Management of severe extra-articular contracture of the elbow by open arthrolysis and a monolateral hinged external fixator

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Arthrolysis and dynamic splinting have been used in the treatment of elbow contractures, but there is no standardised protocol for treatment of severe contractures with an arc of flexion < 30°. We present our results of radical arthrolysis with twin incisions with the use of a monolateral hinged fixator to treat very severe extra-articular contracture of the elbow. This retrospective study included 26 patients (15 males and 11 females) with a mean age of 30 years (12 to 60). The mean duration of stiffness was 9.1 months (5.4 to 18) with mean follow-up of 5.2 years (3.5 to 9.4). The mean pre-operative arc of movement was 15.6° (0° to 30°), with mean pre-operative flexion of 64.1° (30° to 120°) and mean pre-operative extension of 52.1° (10° to 90°). Post-operatively the mean arc improved to 102.4° (60° to 135°), the mean flexion improved to 119.1° (90° to 140°) and mean extension improved to 16.8° (0° to 30°) ($p < 0.001$). The Mayo elbow score improved from a mean of 45 (30 to 65) to 89 (75 to 100) points, and 13 had excellent, nine had good, three had fair and one had a poor result. We had one case of severe instability and one wound dehiscence which responded well to treatment. One case had deep infection with poor results which responded well to treatment.

Our findings indicate that this method is very effective in the treatment of severe elbow contracture; however, a randomised controlled study is necessary for further evaluation.

The elbow is a stable, congruent and complex hinge. However, the interlinking of three joints make it prone to stiffness.[1] Depending on the cause and the tissues affected, elbow stiffness can be classified as intrinsic or extrinsic.[2] Extrinsic stiffness is more common and more responsive to treatment than intrinsic stiffness.[3] An active range of movement of the elbow of 30° to 130° is needed for the activities of daily living,[4] and a 50% loss of movement impairs elbow function by as much as 80% whenever terminal flexion is restricted.[5] The severity of stiffness is graded according to the arc of flexion, with very severe stiffness defined by an arc < 30°, severe stiffness defined by an arc of 31° to 60°, and moderately severe stiffness defined by an arc of 61° to 90°.[4] In India the belief in traditional methods of treatment and neglect on the part of the patient often leads to chronic and severe elbow stiffness, resulting in fixed deformities. Various methods have been devised for its treatment, including physiotherapy and splinting,[6] open capsulotomy and arthrolysis,[7-12] arthroscopic release[13] and joint replacement.[14] However, in cases with very severe stiffness the optimal method of treatment remains uncertain. Non-operative treatment should be considered in mild contractures of short duration, usually of six months or less.[15] The limitations of elbow arthroplasty and arthroscopy make open arthrolysis the most effective treatment of severe stiffness.[16,17]

The principles of dynamic and static progressive splinting have been well documented in the treatment.[18,19] Both the hinged compass fixator[20,21] and the Ilizarov ring fixator[22] have been used to apply these principles in the post-operative management of open arthrolysis of the elbow. Monolateral hinge fixators have recently been shown to offer good stability, better tolerance and reduced complications compared to compass and Ilizarov fixators.[23-25]

Very severe stiffness and fixed deformities of the elbow pose difficult challenges in terms of both surgery and rehabilitation. We used a radical arthrolysis of the elbow through twin incisions to achieve a maximum intra-operative arc of movement. A monolateral hinged fixator was used to allow healing of the capsuloligamentous structures and to provide controlled static and dynamic splinting in the post-operative period. The aim of this study was to determine the effectiveness of this treatment.

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Table I. Comparison of post-operative improvement in elbow movement parameters

Variables	Pre-operative	Post-operative	p-value*
Arc of movement (°)	15.6 (0° to 30°)	102.4 (60° to 135°)	< 0.0001
Flexion (°)	64.1 (30° to 120°)	119.1 (90° to 140°)	< 0.0001
Extension (°)	52.1 (10° to 90°)	16.8 (0° to 30°)	< 0.0001

* paired *t*-test

Patients and Methods

We undertook a retrospective review of 89 patients presenting with a stiff elbow to our institute between 1999 and 2005. For inclusion in the study, the arc of movement of the elbow had to be < 30°, with radiological and intra operative appearances of minimal damage to the articular cartilage. There were 26 patients (15 males and 11 females) who fulfilled these criteria. The mean age at the time of presentation was 30 years (12 to 60) with a mean duration of stiffness of 9.1 months (5.4 to 18). There were 21 patients with post-traumatic stiffness, three with rheumatoid arthritis, one case secondary to tuberculous synovitis, and one secondary to pyogenic bacterial synovitis. The mean pre-operative arc was 15.6° (0° to 30°), mean pre-operative flexion was 64.1° (30° to 120°) and mean pre-operative extension was 52.1° (10° to 90°) (Table I). There were nine patients with a completely stiff elbow, three with rheumatoid arthritis, two with myositis ossificans following a blunt injury to the elbow and four following dislocation. One of these patients had the elbow fixed in 10° of flexion. The remainder were fixed at various degrees of flexion ranging from 30° to 70°. Radiographs were taken to rule out intrinsic causes. None of these patients had been previously operated on, although most of the traumatic cases had been treated with forced manipulation, massage and prolonged immobilisation.[26] Surgery was considered in these patients when conservative treatments had failed to achieve significant improvement.

