α-TNF specifically modulates the functions of myofibroblasts through regulation of PGE2 synthesis and therefore plays a crucial role in the pathogenesis of joint capsule contracture. Knowing and understanding the cellular pathways of elbow stiffness provides us an opportunity to intervene and block these pathways to prevent it.

Myositis ossificans

MO/HO is the formation of mature lamellar bone in soft tissue structures and not deposition of amorphous calcium salts in the soft tissues. It is histologically identical to mature bone but is more metabolically more active and lacks a true periosteal layer. It is formed by stimulation of pluripotent stem cells, which produce osteoid and then mineralizes. The risk factors for the development of MO are concomitant head injury, forceful and repeated manipulations, multiple surgical interventions within 1st week of injury, thermal burns, longer time to surgery, and longer time to mobilization after surgery.[3,10]

Hastings and Graham presented a classification of myositis around the elbow.[11]
- Class I - not causing functional limitation
- Class II - causing functional limitation
- Class IIA – flexion extension <100°
- Class IIB – supination–pronation <100°
- Class IIC - restriction of movements in both planes
- Class III - ankylosis in any plane
- Class IIIA - ankylosis in flexion extension plane
- Class IIIB - ankylosis in rotation plane
- Class IIIC - no motion in either direction.

Malunions and nonunions

Malunions and nonunions of the distal humerus, proximal ulna, and radial head contribute to elbow stiffness in different ways.[10] The lateral column of the humerus is curved anteriorly. If a straight plate is applied to it, it causes less space for coronoid and soft tissues during flexion. The coronoid and olecranon fossae can be crowded due to malunion, fibrosis, implants, myositis mass, and callus. They should be debrided and deepened even to the extent of making a hole. Anterior shear fractures of distal humerus commonly malunite to cause stiffness. They usually need osteotomy and capsular release. Radial head malunion requires radial head resection. Nonunion of distal humerus commonly occurs at metaphyseal region and not intraarticular region. It requires debridement, internal fixation, and bone grafting. In elderly, it can be managed by total elbow replacement. Nonunion of proximal ulna requires debridement, internal fixation, and bone grafting.

Prevention of elbow stiffness

Studies have shown that the process of inflammation, fibroblast, and myofibroblasts activation start early after the injury. Hence, to prevent the stiffness of elbow joint, it is important to start the elbow motion early after injury or surgery. Early motion can be initiated by active exercise or continuous passive motion (CPM) with or without nerve blocks. Pain relief is important after injury or surgery to start elbow movements. However, there would be occasions when elbow movements cannot be started or continued for some time. During such periods, the elbow should be splinted in extension. Splinting the elbow in extension creates enough pressure within the tissues around the elbow to minimize the bleeding and extravasation of fluid.[2] All these help to decrease the stiffness of elbow joint.

Recently, botulinum toxin A has been used intraoperatively after fracture fixation and also after contracture release to prevent elbow stiffness in postoperative period.[12]

Prevention of MO can be done by three methods.[10]
1. Disrupting the signal pathways – PGEs and bone morphogenetic proteins are required for formation of ectopic bone. Nonsteroidal anti-inflammatory drugs (NSAIDs) lower the formation of PGEs by inhibiting the enzyme cyclo-oxygenase. That is why drugs such as indomethacin, ibuprofen, and naproxen are used for prevention of myositis, particularly in the hip. Their role in elbow is unclear, but they are used.
2. Altering the relevant progenitor cell in the target tissue – stem cells are very sensitive to radiation and irradiation prevents them to differentiate into osteoblasts. Radiation dose of 600–100 cGy is used to prevent MO.
3. Modifying the environment conducive to HO – sodium etidronate inhibits angiogenesis needed for mineralization and can prevent ossification.

Radiation therapy can be combined with NSAIDs to prevent HO. However, in the presence of a fracture, NSAIDs and irradiation have to be used with caution since they can cause nonunion.[13] Etidronate is rarely used as it predisposes to osteomalacia.

