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Management of the stiff elbow: a literature review

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- The elbow is prone to stiffness due to its unique anatomy and profound capsular reaction to inflammation. The resulting movement impairment may significantly interfere with a patient's activities of daily living.
- Trauma (including surgery for trauma), posttraumatic arthritis, and heterotopic ossification (HO) are the most common causes of elbow stiffness.
- In stiffness caused by soft tissue contractures, initial conservative treatment with physiotherapy (PT) and splinting is advised. In cases in which osseous deformities limit range of motion (e.g. malunion, osseous impingement, or HO), early surgical intervention is recommended.
- Open and arthroscopic arthrolysis are the primary surgical options. Arthroscopic arthrolysis has a lower complication and revision rate but has narrower indications.
- Early active mobilization using PT after surgery is recommended in postoperative rehabilitation and may be complemented by splinting or continuous passive motion therapy. Most results are gained within the first few months but can continue to improve until 12 months.
- This paper reviews the current literature and provides state-of-the-art guidance on the management regarding prevention, evaluation, and treatment of elbow stiffness.

Keywords

- arthrofibrosis
- posttraumatic
- soft tissue contracture
- osseous impingement
- treatment

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Introduction

Elbow stiffness can be a debilitating condition that significantly impacts a patient's ability to perform activities of daily living (1, 2). The elbow joint is particularly susceptible to stiffness due to its highly congruent bony anatomy, relatively confined joint space tightly stabilizing collateral ligament complex, and the close relationship of the surrounding muscles acting as secondary stabilizers (3). While trauma, surgery, posttraumatic arthritis, and possible concomitant occurrence of heterotopic ossification (HO) are among the most common causes of stiffness, joint degeneration resulting from aging might also contribute. Elbow stiffness can be caused by osseous impingement or deformity, soft tissue contracture, or a combination of both. Morrey *et al.* reported that most of our daily activities could be accomplished within a range of 30°–100° of elbow flexion (1). However, more recent studies showed that a greater flexion arc is required for modern daily activities such as using a mobile cellular phone (2). Whether elbow stiffness is symptomatic is patient specific and depends on the patient's flexion arc required to perform work, sports, or hobbies. Therefore, the definition of elbow stiffness cannot be specified by precise values but is patient specific. Restoring adequate range of motion (ROM) can be challenging in some cases (1). For that reason, it is crucial that the proper treatment options are utilized and the right treatment workup is followed. It is important to note that rotational elbow impairment has a distinctly different treatment workup and is beyond the scope of this review.

The purpose of this paper is to present a review of the current literature on posttraumatic elbow stiffness and to provide state-of-the-art guidance on the management regarding prevention, evaluation, and treatment of elbow stiffness.

Etiology of elbow stiffness

Multiple causes contribute to elbow stiffness, with trauma being the most common (4). Posttraumatic stiffness occurs as a result of four stages: bleeding, edema, granulation, and fibrosis (5). Regarding the latter, histopathologic studies show an increased number of myofibroblasts, collagen crosslink formation, and expression of transforming growth factor-beta, leading to excessive capsular scarring (6, 7). Moreover, a decreased capsular content of proteoglycan and water leads to

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further contraction, additionally limiting the ROM (8). HO is another important factor for stiffness, induced by the upregulated expression of bone morphogenetic protein in response to inflammation (9). This leads to the formation of mature lamellar bone in the soft tissues around the joint, creating a mechanical block that restricts elbow motion. The incidence of HO ranges from 1.6% up to 56%, increasing with the extent of trauma, concomitant joint dislocation, surgery, prolonged immobilization, burns, or neurological injury (10, 11). Morrey *et al.* divided elbow stiffness into a classification consisting of intrinsic, extrinsic, and combined contractures (12). Herein, intrinsic contractures are associated with intra-articular (IA) injuries, such as IA adhesions or malunions, loss of articular cartilage, protruding metalwork, loose bodies, and infection. Conversely, extrinsic contractures do not have a direct relation with the joint. These consist of capsular and ligamentous contractures, skin contractures following burns, HO, neural adhesion, extra-articular malunions, and extra-articular infection. Most posttraumatic contractures include both intrinsic and extrinsic factors, classifying them as mixed.

