

Primary open elbow arthrolysis in post-traumatic elbow stiffness – A comparison of outcomes in severity of elbow injury



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ABSTRACT

Purpose: Stiffness is a sequelae of elbow trauma. Arthrolysis may be considered to increase range of movement (ROM). Little is published on the outcomes/complications of elbow arthrolysis. We present our series of primary open arthrolysis in posttraumatic elbow stiffness.

Methods: A consecutive series of patients that underwent primary open arthrolysis for posttraumatic elbow stiffness in our unit (2011–2018) were analysed. All procedures were performed by an elbow surgeon. Postoperative rehabilitation followed protocol with early motion; continuous passive motion (CPM) was utilised if requested. Data collected included patient demographics, traumatic injury type, arthrolysis technique, preoperative, intraoperative and postoperative elbow ROM, complications and postoperative Oxford Elbow Score (OES).

Results: 41 patients were included. 59% were male. Mean age at time of arthrolysis was 43 years (range 12–79 years). Mean duration of follow-up was 53 months (range 8–100 months). Median duration from time of injury to arthrolysis was 11 months (range 2–553 months). Mean preoperative flexion–extension arc (FEA) was 70°, improving to 104° postoperatively ($p < 0.001$). Mean preoperative pronosupination arc (PSA) was 125°, improving to 165° postoperatively ($p < 0.001$). Mean postoperative OES was 37 ($n = 28$). Complication rate was 24% with 7 recurrence requiring surgery, 2 nerve injuries and 1 infection. CPM, 10 patients, saw mean FEA improvement of 56°. Mean PSA improvement was 36°. Complication rate for these patients was 40%. Severe traumatic injury was associated with increased preoperative stiffness (FEA 61° vs 84°, PSA 111° vs 149°) but larger improvements in ROM (postoperative FEA 98° [$p < 0.001$], PSA 165° [$p < 0.001$]).

Conclusion: This series demonstrates improvement in elbow ROM following open arthrolysis with significantly higher gain in pronosupination for those with severe injury. Moderate results were seen in a patient reported outcome measure. Patients considering arthrolysis should be counselled regarding expectations/complication rate.

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1. Introduction

Elbow stiffness following trauma is common and has a significant detrimental impact upon function.^{1–3} The objective definition of elbow stiffness varies: a flexion–extension arc (FEA) less than 30–130°⁴ or 20–120°,⁵ less than 100° total FEA,^{6,7} or 130° flexion for modern activities of daily living,⁸ including using a keyboard/mouse. Consequently, post-traumatic elbow stiffness resulting in reduced FEA is debilitating. Such stiffness can occur following

relatively benign elbow fractures, simple dislocations or following surgical treatment of complex elbow injuries.

There are relatively few recent reports of outcomes in open elbow arthrolysis for post-traumatic stiffness consequently we evaluated this in our unit. The aim was to determine whether open elbow arthrolysis yielded a significant increase in range of movement (ROM) for those that had failed therapist-led rehabilitation following elbow trauma. Furthermore, we sought to determine influence of severity of initial injury on outcomes and assess our complication rate and patient-reported function. Our goal is to inform general orthopaedic surgeons in a fracture clinic setting about appropriate indications and expectations from open elbow arthrolysis in post-traumatic elbow stiffness.

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2. Patients and method

We conducted a review of consecutive patients that underwent open elbow arthrolysis for post-traumatic stiffness in a single centre in the United Kingdom (UK). All patients had a documented traumatic injury to the elbow. Patients had failed non-operative treatment including physiotherapy prior to proceeding with surgery. Arthrolysis was performed 2011–2018 by a fellowship-trained elbow surgeon.

Data collected included patient demographics, traumatic injury type, treatment prior to arthrolysis, arthrolysis technique, pre-operative, intraoperative and post-operative elbow ROM, complications and post-operative Oxford Elbow Score (OES). Patients with pre-existing elbow arthritis or less than 6-months follow-up were excluded.

Traumatic injury type was utilised to subdivide patients into mild and severe traumatic injury cohorts. Mild traumatic injuries included simple dislocations and isolated radial head fractures where minimal concurrent soft tissue injury would be expected. Severe traumatic injuries included fracture-dislocations and intra-articular distal humerus fractures.