All patients were treated by one of the two senior authors (GSK or VSK) with radical, medial and lateral arthrolysis, and given immediate mobilisation with a hinged monolateral fixator.

Surgical technique. Surgery was performed under brachial plexus block in the supine position. The medial incision started over the medial supracondylar ridge and crossed the elbow joint. The ulnar nerve was located and isolated. The joint was entered through the interval between flexor carpi ulnaris and pronator teres. An anterior capsulectomy was then performed and any intra-articular adhesions were released with excision of all fibrous tissue. In all cases the medial collateral ligament was found to be either torn or fibrosed and contracted, and a release was performed. Next, a lateral incision was made and the joint entered between the extensor carpi ulnaris and anconeus muscle. The joint was thoroughly debrided, and any heterotopic ossific mass removed. If the lateral collateral ligament was found to be torn or contracted, a release was performed to achieve an improved arc of movement. Bone nibblers were used on the tips of the coronoid and olecranon processes to clear the coronoid and olecranon fossae and improve flexion and extension. The flexor pronator origin was elevated to achieve maximal flexion and the biceps elevated from the coronoid process to achieve extension. The ulnar nerve was transposed anteriorly and stabilised by fascial slings which allowed excursion of the nerve throughout the newly-acquired range of movement. The range of movement was checked and a range of -10° extension to 140° flexion was considered adequate. In only one patient was this range not achieved, with flexion restricted to 100°. We performed triceps lengthening in this patient and achieved 130° of flexion intra-operatively. A monolateral hinged elbow fixator (Orthofix, Verona, Italy) was applied with the axis centred over the capitellum and Schantz pins in the humerus and ulna. The flexor-pronator origin was sutured and the wound closed over a drain.

Post-operative protocol. Post-operative analgesia was administered via an indwelling brachial plexus catheter and periodic bupivacaine infiltration. Passive assisted exercises began from the first post-operative day. The fixator was unlocked and the patient was asked to move their elbow through a range of flexion-extension which was actively assisted to the limit of comfort. The fixator was locked on alternate nights in the extremes of flexion and extension achieved by the patient each day. Active assisted exercises were undertaken for 30 minutes, four times a day, with encouragement to achieve progressively greater upper limits of flexion and extension, within the limits of pain. The drain was removed when the 24-hour output was less than 50 ml, which was usually by the third day. The indwelling brachial plexus catheter was removed on day two or three, depending on the patient's level of pain. It was noted that patients attained progressively increasing ranges of movement over the first ten to 14 days, after which it decelerated. Patients were instructed to unlock the fixator and perform range of movement exercises every day. They were called for biweekly follow-up, and the range of movement was assessed with strict adherence to our described mobilisation programme. The fixator locking in maximum flexion and extension, on alternate nights, was continued for six weeks and then removed and replaced by a hinged elbow splint, with continued range of movement exercises. All patients took 75 mg sustained-release indometacin tablets once daily for the first six weeks.[27] Pin track infections were managed with local wound care and oral antibiotics. This protocol was followed rigorously for every case.

Fig. 1a

Fig. 1b

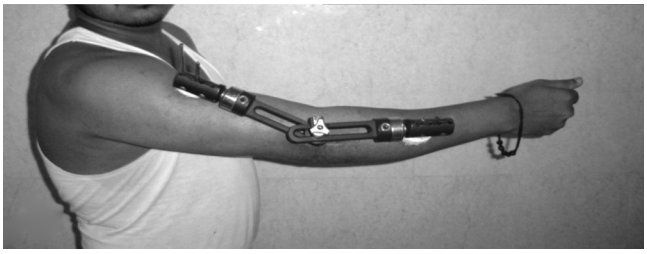

Fig. 1c

Photographs of male patient showing a) fixed flexion deformity of the right elbow and post-operative gain in movement arc and rehabilitation with fixator *in situ* at b) flexion and c) extension.

Fig. 2a

Fig. 2b

Same patient as in Fig. 1) Photographs showing flexion and b) extension at four-year follow-up demonstrating arc of movement at the elbow joint.