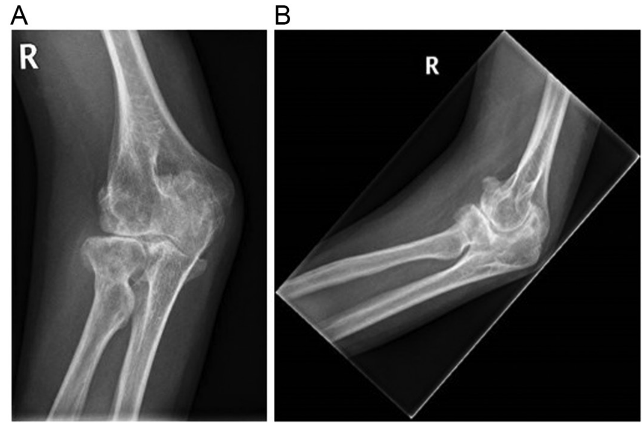

Figure 1
Plain elbow radiographs during maximum extension in a 23-year-old girl with posttraumatic stiffness of the right elbow. (A) Anteroposterior view showing degenerative joint changes along with the presence of osteophytes of the medial coronoid and deformation of the radial head. (B) Lateral view showing an additional osteophyte at the coronoid fossa, possibly causing impingement during elbow flexion.

Evaluation

Clinical evaluation

Elbow flexion and extension should be measured and compared to the contralateral side as maximal flexion ranges from 140° to 150° and maximal extension from –10° to 10° in healthy subjects and is dependent on sex and age (13, 14). Despite elbow stiffness usually being relatively pain free, end-range tenderness can be found in most cases. Elbow stability is often not abnormal; however, it can be difficult to test in patients with limited ROM. In stiff elbows, pathological changes of the posteromedial capsule, as well as tissue scarring or even protruding metalwork due to previous surgery, increase the likelihood of ulnar entrapment, especially in posttraumatic stiffness (15). Therefore, the ulnar nerve should be carefully examined for signs of either entrapment or instability, and the location in its sulcus should be carefully documented. Signs of ulnar entrapment or adhesion can be provoked during deep flexion.

Radiological evaluation

Plain elbow radiographs in anteroposterior (AP) and lateral view are used to evaluate joint congruence, degeneration, osteophytes, and the presence of HO or loose bodies (Fig. 1). It can, however, sometimes be difficult to get a clear AP view due to the extension deficit. Computed tomography (CT) is recommended in all symptomatic stiff elbows suspected of osseous impingement or deformities requiring treatment. The addition of three-dimensional (3D) and 4D visualization of CT scans to distinguish between osseous impingement and mainly soft tissue contracture as the cause of the stiff elbow can be valuable (Fig. 2) (16). Electromyography and/or nerve conduction studies with additional ultrasound are indicated in suspected ulnar neuropathy.

Prevention of stiffness

Prolonged immobilization and multiple previous surgeries are additional risk factors for developing stiffness (17, 18). Lordens *et al.* analyzed the results of the FuncSiE multicenter randomized clinical trial, comparing early mobilization starting 2 days post-injury to plaster immobilization for 3 weeks in 100 patients with simple elbow dislocations (18). In this study, early mobilization resulted in earlier recovery and return to work without further increasing the risk of recurrent elbow dislocations or persistent instability. Furthermore, at 6 weeks of follow-up, patients in the early mobilization group reported significantly better functional outcome scores, measured using the Quick Disabilities of the Arm, Shoulder and Hand score (*quick*-DASH) and Oxford elbow score, and a larger arc of ROM during flexion and extension. At 1 year, both groups had similar results and similar rates of complications and secondary interventions. In line with these findings, the elbow should be mobilized as early as possible to prevent stiffness in other pathology as well. For the prevention of HO, non-steroidal anti-inflammatory drugs can be considered (19). Perioperative IA corticosteroid injections remain a topic

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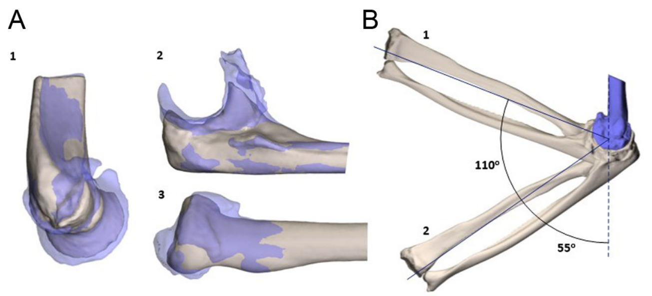

Figure 2
Three-dimensional (3D) and four-dimensional (4D) bony reconstruction of the elbow of the patient shown in Figure 1. (A) Detailed images of the distal humerus (1), proximal ulna (2), and proximal radius (3). The mirrored non-affected side is overlain with the affected side (in transparent purple). Osteophytic bone spurs in the radial fossa and coronoid fossa and a deformed osteophytic border of the medial trochlea (1), together with profound osteophytes of the olecranon and coronoid process (2) and radial head deformation (3), can be seen. (B) Lateral view showing a maximum flexion of 110° (1) and an extension deficit of 55° (2).

of debate, with significant effects in the prevention of HO (20). However, multiple studies have shown that IA corticosteroid injections are significantly associated with the development of postoperative infection (20, 21, 22).