Clinical examination

History

A thorough history is very useful in the management of stiff elbow. The surgeon should know about the onset and duration of stiffness, any previous treatment, surgical or nonsurgical, and any local infection. Information should be gathered for any existing inflammatory arthropathy or neuropathy. The patient's profession and hobbies should be determined to know the demands of elbow function and give a correct estimate of the prognosis.[10,12] Pain during motion suggests arthrosis and/or ulnar nerve dysfunction and pain at rest suggests infection.

Physical examination

Beside evaluation of elbow, there should be an examination of hand, wrist, shoulder, and cervical spine because they affect the function of elbow. The surgeon should look for local skin condition, active and passive range of motion, and stability of elbow joint. Preoperative assessment of ulnar nerve function and mobility should be documented. It should be verified if the ulnar nerve has been transposed in any previous surgery. Active and passive range of motion should be carefully noted.[12] A firm painless endpoint to motion suggests a bony block. A soft endpoint suggests capsular and muscular contractures. Crepitus and/or pain suggests fracture, synovitis, loose bodies, or degeneration.

Myositis mass in the early stages can present with redness and warmth and can be mistaken for infection.

Imaging

Plain radiographs are useful to see joint congruity, osteophytes loose bodies, and myositis mass. They should include anteroposterior, lateral, and two oblique views. A computed tomography scan can delineate all these much better. MRI is rarely required in the evaluation of a stiff elbow.

Nonsurgical treatment

This modality is suitable for minimal contractures, contracture of the duration of 6 months or less, and nonosseous reason of stiffness.

The different modalities which can be used are serial casting, static splinting, dynamic splinting, CPM, manipulation, and botulinum toxin A. Splints extend the benefits of therapy beyond the duration of medical setting into the remainder of patient's daily life. Static progressive splints (turnbuckle splints) place the tissues at maximally tolerable load and then as the tissues stretch, the load decreases. This uses the viscoelastic properties of the tissues; tissue tension decreases over time when placed at a constant length. The dynamic splints use springs or rubber bands. They employ the principles of creep; changing length under constant load. The goal of both the methods is to produce plastic deformation of tissues leading to permanent lengthening. Both the types of splits are effective for managing elbow contractures.[12] In a systematic review and meta-analysis, Müller *et al*. compared the effectiveness of dynamic, static, and static progressive splints in elbow stiffness of posttraumatic and postsurgical origin.[14] They suggested that static – progressive stretching three times 30 min/day in each direction should be the first line of treatment in patients with posttraumatic and postsurgical elbow stiffness.[14] If it fails or is not applicable due to osseous reasons of stiffness, surgical intervention should be considered.[14]

Manipulation of elbow under anesthesia can be beneficial in some, but it has its own risks. Complications include transient ulnar nerve palsy, periarticular fractures, and HO.[2] Araghi *et al*.[15] carried out manipulation under anesthesia (MUA) of elbows which underwent surgical contracture release but did not show good progress in a range of motion. MUA was done at an average time of 40 days after surgery. The average improvement was 38° with the only complication of ulnar nerve paresthesia.

Review of literature has shown a paucity of reports concerning stretching exercises, local heat application, and joint mobilization even though these are widely used modalities.[15,16] There are only case series showing the benefit of using splints, but these do not show any benefit over the self-administered exercises. The benefit of all the modalities is highest in the first 3 months. However, it continues till 1 year.

Surgical treatment

- The decision to operate on a stiff elbow is very much need based. Different people tolerate elbow stiffness in different ways. Surgical treatment is never the less indicated when there is a failure of nonsurgical treatment, bony block to movements, flexion contracture is >30°, and flexion is <130°
- It may be carried out for lesser deficiencies if it interferes with the patient's lifestyle or vocation. The selection of a particular procedure is dependent on surgeon's experience, site of the pathology, and direction of motion loss.