Elbow flexion-extension and pronosupination ROM was measured with a goniometer and documented at a pre-operative assessment clinic prior to arthrolysis and at most recent follow up or prior to a revision procedure if this was required. Repeat arthrolysis was considered if achieved ROM deteriorated to an extent unacceptable to the patient.

All patients were asked to complete a postal OES in December 2018 to obtain a current patient-reported outcome measure. Patients that did not return their questionnaire were then promptly contacted by telephone to obtain their OES responses.

Statistical analysis was performed using SPSS (SPSS Inc. SPSS for Windows, Version 17.0. Chicago: SPSS Inc) and a paired, two-tailed Student's T test. A two-sample Student's T test assuming unequal variances was used to compare improvement in movement arcs between subgroups. Statistical significance was set at 5%. Mean values are reported with standard deviation. Ethical approval was not required as the centre clinical governance department classified this study as a service evaluation.

3. Surgical procedure

Open elbow arthrolysis was performed with regional anaesthesia where possible; if this was not possible, general anaesthesia was utilised.

The patient was positioned laterally with the operated elbow on a 'L-bar'. If a dedicated lateral approach was intended a supine position was used with the elbow flexed and pronated on an arm board. An upper arm tourniquet was positioned and inflated prior to incision.

Choice of approach was determined preoperatively following consideration of previous approaches, scars, implants in situ, presence and location of heterotopic ossification and relative severity of flexion, extension and pronosupination stiffness.

A posterior approach allowing access to deep lateral or deep medial intervals was utilised where both flexion and extension stiffness was present. A posterior longitudinal incision was made and full-thickness soft tissue flaps raised to expose lateral and medial intervals.

The deep lateral interval was commenced at the supracondylar ridge of the distal humerus and was extended distally between the radial wrist extensors and extensor digitorum communis. The interval was continued between brachialis and the anterior capsule. The capsule was excised and articular surfaces inspected for intrinsic blocks to motion. The proximal radius and radioulnar joint

could be exposed by extending the common extensor split. The posterior capsule was then exposed by elevating the lateral triceps. The capsule was excised and the olecranon fossa examined and debrided.

The deep medial interval required ulnar nerve release. The nerve was identified at the medial edge of triceps, released from the Arcade of Struthers distally through Osborne's ligament and the fascia of flexor carpi ulnaris. The nerve was mobilised. The pronator teres and anterior half of the flexor origin was elevated anteriorly. The interval between brachialis and the anterior capsule was identified and the capsule excised. The medial triceps was elevated to expose the posterior capsule, which was excised. The olecranon fossa was debrided. If flexion remained limited the posterior and transverse bands of the medial collateral ligament were released.

A dedicated lateral approach was utilised if preoperative planning determined that only this approach would be required.

Implants were removed concurrently if indicated. The tourniquet was deflated prior to closure to ensure adequate haemostasis. Extensor and flexor origins were reattached to the humerus with drill holes and non-absorbable sutures. Drains were not used. Analgesic catheters were utilised solely when post-operative Continuous Passive Motion (CPM) was prescribed.

Unless contraindicated, patients were given a dose of tranexamic acid at induction of anaesthesia to help prevent swelling in the immediate post-operative period. Post-operative compressive bandaging was used for 48 h. Inpatient stay was dictated by extent of surgical release, pain control and physiotherapy requirement. If patients were deemed suitable for same day discharge this was facilitated.

Prior to discharge all patients were seen by a physiotherapist and instructed to commence hourly ROM exercises of the elbow, wrist and hand. Urgent outpatient physiotherapy commenced within 72 h. Active exercises with end range passive over-pressure were utilised, with instructions to push to a degree of discomfort as tolerated by the individual. All patients were educated as to the nature of the surgery, use of analgesia and the vital importance of regular ROM activity to regain and maintain the range achieved intra-operatively. Where extension deficit was the main concern, supine active resisted elbow extension was performed to encourage relaxation of antagonist elbow flexors.

Follow up regime included wound review and provision of a night extension splint at two weeks and subsequent clinical review at six weekly intervals. Once adequate ROM had been regained, rehabilitation would involve strengthening and functional restoration tailored to the individual (e.g. gym exercise, occupational therapy, work hardening).

Prophylactic indomethacin 25 mg three times daily was prescribed for 6 weeks with gastric irritation prophylaxis in patients that required heterotopic ossification excision during their arthrolysis.