Conservative treatment

Physiotherapy (PT) and splinting play an important role in the treatment of stiffness both as a conservative treatment modality and during postoperative rehabilitation. The goal of conservative treatment is to improve the ROM, whereas postoperative rehabilitation is used to maintain the achieved ROM during surgery. Best results of conservative treatment can be attained if the therapy is started within 6 months of the injury (11). In symptomatic posttraumatic stiffness with underlying soft tissue contracture, conservative treatment is indicated as primary treatment. If adequate treatment does not lead to a further improvement in ROM after 3–6 months, surgical treatment is advocated. Conversely, conservative treatment is contraindicated if disturbance of the osseous anatomy is the main cause of stiffness. In these cases, early surgical treatment is recommended.

Physiotherapy

PT plays a crucial and versatile role in the treatment of the posttraumatic stiff elbow. Best results are gained if started within 6 months after the onset of the stiffness (10, 11). Active mobilization is best performed in a supine position while elevating the upper arm, reducing stress in the joint stabilizers (23). Apart from active and passive mobilization, additional exercises stimulating wrist and hand vascular circulation to decrease edema, as well as exercises improving proprioception, can be added accordingly.

Splinting

Static, static progressive, and dynamic splinting are commonly utilized techniques in the conservative treatment of posttraumatic elbow stiffness. Static splinting involves immobilizing the joint using a static splint, providing stretch in the direction requiring most improvement. The static progressive type uses a turnbuckle or a strap and loop to facilitate the patient to gradually increase the tension and therefore increase joint mobility (Fig. 3). Static (progressive) splints are recommended to be worn three times per day for a 30-minute period (24, 25). Dynamic splints, on the other hand, use a spring to facilitate a lesser amount of tension in the direction requiring improvement whilst allowing flexion or extension in the other direction during active movements. Dynamic splits are recommended to be worn for a subsequent period of 6–8 h, preferably during the night. However, in general, the dynamic splints are very bulky, which makes the use of these splints during the night unattractive. Moreover, these splints are more expensive than turnbuckle splints. Both systematic reviews of Veltman *et al.* and Muller *et al.* analyzed the effects of static, static progressive, and dynamic splinting in managing elbow stiffness (24, 26). All splinting techniques resulted in a substantial and sustainable improvement in ROM, with around 40° of improvement in ROM in the static progressive and dynamic splinting groups. The results of static splinting to improve the flexion were, however, inferior compared to static progressive splinting and dynamic splinting (26). It must be noted that there

Figure 3
A patient wearing two different types of static progressive splints for the conservative treatment of elbow stiffness. (A) A static progressive turnbuckle splint applying torque to the elbow in extension. Tuning of extension can be achieved by turning the red pin. Note: The red pin is shown for illustrative purposes but must be removed after the desired amount of flexion or extension torque is achieved. (B) A static progressive splint with a non-elastic strap and loop applying torque to the elbow in flexion.

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was great variability between the reviewed studies in treatment duration and timing when the treatment was initiated (defined as the period between trauma and initiation of splinting). The optimal timing after trauma to start splinting treatment for posttraumatic elbow stiffness and the effects of splinting in chronic contractures (>1 year after trauma) should be further investigated. Based on the literature and own experience, we prefer to use static progressive splinting three times daily for 30 min for flexion deficits and static progressive splinting overnight for extension deficits (Fig. 3). As posttraumatic elbow stiffness can improve with splinting over a period of 6–12 months, patience is warranted (25). Therefore, we recommend a treatment duration of at least 6 months or until a pending contracture is reached. The development of ulnar nerve symptoms, mostly seen during bracing in flexion, is an indication to stop splinting.