The longer the intervention is delayed, the more contracted muscles and tendons become. The articular cartilage is also compromised due to immobility particularly when there is complete ankylosis. Therefore, the patient should be preferably treated within 1 year of onset of stiffness to obtain good results.

If flexion of elbow is <100°, it requires the release of posterior band of medial collateral ligament (MCL) of elbow. This band lies on the floor of the cubital tunnel. Hence, that requires ulnar nerve isolation and then release of the posterior band of MCL. William *et al*. found that the rate of postoperative ulnar nerve symptoms was 8.1% who did not undergo ulnar release during surgery.[17] The rate was higher if preoperative flexion was <100° (15.2%) compared with preoperative flexion >100° (3.7%).[17]

Open contracture release

The approach to the elbow joint could be medial, lateral, or anterior depending on the pathology, previous skin incisions, and need for ulnar nerve decompression. There could be separate skin incisions for medial and lateral approach or a single posterior skin incision can help to approach the elbow joint on either side. The anterior approach to elbow is rarely used in situations when there is an isolated flexion contracture without any pathology in olecranon or olecranon fossa. Whatever be the approach, every effort is made to preserve the lateral collateral ligament and the anterior band of MCL. This is important to maintain the stability of the joint.

(a) Lateral column procedure – proximal to the elbow joint, this approach is between the humerus and extensor carpi radialis longus (ECRL) anteriorly and the humerus and triceps posteriorly. Distal to the joint, this approach is between ECRL and extensor carpi radialis brevis. Posteriorly, the capsule is incised and olecranon and olecranon fossa reapproached. Any osteophyte, fibrous tissue, or loose body is excised. Anteriorly, the muscle mass is taken off the capsule, which is then excised. Any osteophyte, loose body, or fibrous tissue is also taken off from the distal humerus and radial head. The view toward the medial side is limited through this incision, and if any procedure is required on the medial side, a separate incision on the medial side is required.

(b) Medial column approach – the ulnar nerve is isolated and mobilized. Posteriorly, the posterior band of MCL is cut and excised to improve flexion beyond 100°. The triceps is reflected off the humerus, and posterior elbow capsule is cut. Any osteophyte, loose body, or fibrous tissue from olecranon and olecranon fossa is excised. Anteriorly, the brachialis is raised off the humerus after cutting the medial septum. The anterior half of the flexor-pronator muscle mass is raised from the medial epicondyle in continuation with the distal brachialis. The medial anterior capsule is excised and any osteophyte, loose body, or fibrous tissue is removed from the distal humerus and coronoid.

(c) Anterior approach – a curvilinear incision starting superolaterally and ending inferomedially is made. The structures to be protected are medial and lateral antebrachial cutaneous nerves, brachial artery, median, radial, and musculocutaneous nerves. Medially, the interval between the common flexors and biceps is developed. Laterally, the interval between brachioradialis and biceps is developed. The brachialis is then isolated and separated from the anterior capsule. Capsule can then excised, and rarely brachialis may have to be detached distally to gain extension.

Ring *et al*. reported that open elbow capsulectomy restores a near 100° arc of motion. Second elbow surgery provided only a limited additional gain in movements.[18] The second surgery for gain in motion and/or for ulnar nerve symptoms may be considered in nearly one-third of cases. The patient specific scores are not determined by range of motion but by pain and ulnar symptoms.[18] Yu *et al*. carried out a study to know the effect of radial head excision and radial head replacement in stiff elbows.[19] They found that both resection and prosthetic replacement with open arthrolysis were feasible and gave equal outcomes. They recommended that if elbow is stable, resection is preferable to replacement. Koh *et al*. reported good results of surgical release of a stiff elbow that develops after internal fixation of intercondylar fracture humerus.[20] However, they cautioned against refracture when the implants were removed at the same sitting.[20]