CPM was not used routinely post-operatively - early in our series its use had been requested by the operating surgeon in select cases. CPM was set to utilise the full ROM achieved intra-operatively (with indwelling catheter to provide a continuous brachial plexus block). This was removed after 3 days and the patient remained an inpatient until they were able to maintain the same ROM with oral analgesia.

4. Results

41 patients underwent primary open arthrolysis for post-traumatic elbow stiffness during our study period with minimum 6-month follow-up available for all patients.

59% were male with a mean age of 43 ± 16 years (range 12–79 years). Mean duration of follow-up (to current date or time of

revision surgery) was 53 ± 25 months (range 8–100 months).

Median duration from time of initial traumatic injury to arthrolysis was 11 months (range 2–553 months). 78% were treated operatively for their initial injury.

15 patients had mild traumatic injuries (10 radial head fractures, 3 extraarticular single bone elbow fractures, 2 simple elbow dislocations). 26 patients had severe traumatic injuries (22 fracture-dislocations, 4 intraarticular distal humerus fractures) (See Table 1). Heterotopic ossification was not seen following any mild injury. 27% of severe injuries developed heterotopic ossification.

A posterior approach was utilised in 68%. A dedicated lateral approach was used in 27%. Combined lateral and medial approach with separate incisions was used in 5%. 41% had concurrent implant removal.

Mean baseline FEA for all patients was 70° ± 34°, increasing by 34° to 104° ± 29° post-operatively (p < 0.001) [Graph 1]. Mean intraoperative FEA was 128° ± 15°.

Mean baseline pronosupination arc for all patients was 125° ± 65°, increasing by 40° to 165° ± 34° post-operatively (p < 0.001) [Graph 2]. Mean intraoperative pronosupination arc was 165° ± 26°.

In those patients classified as having a mild injury mean baseline FEA was 84° ± 33°, increasing by 29° to 113° ± 24° (p < 0.001) [Graph 3]. This cohorts mean baseline pronosupination arc was 149° ± 45°, increasing by 18° to 167° ± 33° (p < 0.02). [Graph 4].

In those patients classified as having a severe injury mean baseline FEA was 61° ± 32°, increasing by 37° to 98° ± 30° (p < 0.001) [Graph 3]. This cohorts mean baseline pronosupination arc was 111° ± 72°, increasing by 54° to 165° ± 35° (p < 0.001). [Graph 4].

Significantly greater improvement in pronosupination arc was seen in those patients that had originally sustained a severe traumatic injury (18° versus 54°, p < 0.05). Significant differences were not seen in FEA improvement.

Mean improvement in FEA was 32° ± 31° with a posterior approach and 39° ± 19° with a dedicated lateral approach. Mean improvement in pronosupination arc was 31° with both posterior and lateral approaches.

Complication rate for all patients was 24%. 7 patients (17%) developed a recurrence of objective elbow stiffness that necessitated repeat arthrolysis. 2 had a transient posterior interosseous neuropraxia post-operatively that resolved with expectant management. 1 patient had an infected haematoma that required wound washout and closure. Post-operative heterotopic ossification formation did not occur in any case.

CPM was utilised post-operatively at the operating surgeons request in 10 patients, 80% of which were classified as having a severe traumatic injury initially. For this cohort mean baseline FEA was 40° ± 26°, increasing by 56° to 96° ± 32° (p < 0.003). This cohorts mean baseline pronosupination arc was 132° ± 56°, increasing by 36° to 168° ± 33° (p = 0.104). Complication rate for

this cohort was 40% (3 recurrence requiring repeat arthrolysis [30% of cohort], 1 transient neuropraxia).

Median length of stay for the entire cohort was 1 day; with 21 cases performed as a daycase (length of stay less than 24 h). However, due to our CPM patients remaining as inpatients the mean length of stay was 2 ± 1.6 days and range was 8 days (1–9 days). Mean length of stay for our non-CPM group was 1.6 ± 0.9 days. Mean length of stay for our CPM group was 3.4 ± 2.6 days.

A completed post-operative Oxford Elbow Score was available for 29 patients (71%). Mean total score was 37/48 (±13).