Surgical treatment

Surgical treatment is indicated for elbows with osseous impingement or soft tissue contractures resistant to conservative treatment. Open arthrolysis or arthroscopic arthrolysis are the primary surgical options, for which the decision is based upon multiple factors, including the etiology, site of previous surgery, and ulnar nerve involvement. Arthroscopy offers improved joint visualization, reduced scarring, lower infection risk, less pain and swelling, and faster recovery compared to open arthrolysis (27, 28, 29, 30, 31). However, the technique is more difficult to perform in cases of deformed elbows resulting from trauma, burns, skin grafts, severe rheumatoid arthritis, and previous elbow surgeries and in congenital deformities. Relative contraindications for arthroscopy are the inability to palpate or localize the ulnar nerve or ulnar nerve instability (30). In these cases, we recommend open arthrolysis or open identification of the ulnar nerve prior to the arthroscopy. Additionally, open arthrolysis is a more viable option if the pathology is mainly extra-articular (e.g. HOs), in accompanying rotational impairments, and in case of previous surgery with multiple incisions leading to concomitant local anatomic changes. Herein, caution is advised for an abnormal radial nerve position. Furthermore, cases of long-standing severe flexion contractures with a flexion arc <90° could also benefit from an open approach with the release of the posterior band of the medial collateral ligament (MCL) and ulnar nerve release, ensuring safe cubital tracking without traction injuries due to scarring of the cubital tunnel.

Both methods yield similar results regarding functional outcomes, treatment success, and arc of motion, while complications and revisions are significantly lower with arthroscopic arthrolysis compared to open arthrolysis (Table 1) (32). It was critically noted by the authors that arthroscopic arthrolysis has narrower indications than open arthrolysis. These rates are in line with the conclusions of Kodde *et al.*, reporting arthroscopic arthrolysis as a safer surgical procedure (33). Because the number of complications and revision rates increases with the invasiveness of the treatment, arthroscopic arthrolysis might be favored if surgery is indicated (33, 34).

Arthroscopic arthrolysis

Arthroscopic arthrolysis allows debridement of anterior, posterior, and posterolateral compartments, synovectomy, removal of adhesions and osteophytes, capsular release, and removal of loose bodies.

It can, however, be a challenging procedure due to the proximity of neurovascular structures and restricted workspace. The capsular compliance is additionally limited in a stiff elbow, making the workspace even smaller. Due to the small working space, the ulnar and radial nerve are particularly at risk of iatrogenic injury (30, 35). Prior to the procedure, physical examination under anesthesia should be performed, measuring the ROM, testing the elbow for instability, and localizing the position of the ulnar nerve. The patient is placed in the lateral decubitus position, with the upper arm on a support with the elbow in 90°, allowing a small range of elbow motion. The elbow itself should be left completely free, avoiding external pressure on the anterior capsule (29, 30). The anatomical landmarks and portals are marked (Fig. 4), and a tourniquet is used at 250 mmHg (28, 29, 30, 36). Distention of the joint is achieved by injecting 20-30 mL saline solution into the fossa olecrani or 'soft spot'. This spot can easily be identified as the center of the triangle formed by the lateral epicondyle, the radial head, and the olecranon. Successful injection will cause

Table 1 **Outcomes comparing open arthrolysis to arthroscopic arthrolysis (31).**

Outcome	Open	Arthroscopic	*P*
MEPS improvement (preoperative–postoperative)	28.9 (61.4–89.7)	25.7 (63.1–88.8)	-
Treatment success	88.8%	91.8%	0.231
Average arc of motion (preoperative–postoperative)	70.4° (42.7°–113.2°)	39.2° (68.1°–108.0°)	–
Complications	18.1%	9.1%	≤0.001*
Revisions	6.3%	1.6%	≤0.001*

*Statistically significant.
MEPS, Mayo Elbow Performance Score.

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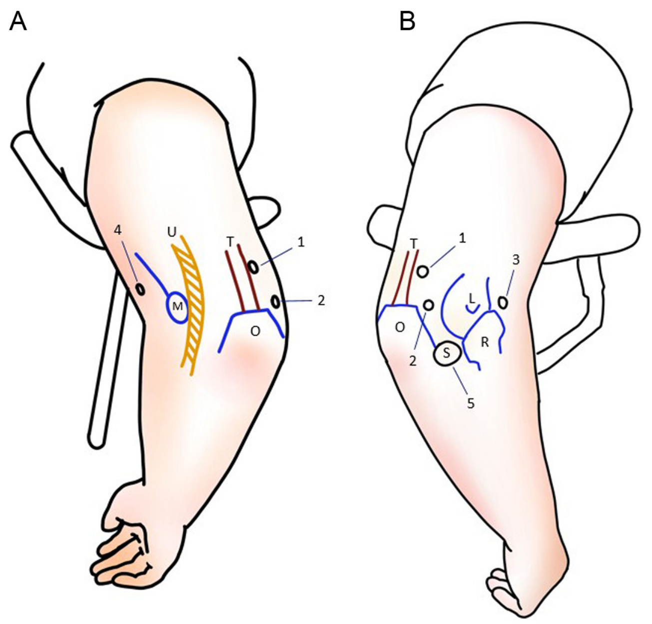