Evaluation. Clinical data were obtained from medical records. All patients were recalled for final follow-up and examined by at least two of the authors. The arc of movement was measured using a standard goniometer.[28] The Mayo Elbow Score[4] was calculated for each case pre-operatively and at the last follow-up. Anteroposterior and lateral radiographs were taken at one and three months after surgery to check for myositis and thereafter radiographs were taken every six months and at final follow-up to check for any intra-articular changes.

Statistical analysis of arc of movement parameters was performed using Student's paired *t*-test.

Results

The mean follow-up was for 5.2 years (3.5 to 9.4). Post-operatively, the mean arc improved to 102.4° (60° to 135°), the mean flexion to 119.1° (90° to 140°) and the mean extension to 16.8° (0° to 30°). The p-value was < 0.001 on paired Student's *t*-test for all the above variables (Table I). The Mayo Elbow Score improved from a mean of 45 (30 to 65) to 89 points (75 to 100), with excellent results in 13, good in nine, fair in three and poor in one case. Figures 1 and 2 show the pre-operative, post-operative and four-year follow up range of motion in one of the patient in our series.

There were 11 patients with minor pin track infections, predominantly over the humeral pins. These subsided with oral antibiotic therapy. Five patients showed a gain in the mean arc of movement of 11° after removal of the fixator until final follow-up. Four patients lost a mean arc of 6.8°. None required re-manipulation in the post-operative period. None required repeat arthrolysis. One patient underwent percutaneous fractional lengthening of the triceps to gain a further 9° arc of terminal flexion two weeks after the primary surgery. No patient had medial elbow pain as a consequence of transposition of the ulnar nerve. One patient who had medial elbow pain prior to arthrolysis had relief of pain after transposition of the ulnar nerve.

Three patients had crepitus of the elbow which started at a mean of 3.1 (2 to 4) months after the arthrolysis. All of these had grade 1 osteoarthritis[29] on the pre-operative radiographs, but this had not deteriorated by the time of final follow-up. The crepitus was associated with mild pain which did not hamper daily activities.

On clinical examination, six patients were found to have grade 1 medial instability[4] and three had grade 1 lateral instability.[4] This was asymptomatic in all patients, none of whom were involved in high-demand activities such as throwing. One patient developed severe lateral instability two months after surgery. Lateral collateral reconstruction was subsequently performed using an ipsilateral palmaris tendon free graft. The instability improved to a residual grade 1, but the patient lost 14° of the gained arc of movement. One patient developed deep infection which required serial debridements, leading to severe stiffness. Another had dehiscence of the wound, which required salvage surgery using an abdominal flap. Surprisingly, he only lost 12° of his gained arc of movement.

None of the patients experienced avulsion of the triceps, none lost strength in the flexor-extensor group of muscles and none had recurrence of heterotopic ossification at the final

Table II. Comparison of our series with the literature

	Number of patients	Pre-operative arc (mean, °)	Post-operative arc (mean, °)	Instability	Infection (number of patients)	Nerve lesions
Ruch et al[31] (collateral release)	14	53	108	0	0	0
Kayalar et al[17] (arthrolysis)	18	25	92	0	2	0
Hertel et al[30] (transhumeral arthrolysis)	26	66	100	0	0	4
Sharma and Rymaszewski[16] (total arthrolysis)	25	55	105	0	0	3
Salini et al[13] (arthroscopic lysis)	14	40	124	0	0	1
Tosun et al[12] (combined medial and lateral release)	20	35	86.2	0	0	3
Tan et al[32] (open arthrolysis)	52	57	116	2	3	3
Our series (radical release with fixator)	26	15	102	1	1	0

follow-up. The pronation/supination range remained unaffected in all patients and none had malalignment of the elbow. Overall, 25 of the 26 patients were satisfied with the results.

Discussion

Management of the stiff elbow is demanding. Anything less than the restoration of a functional range of movement represents a failure of treatment. Various protocols[12,13,17,30-32] have been presented for the management of a stiff elbow, and this study aimed to combine the principles outlined in these protocols.

Arthroplasty has a limited role in the stiff elbow. It is generally used in patients over the age of 60 and the patient rarely gains a functional range of movement.[2] It has a high incidence of complications.[33,34] Arthroscopic release is limited to mild and moderate stiffness of the elbow.[13] Limited intra-articular capacity[35] makes arthroscopy in a very stiff elbow prone to neurovascular complications.[36]