5. Discussion

Our series confirms primary open elbow arthrolysis yields significant improvement in post-traumatic elbow stiffness refractory to non-operative treatment; as demonstrated by ROM gain and a patient-report outcome measure.

Our data suggests greater improvement of pronosupination in those that initially sustained a more severe elbow injury. It should be noted that baseline deficit was more marked in this group potentially facilitating an apparent greater gain. Therefore this comparison should be noted with caution. However, a severe elbow injury is associated with greater soft tissue injury and subsequent capsular contraction. Consequently contracted capsular excision in arthrolysis may account for this greater gain following severe injury.

Published outcomes for primary open arthrolysis for post-traumatic elbow stiffness are relatively scarce. Eleven cohort studies and a systematic review of complications have been published in the preceding fifteen years. Two included patients treated after 2008. Consequently, our series reports a contemporary overview of expected outcomes in a UK centre.

Our series of 41 patients represents one of the largest reported, with few others having greater numbers.^{2,3,9} The demographics of our cohort were similar to other series; however it should be noted that our mean age of 49 years was higher than several other series (mean age range 27–35 years^{2,10–13}). Also, while our ROM gains are similar to the literature, some studies with smaller/younger cohorts yielded larger increases in FEA.^{5,10,11} Therefore our series can inform potential outcomes in a wider age demographic than most previously reported.

Our cohort included a wide spectrum of index traumatic injuries. 78% required operative intervention for their primary elbow injury suggesting the majority of our cohort had sustained significant elbow injuries.

Using a lateral approach demonstrated a trend for greater increase in FEA. Mean improvement in pronosupination arc was identical between lateral and posterior approaches. We feel both lateral and posterior approaches can be utilised successfully in open arthrolysis for post-traumatic elbow stiffness. Intraoperative FEA and pronosupination arc data suggest effective surgery was

Table 1

Mean age, baseline and postoperative flexion-extension arc (FEA) and pronosupination arc for all patients, those that sustained a mild traumatic injury, those that sustained a severe traumatic injury and those that received postoperative Continuous Passive Mobilisation (CPM). All mean values reported with standard deviation.

	All	Mild	Severe	CPM
Patients	41	15	26	10
Age (Years)	43 ± 16	41 ± 15	44 ± 17	41 ± 14
FEA (°)	Baseline	70 ± 34	84 ± 33	61 ± 32
	Postoperative	104 ± 29	113 ± 24	98 ± 30
	p value	<0.001	<0.001	<0.001
Pronosupination (°)	Baseline	125 ± 65	149 ± 45	111 ± 72
	Postoperative	165 ± 34	167 ± 33	165 ± 35
	p value	<0.001	<0.02	<0.001