Figure 4
Marked anatomical landmarks and portals for arthroscopic arthrolysis on the right arm in a patient lying in the lateral decubitus position. Note the free range of motion for extension and the space for the arthroscope on the axillary side. (A) Anatomical landmarks and portals shown for medial view. (B) Anatomical landmarks and portals shown for lateral view. U, ulnar nerve; M, medial epicondyle; T, triceps central band; O, olecranon; L, lateral epicondyle; R, radial head; S, soft spot; 1, straight posterior portal; 2, posterolateral portal; 3, anterolateral portal; 4, anteromedial portal; 5, soft spot portal.

bulging of the posterolateral corner of the elbow (30). Joint distention moves the anterior capsule together with the neurovascular structures away from the joint surface. It does, however, not change the distance between the capsule and nerves (28, 29, 30, 36). The procedure can be started in the posterior or the anterior compartment, depending on the surgeon's preference. An overview of portal locations and considerations during placement is provided in Table 2.

Open arthrolysis

For open arthrolysis, a multitude of approaches is possible. The specific approach is dependent on the location of the pathology and previous incisions if present. The specific goals for each specific approach are stated in Table 3. It may, however, not always be possible to regain full ROM during arthrolysis due to the concurrent posttraumatic changes in anatomy and capsular reaction. For most cases, a lateral approach provides sufficient exposure to perform the arthrolysis (10, 37, 38). This approach is highly versatile and widely used in practice. It offers high satisfaction rates and improves elbow motion by preserving the lateral collateral ligament. A Kaplan or extensor digitorum communis-split approach can be used for the procedure, using a curved skin incision on the lateral side of the elbow (Fig. 5). The origin of the extensor carpi radialis longus and the brachioradialis muscles are subsequently released from the lateral distal humerus column (Fig. 5), and the anterolateral capsule can be opened. More distally, the joint capsule and annular ligament are incised collinearly with the muscle split and anteriorly to the capitellum to avoid injuring the lateral ulnar collateral ligament (Fig. 5). Adhesions in the anterior compartment can be removed, the anterior capsule can be released from the distal humerus, and osteophytes or loose bodies can be removed. In addition, the posterior capsule can be visualized by elevating the triceps from the posterior aspect of the distal humerus. The posterior capsule can be opened and excised, and the olecranon fossa can be cleared of scar tissue and osteophytes.

The medial approach is indicated when surgery to the ulnar nerve is necessary, when the pathology is medially located, or when a release of the posterior band of the MCL is needed (37). The medial approach, also known as the medial column procedure, involves a curved incision on the medial side of the humerus. This incision extends from the distal humerus over the cubital tunnel. The ulnar nerve is then identified and released to allow access to the posterior bundle of the MCL, which forms the floor of the cubital tunnel. A subsequent semilunar release of the contracted posterior bundle of the MCL can be performed to improve the flexion of the elbow. Care must be taken during the release of the posterior bundle to prevent damage to the anterior bundle and subsequent iatrogenic medial-sided instability (10). The olecranon fossa and overlying posterior capsule can be accessed by elevating the triceps muscle. Access to the anterior compartment is achieved by creating a window through the flexor-pronator mass with proximal extension.

When the pathology is both medial and lateral, a two-incision technique (medial and lateral) can be used. As an alternative, the posterior approach can be used, allowing an extensive release from both medial and lateral sides. The approach consists of creating a lateral and medial full-thickness skin flap, followed by identification and mobilization of the ulnar nerve. A medial and lateral paratricipital window is created, elevating the triceps and revealing the posterior capsule and posterior band of the MCL (Fig. 6). Additionally, the anterior compartment can be addressed by creating a window using the lateral extensor split approach and/or the medial flexor-pronator approach, as described above. The posterior approach is favored in case of previous posterior incision (e.g. after surgery for distal humerus fracture). Using this technique, the release of both the anterior and posterior capsule is possible.

The anterior approach has limited indications for posttraumatic stiffness. It is mainly used for the removal of

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Table 2 Overview of portal placement for each compartment and considerations during placement for arthroscopic arthrolysis.