HO is generally considered a negative predictor for outcome after open release. Lindenhovius *et al*. found that after surgery, the gain in the arc of motion was more in the cases with myositis mass as compared to the elbow where it was absent though the final range of motion was similar.[21] These patients also required fewer additional procedures. The same study group found that the outcomes of elbow release after complete ankylosis due to HO were similar to the release after partial ankylosis due to HO.[22] Hence, the degree of ankylosis due to HO did not matter in the final outcome. Baldwin *et al*. found that the results were good irrespective of the etiology of the HO.[23] They also found that the HO tends to recur more when there is a neurological etiology. Functional range was poor if surgery was delayed beyond 12 months; functional range was poor if limitation was in both planes before surgery and functional outcome poor if the anterior mass was present.

Rex *et al*.[24] found that the results of HO excision were better when done before 6 months. However, these were cases without neurogenic origin of HO. The authors conceded the fact that this was contrary to popular belief that this should be done after 6 months. Similar argument for early excision was also given by Lindenhovius and Jupiter[10] also. Moritomo *et al*. performed early excision of HO from the medial elbow and obtained good results.[25] They only excised the thickened gelatinous mass from the posterior border of anterior band of MCL to anterior triceps without touching anterior, posterior, or lateral structures. The authors concluded that the structures other than medial structures are involved secondarily and become fibrosed when the elbow remains stiff for a longer time due to HO on the medial side. However, in children, the nonbridging myositis mass should be observed because they usually get resorbed without any intervention.[25]

The complications after excision of HO are similar to those of operating any stiff elbow without HO. In addition, there are chances of recurrence of HO. Lee *et al*. found that those with burns had least complication rates and those with a head injury had the maximum complication rates.[26] They also found that the best outcome after surgery was possible if there was increased postoperative arc of motion, etiology was burns, and CPM was used postoperatively.

However, Koh *et al*. obtained good results irrespective of the preoperative range of motion.[27] They had less favorable results in presence of recurrence of HO and delay of more than 19 months in surgery. The incidence of infection after open release is around 6.5%.[28] Yan *et al*. described that local application of vancomycin powder before closure of wound dramatically reduces the rate of postoperative infection in stiff elbows.[28]

Hinged external fixator
This modality is used when the collateral ligaments are damaged after the release of stiff elbow. The ligament deficit may be on one side or it may be global. Kulkarni *et al*. used the hinged external fixator after the release of ligaments and showed an improvement of arc of motion of 87° with only one case of ligament instability.[29] Ouyang *et al*. used the fixators after partial ligament release and obtained an improvement of 85°.[30] Wang *et al*.[31] released the ligament origins from humerus during the open arthrolysis. They then fixed the ligaments with suture anchors and applied a hinged elbow fixator. The average improvement was 101°.

Arthroscopic release
This method is generally considered suitable for mild to moderate contractures, with the absence of HO, articular incongruity, and ulnar nerve symptoms/prior transposition. When a posterior band of MCL needs to be released in the presence of flexion limited below 100°, it may be performed through a small incision medially without opening the joint or by the arthroscopic method.[12] The average gain ranges from 26° to 38°. In the presence of capsular fibrosis, the distension of capsule is minimal and that makes visualization inside the joint difficult and also places the neurovascular structures very close to the joint and are at risk. The use of multiple portals and retractors inside the joint help in visualization and protection of vital structures anterior to the capsule. In the presence of poor visualization and higher risk to neurovascular structures, this option is mostly carried out by the highly trained elbow arthroscopists.

Interposition arthroplasty
Whenever there is a joint incongruity in a young patient, this a good option to restore the movements. A lateral approach is generally used and capsule is excised. Bone ends are contoured with a burr. The articular surface of distal humerus is resurfaced using autologous fascia lata, autologous skin, or allograft Achilles tendon. The ligaments are repaired and an articulated fixator is applied. Nolla *et al*. concluded that interposition arthroplasty could improve elbow motion and function but at the expense of elbow stability despite hinged external fixation.[32]

Total elbow arthroplasty
It is a salvage procedure for stiff elbows in old people. This is because the procedure imposes a lot of limitations on the activities of the elbow. A linked semiconstrained design is most suitable.