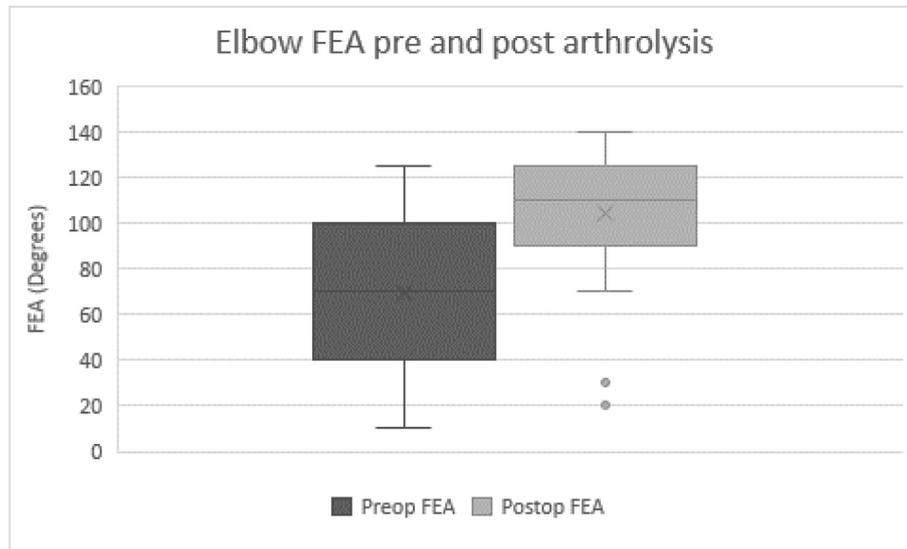


Fig. 1. Elbow FEA pre and post arthrolysis

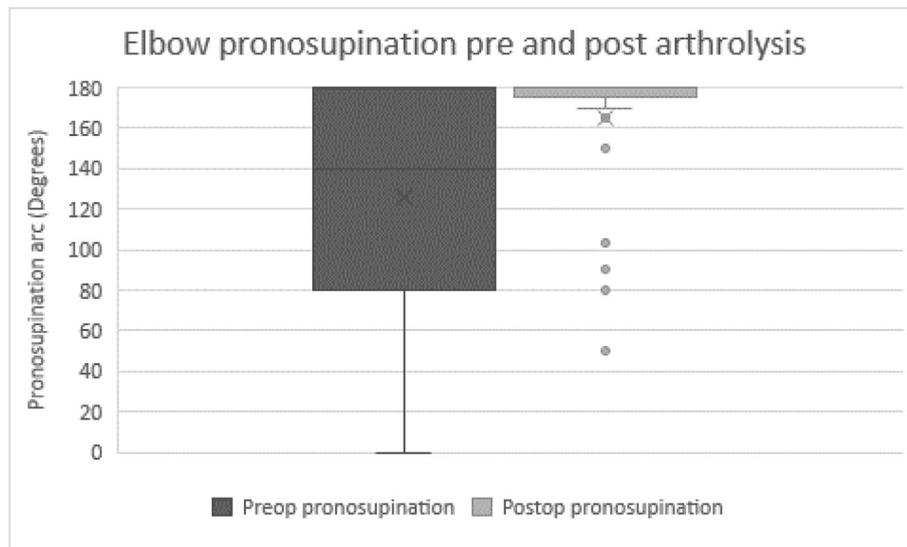


Fig. 2. Elbow pronosupination pre and post arthrolysis

performed. Subsequent loss of motion is a consistent feature of reported elbow arthrolysis series.

Our duration of follow-up can be considered a strength of our series. Our mean follow up (53 months) is longer than most reported series; only four list mean follow up greater than 48 months.^{1,10–12} Reports of post-operative rehabilitation are variable in the literature with no established gold standard.¹⁴ Rehabilitation protocols in other series include immediate mobilisation,^{3,11} cast immobilisation followed by mobilisation^{5,10} and inpatient CPM with brachial plexus blockade via a catheter.^{1,9,12,13} Though some of our cohort received CPM, our main rehabilitation focus is early mobilisation which is supported by recent literature.^{3,15}

In other series post-operative CPM use resulted in significantly greater inpatient length of stay (range 3–12 days^{1,10,13}) compared to our own (mean 2 days, median 1 day). Our reduced inpatient length of stay has financial/productivity benefits and was not detrimental to our clinical results. Although patients receiving post-operative inpatient CPM had a trend for greater improvement in FEA, this

was not significant. Furthermore, an increased complication rate was seen in this group.

Despite high satisfaction most series report significant complication rates ranging from 11%¹⁰ to 47%.³ Our complication rate of 24% is consistent with that reported in a systematic review of complications.⁴ Frequent complications in the systematic review included nerve injury (8.6%), heterotopic ossification (5.6%), infection (1.6%), instability (1%) and 4% had a recurrence of stiffness requiring repeat arthrolysis. Our individual complications were similar: nerve injury (4.9%) and infection (2.4%). 17% of our patients had pre-operative heterotopic ossification however, we did not encounter post-arthrolysis heterotopic ossification; in the literature rates range from 5.6%⁴ to 16%.² It is possible that our heterotopic ossification prophylaxis regime and timing of arthrolysis influenced our absence of recurrence.