	Compartment		
	Posterior	**Radiocapitallar**	**Anterior**
Portal placement			
Arthroscope	Straight posterior	Posterolateral	Anteromedial
Working portal	Posterolateral	Elbow soft spot	Anterolateral
Access locations			
1	3 cm proximal to the olecranon tip	Radial side of the olecranon tip	Anterior and proximal to the medial epicondyle
2	Radial side of the olecranon tip	Elbow soft spot	Anterior and proximal to the lateral epicondyle
Considerations			
1	Avoiding triceps central band	Slightly extend elbow during insertion to prevent subcutaneous placement	Palpate medial intermuscular septum confirming proper placement
2		Blade insertion at 45° angle to posterior olecranon plane; penetrate capsule using curved clamp, confirmed by popping sensation and fluid outflow	Skin-only incision to prevent MABCN damage; insert trocar toward joint, while slightly lifting the forearm, while maintaining contact with the anterior humerus surface
3			Insert needle from the lateral side under arthroscopic view
4			Caution at anterior capsule near the radial head to avoid PIN damage
Visualization			
1	Fossa olecrani	Posterolateral compartment	Coronoid fossa
2	Posterolateral space	Radial head	Capitellum
3	Olecranon tip	Proximal radioulnar joint	Radial head
4		Ulnohumeral joint	Anterior capsule
5			Ulnar joint side
6			Coronoid process
Goals			
1	Fibrous tissue debridement for improving view and elbow extension	Loose body removal	Synovectomy from lateral portal
2	Osteophytectomy reducing posterior impingement and improving extension	Removal of fibrous tissue	Removal of osteophytes from coronoid process
3			Loose body removal
4			Blunt release of anterior capsule

MABCN, medial antebrachial cutaneous nerve; PIN, posterior interosseous nerve.

anterior HOs. It carries the risk of damage to the median nerve and brachial artery and often requires an additional posterior release (37).

Total elbow arthroplasty and interposition arthroplasty

For older patients experiencing elbow stiffness secondary to advanced posttraumatic osteoarthritis, replacing the joint can give a significant reduction in pain while restoring a fair amount of elbow motion. Interposition arthroplasty, on the other hand, can be an alternative to joint replacement for younger, more active patients, as it aims to alleviate pain and enhance function while preserving functional stability. This is achieved by reshaping the distal humeral and ulnar articular surfaces, creating a new congruent joint, and resurfacing it with biological materials such as fascia lata allograft, Achilles tendon, or dermal allographs. Additionally, the collateral ligaments can be reconstructed. However, the predictability of the outcomes of this technique is limited (39).

Postoperative management

The goal of postoperative rehabilitation is to maintain the maximum ROM gained during surgery. Therefore, early

Table 3 Surgical goals for each approach in open arthrolysis

	Lateral	**Medial**	**Combined mediolateral or posterior**	**Anterior**
Goals				
1	Adhesion removal in the anterior compartment	Ulnar nerve release	Ulnar nerve release	Anterior HO removal
2	Anterior capsule release from humerus	Posterior MCL bundle release	Posterior MCL bundle release	
3	Removal of osteophytes or loose bodies	Scar tissue and osteophyte removal from olecranon fossa	Posterior capsule release	
4	Posterior capsule release and osteophyte removal from olecranon fossa	Removal of medially sided osteophytes	Anterior capsule release	
5			Removal of osteophytes and loose bodies	

HO, heterotopic ossifications; MCL, medial collateral ligament.

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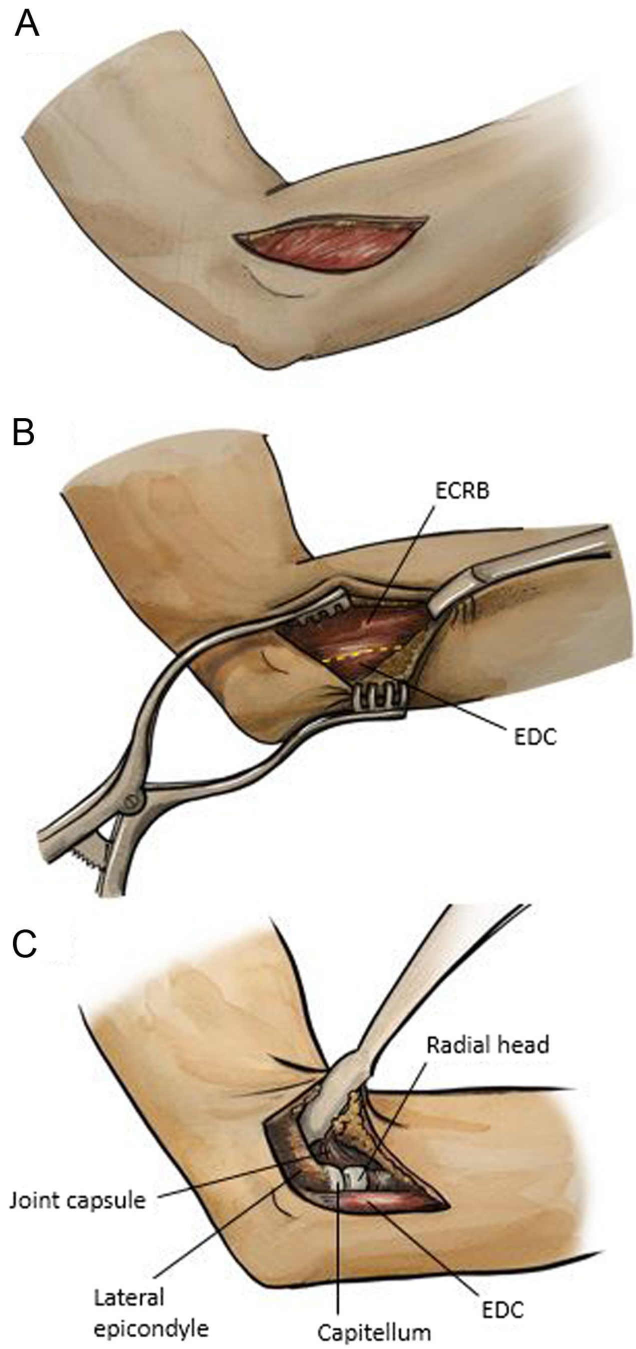