There is no high-level guideline to choose a particular surgical procedure for the stiff elbows. Kodde *et al*. carried out a systematic review of published literature.[33] All the procedures could be grouped in one of the following – open arthrolysis, arthroscopic arthrolysis, open arthrolysis with an external fixator, and open arthrolysis with distraction arthroplasty. The choice of procedure is partially dependent on a preoperative range of motion. They found that the current literature is not sufficient to draw a firm statistically base conclusion, and the amount of complications rises with the extent of surgical procedures.[33] Hence, they advised that the procedure selected should be as less invasive as possible.

Lindenhovius *et al*.[34] correlated the health status after open release. They found an average of 55° improvement in flexion extension and significant improvement in disability of arm, shoulder and hand questionnaire, and short form-36 scores. However, it was not the range of motion or the improvement in range of motion that correlated with the outcomes scores. It was pain and ulnar nerve dysfunction that correlated with the outcome scores.

Postoperative care
The success of treatment is dependent on patient's understanding and willingness to comply with a rigorous

postoperative protocol. It is best to keep the patient admitted to the hospital for a few days to start and then supervise the physiotherapy of the operated elbow. Pain control can also be better achieved if the patient remains in the hospital. There is no consensus in the literature for the optimum postsurgical rehabilitation protocol. Instead, there are general guidelines.

The swelling of the elbow in postoperative period is controlled by elevation and anti-inflammatory drugs. It is important that the movements of the elbow are started early to avoid adhesion formation and recurrence of stiffness. To enable the movements of elbow, it is mandatory to have good pain control in the postoperative period. The pain control can be achieved by multimodal therapy. These include nerve blocks, NSAIDs, paracetamol, narcotics, pain modulator, and steroids. The route and dosage of these drugs can vary depending on the profile of the patient. Help from a pain specialist or anesthetist can be of great value in this regard. It has been shown that the patient-related outcomes of the procedure correlate more with pain than with a range of motion achieved.

The easiest method of mobilization of elbow is passive manipulation in the early phase and then active assisted exercises in the later phase. The surgeon or the physiotherapist can initiate the passive manipulations of elbow on the 1st or 2nd postoperative day. Effort is made to achieve the range of motion of elbow that was achieved on the operating table though the final outcome is usually much less. Both flexion and extension are gained simultaneously and not one after the other. No effort is made to gain supination or pronation if the ipsilateral wrist is also stiff after trauma. It is usual to have good active/active-assisted range of motion by the 4th or 5th postoperative day. By this time, the patient can be taught to assist the elbow movements with opposite hand while lying in a lateral position. While the patient is lying in the supine position, forward flexion of shoulder to 90° can also help the patient to flex the elbow. In this position, the gravity tends to flex the elbow.

Adjuncts to physiotherapy

- Cryotherapy/ice packs – these can help to decrease the swelling of the part and hence the local pain. They can also help to reduce the requirement of analgesics
- Continuous passive motion – the role of CPM is debatable. There are reports which claim benefits of CPM in the postoperative period. The proponents of this modality consider almost mandatory to employ it in the postoperative period.[35-39] However, there are reports which consider it nonessential. Lindenhovius *et al*. demonstrated in a retrospective-matched case–controlled study that the use of CPM did not produce any benefit.[40] The authors felt that the use of CPM was based on anecdotal reports and not on scientific study.[40] Use of CPM requires additional cost of equipment and hospitalization. Hence, its use should be viewed in this light and judicious decision made
- The progressive static splints are useful after 6 weeks. It can be applied in flexion or extension during night depending on the deficit
- Use of intraarticular steroid, MUA, or botulinum toxin A can be performed. Evans *et al*. have used botulinum toxin A intraoperatively during the contracture release and also up to 2 months postoperatively in those who show sudden decrease in motion.[20]

The physical therapy after surgery can be continued till 12 months after surgery or a plateau is reached.