Open arthrolysis for elbow contracture was first described in 1944,[37] and since then several studies describing various approaches to treatment been published. A comparative study of the literature is presented in Table II. An anterior approach has been used for moderate deformities and is especially indicated for isolated flexion contracture. However, this approach cannot address posterior contractures and thus has limited use in most cases of severe stiffness.[9] The posterior approach has been associated with good results, but neither anterior contractures nor the coronoid fossa can be accessed.[38] A lateral approach allows access to the radiohumeral joint, and both anterior and posterior release can be performed via this approach, however, a high incidence of traction injury of the ulnar nerve has been reported with this approach.[39] A medial approach provides good exposure and transposition of the ulnar nerve and removal of fibrous tissue from the posteromedial corner can be performed, but radiohumeral joint problems and contracture of the lateral collateral ligament are difficult to assess.[40]

Various studies have reported progressive loss of movement in the post-operative period compared with the range achieved at operation.[3,12,41] We therefore aimed to achieve maximum intraoperative correction using a combined mediolateral approach to address the joint contracture from all sides, and perform an extensive radical release. As the collateral ligaments have been shown to be contracted and to limit correction of the deformity,[17] we advocate their sequential release. The wide exposure, radical arthrolysis and release of collateral ligaments enabled us to achieve an intra-operative range of -10° extension to 140° flexion.

Several authors have advocated preservation of the collateral ligaments in order to prevent post-operative instability.[30,42,43] Some studies have included release of the medial collateral ligament to achieve flexion.[31,44] Some authors have additionally released the lateral collateral ligament to gain a further range,[41] whereas others have advocated partial release of both collaterals in long-standing cases.[17] Several principles and findings helped us in planning the protocol. A complete tear of collateral ligaments occurs in most cases with simple dislocation of the elbow,[45] yet if adequately treated most do not have overt instability or osteoarthritis in the long term.[46] The intrinsic stability afforded to the elbow by the osseous and articular components of the articulation is sufficient to ensure healing and restoration of function of the capsuloligamentous stabilisers.[47] A hinged elbow fixator can be applied to maintain concentric reduction of the elbow during mobilisation,[48] and good results have been achieved with its use in patients with a stiff elbow.[20-22] A monolateral hinged fixator has shown promising results when used for acute fracture-dislocations of the elbow, and is better tolerated than ring fixators around the arm.[23,24,49,50] The progressive static splinting principle,[51] when a prolonged stretch is applied to dense connective tissue, creates a load that dissipates over a period of time. This stimulates a biological response in which a modification to the length or cross-link integrity of the collagen causes a permanent change in the tissue.[52,53]

Following these principles, we performed sequential release of both collateral ligaments in order to achieve the maximum range of movement. We applied a monolateral fixator to provide immediate stability and mobility. A sound rehabilitation programme allowed us to achieve a long-term good range of movement.

We had seven patients with grade 1 instability but it did not restrict their activities. However a longer follow-up is needed to assess the results. There were three patients with major complications, namely, post-operative infection, instability and wound dehiscence. Two patients responded

well to treatment and one had a poor result. Infections have also been reported by other authors,[2,17,21,41,54] and these have contributed to poor results in their patients.

Tan et al[32] described two cases of instability in their series of 52 patients treated by open arthrolysis. They treated these patients with hinged fixators as a second procedure, with one fair and one good result. Morrey[2] noted one case of moderate instability after open release and attributed it to neuropathological changes. The patient was treated with a hinged elbow splint and had good results. Our patient with instability had an ankylosed elbow at 60° pre-operatively and lateral laxity was noted two weeks after fixator removal. He responded well to ligament reconstruction with retention of a functional arc of movement at the elbow.

Post-operative neuropathies have commonly been reported in the literature after release of severe elbow contractures.[12,13,16,41,43] However, in our series there was no case of neuropathy, possibly because all patients underwent transposition of the ulnar nerve.

The need for manipulation under anaesthesia has been noted by Tan et al[32] to be as high as 27%. None of our patients required post-operative manipulation, as the external fixator allowed for aggressive static and dynamic rehabilitation.

Peden and Morrey[55] studied the role of elbow arthroplasty in cases of ankylosed elbows. They had 13 cases and reported good results in these patients at long term follow-up. However, they had high rates of complication in nine of 13 patients, seven of which required a total of 19 additional operations. We had nine patients with ankylosed elbows treated by our procedure, of whom only one required re-operation for instability. Significant differences exist between their series and ours with respect to patient demography, long-standing ankylosis and intra-articular changes. We recommend radical release with application of a hinged fixator for patients with extra-articular stiffness and minimal articular involvement, with total elbow replacement being reserved for patients with intra-articular stiffness.

Our study has a few weaknesses. First, it is retrospective, with all the shortcomings of such a study. Second, our patients had various causes for their elbow stiffness, although the presentation and treatment philosophy was the same. Third, it was a small group with only a medium-term follow-up.

This study demonstrates that the application of sound principles can lead to achievement of an excellent range of movement in patients with very severe extra-articular elbow stiffness.

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