Figure 5
Subsequent steps in the lateral approach during open arthrolysis. (A) Intraoperative view of the Kaplan approach following incision of the skin and subcutaneous tissue. (B) Further exposed extensor carpi radialis brevis (ECRB) and extensor digitorum communis (EDC) muscles. Note the yellow dotted line, highlighting the interval for the EDC split. (C) Opened joint capsule after EDC split with the exposed lateral epicondyle, capitellum, and radial head. Note the annular ligament is only incised if pathology of the proximal radioulnar joint exists and needs to be addressed.

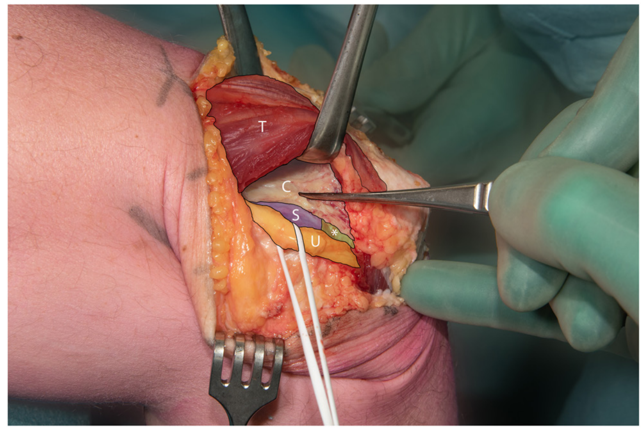

Figure 6
Intraoperative view of the posterior approach during open arthrolysis of a posttraumatic stiff elbow. T, triceps, elevated (red); C, joint capsule (gray); S, ulnar nerve sulcus (blue); *, posterior band of medial collateral ligament (green) which forms the distal part of the floor of the sulcus; U, ulnar nerve (yellow), released and mobilized out of sulcus.

active mobilization within 24–48 h is essential. This requires adequate treatment of postoperative pain. Patients should be motivated to regain muscle strength and reintegrate the elbow into daily life in a dedicated postoperative rehabilitation plan (10). Multiple studies show that most improvement in ROM is gained in the first months of rehabilitation (4, 18, 27, 40). Adjuvant splinting can be used effectively to treat contractures resistant to standard exercise programs with a treatment duration ranging from 20 days up to 3 months (10, 24, 41). Persistence in treatment may be rewarding, as minor increases in ROM are gained up until 12 months of treatment (24, 25).

Continuous passive motion therapy

The efficacy of continuous passive motion (CPM) therapy in postoperative rehabilitation has been a topic of debate for years. It is believed that CPM accelerates the clearance of hemarthrosis whilst preventing further accumulation of periarticular soft tissue edema due to fluctuations in IA pressure (5). Despite a proposed effect, the evidence for a beneficial effect in previous studies was lacking, while using a CPM significantly increased patient costs (42, 43). However, a recent single-center randomized controlled trial of O'Driscoll *et al.* directly compared the use of CPM and PT during 4 weeks after surgical arthrolysis (40). The results showed CPM superior to PT at 3 months, 6 months, and 1 year in terms of recovered total and functional ROM and time prevented from performing normal work while having similar pain scores, opiate usage, and patient-recorded outcome measures.