Higgs *et al*. could achieve mean improvement of 40° in the arc of motion. They also found that the patients with <30° range of motion had the greatest improvement in the arc of motion.[39] This finding was reported by other authors also, but this could not be explained. They noted that though the surgery was carried out to improve the range of motion, there was associated significant relief in pain.[39] This gain in arc of motion could be due to relief from impingement at the end of arc of motion and ulnar nerve entrapment.[39]

Discussion

Stiffness of elbow after trauma is a disabling complication. There is a near universal consensus on the factors causing posttraumatic elbow stiffness, pathology, and prevention of elbow stiffness. Although surgery adds insult to the initial trauma, internal fixation has shown to have a protective effect against the elbow stiffness.[1] This is due to the fact that articular congruity is restored and the joint can be mobilized early without displacing the fragments. The elbow has been traditionally splinted in 90° of flexion after surgery. However, it has been shown that splinting in extension creates enough pressure within tissues around the elbow joint that it prevents extravasation of fluid and minimizes the bleeding.[2] The olecranon fossa, which is the largest fossa in elbow joint, is occupied by olecranon in extension. This decreases the potential space for the fluids in the joint. Although many factors affect the incidence and severity of HO around the elbow joint, most of these are related to the initial trauma.[2,3] The factors which can be modified by the surgeon are time to the surgery and time to mobilize after the surgery.[3] Early surgery and early mobilization help to prevent HO. This fact highlights the importance of good pain relief after the surgery which can help the patient to move the elbow. This single factor is often neglected in our clinical practice, and we often wait too long for the pain to subside and the elbow to be mobilized. However, there are no fixed protocols for early mobilization.[12]

There is a consensus in the literature that conservative treatment can help when the stiffness is of <6 months, minimal, and nonosseous in nature. We feel that when conservative treatment is used for severe deformity which is nonosseous in nature, it can correct the stiffness partially. Hence, it helps to reduce the subsequent surgical procedure in its extent. However, there is no consensus on types of brace to be used, protocols of using the brace, and role of MUA and CPM. Similarly, there is no consensus regarding the surgical treatment. The review of the literature has not shown any guidelines regarding the choice of the procedure. It is mostly dependent on the surgeon's choice and to a lesser extent on the pathology of stiff elbow. It has also been shown that greater the invasiveness of the procedure, higher is the gain in the range of motion but with a higher rate of complications.[33] This fact poses a challenge to the surgeon when a more invasive procedure is required for a severe contracture of elbow. The worst case scenario is when the stiff elbow is associated with intraarticular malunion and loss of cartilage. These elbows have limited treatment options of arthrodesis, elbow replacement, and interposition arthroplasty. There is very limited literature to comment about arthrodesis and interposition arthroplasty. Total elbow replacement should not be used in stiff elbow in young adults as it imposes severe restrictions on the use of limb. It should be used in the elderly population. Hinged elbow fixator, a variant of Ilizarov fixator, is a newer modality for such severe cases and is recommended when collaterals are disrupted during the contracture release. We would recommend that this modality should be used by experts only and not by a surgeon who applies external fixator occasionally around the elbow. Literature does not show any consensus on the protocols for postoperative physiotherapy though there is agreement that it should be instituted as early as possible. Traditionally passive exercises have been considered detrimental to the elbow joint. But now, they form a part of the physiotherapy program and are started early when active exercises are difficult to perform due to pain. In summary, elbow stiffness is a frequent complication of elbow trauma. Various factors contribute to the stiffness. Prevention is the best option and it should be instituted as early as possible in the management of elbow trauma. Nonoperative treatment has shown good results in correctly selected cases. Choice of surgical procedure is based on the pathology of stiffness and the surgeon's preference. Postoperative physiotherapy plays an equally important role in the final outcome.

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Conflicts of interest

There are no conflicts of interest.

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