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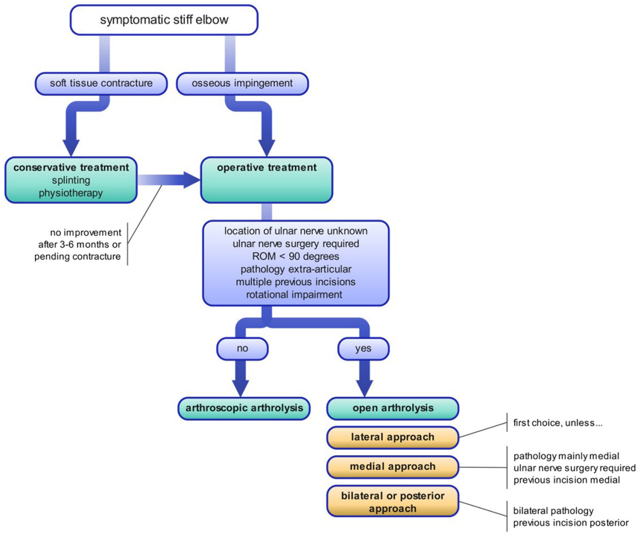

Figure 7
Treatment algorithm for the symptomatic stiff elbow.

Manipulation under anesthesia

Manipulation under anesthesia can be considered a treatment option for early-evolving joint stiffness resistant to intensive PT and splinting. It is an effective addition to therapy for increasing flexion–extension if used within 3 months of the injury, fracture fixation, or arthrolysis (44, 45). However, we recommend not to manipulate under anesthesia more than 8 weeks after trauma or surgery to minimize the risk of iatrogenic fractures by the manipulation (45).

Recommendations

A decision algorithm for the management of the symptomatic stiff elbow is shown in Fig. 7. The first step is to determine whether the aetiology involves a soft tissue contracture, osseous impingement, or both. This is done using careful physical examination, followed by additional imaging. Based on this, either conservative treatment for soft tissue contractures or operative treatment for osseous impingement can be started. Soft tissue contractures resistant to treatment for 3–6 months should be converted to operative treatment. The decision regarding open or arthroscopic arthrolysis is based on multiple factors, summarized in Fig. 6. For open arthrolysis, the lateral approach is deemed the first choice, except in cases where ulnar nerve surgery or release of the posterior band of the MCL is required or in medially sided or bilateral pathology. In these cases, the medial, bilateral, or posterior approaches can be used. All surgically treated patients should undergo extensive postoperative rehabilitation combined with PT and CPM (if available) and/or splinting for treatment-resistant stiffness.

Future research

The role of inflammatory genes and proinflammatory cytokines in the process of contracture genesis has become of increasing interest, providing potential therapeutic targets in preventing the development of joint stiffness (6). Remobilization after a period of immobilization has been shown to induce joint inflammation with the upregulation of genes encoding proinflammatory cytokines (46). IA triamcinolone injections in a rat model for surgical trauma and immobilization showed a dramatic decrease in the development of postoperative stiffness (47). However, risks of potential complications such as infection should be investigated. Similarly, celecoxib has been shown to potentially reduce scar tissue formation and increase the ROM in arthrofibrotic joints in rabbits (48). The mast cell stabilizer ketotifen fumarate had an insignificant effect on posttraumatic stiffness in 151 patients with elbow fractures and/or dislocations. However, since multiple animal studies have had varying results, further research on the pathomechanism of mast cells remains necessary (49, 50). Additionally, the evidence of CPM as an effective treatment for postoperative rehabilitation requires further research. Therefore, multicenter studies as well as studies comparing CPM and PT as concurrent interventions are needed. Thus far, both interventions have only been studied in comparison to one another, while in practice, both measures should ideally be used concurrently (40). A prospective study investigating the concurrent use of PT and CPM, while also comparing the efficacy of exclusive PT, either started early after surgery or 7–10 days post-surgery, will further elucidate the optimal postoperative rehabilitation program (51).

Conclusions

Elbow stiffness poses a significant hindrance to a patient's ADL, while its management remains a challenge for physicians. Adequate preoperative workup consisting of a thorough evaluation with specific attention to the ulnar nerve and radiologic assessment with 3D CT scan is essential to provide a better insight into the underlying aetiology and provides a solid base for the proposed treatment. Treatment is based on the involvement of soft tissue contracture or osseous impingement or a combination of both. If conservative treatment fails, arthroscopic arthrolysis has become a well-established first choice in surgical management. This technique has lower complication and revision rates but narrower indications than open arthrolysis. Postoperatively, early active mobilization is essential, with the addition of splinting or CPM in postoperative rehabilitation. Future research needs to provide further evidence of the role of

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possible inflammatory genes and novel pharmacological management strategies in the battle against arthrofibrosis.

ICMJE conflict of interest statement
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