It is noted that our elbow stiffness recurrence rate is higher compared to the systematic review (17% vs 4%). We classified recurrence as requiring repeat elbow arthrolysis. It is possible our

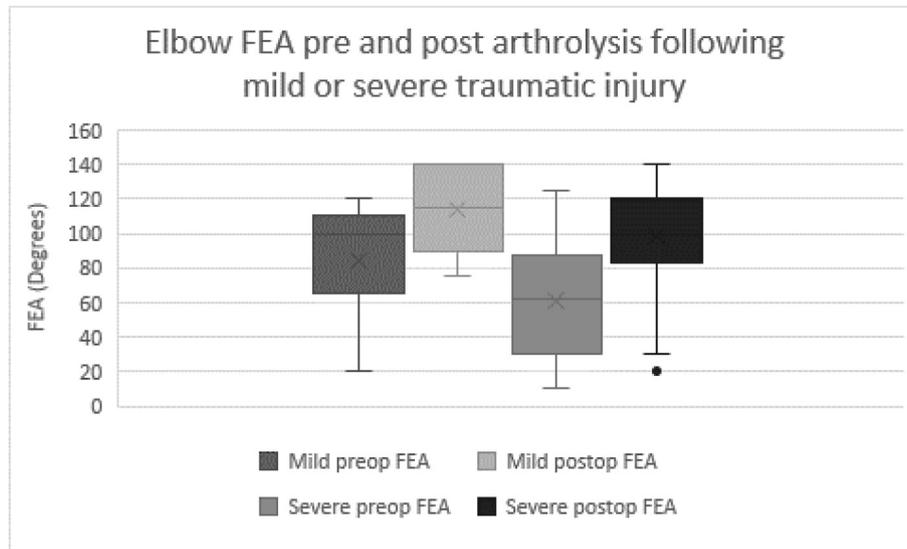


Fig. 3. Elbow FEA pre and post arthrolysis - mild and severe traumatic injury

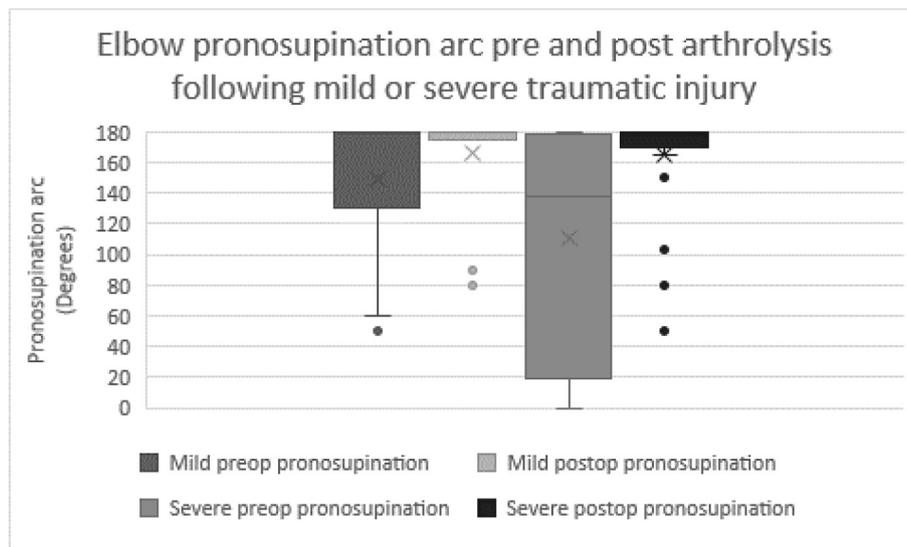


Fig. 4. Elbow pronosupination arc pre and post arthrolysis - mild and severe traumatic injury

threshold for repeat arthrolysis was lower given that our mean ROM gains were consistent with those reported in other series with lower recurrence rates. We may have offered repeat arthrolysis to patients which would have been an acceptable result in other series. The senior author accepts that with experience our technique has become more aggressive (extensive releases) in comparison to an initial conservative approach. Although this is not the focus of this study it should be noted that all our patients had a successful outcome from repeat open elbow arthrolysis.

Arthroscopic arthrolysis offers an alternative approach with similar patient satisfaction.¹⁶ Comparative studies suggest open arthrolysis yields a higher (though not significant) gain in range of motion and complication rate.^{16–18} Arthroscopic approach is technically demanding and relatively contraindicated in those requiring extra-articular procedures. In our cohort 41% required concurrent implant removal. Consequently, in the absence of persuasive literature,¹⁷ the senior authors have opted not to alter their approach to arthroscopic.

We also utilised a patient-reported outcome measure, the OES, for post-operative follow up. This is specific to elbow surgery and well validated.¹⁹ It includes 12 questions covering 3 domains – pain, function and psycho-social factors. The overall maximum OES is 48 with low scores representing more severe symptoms. The OES has good internal reliability²⁰ and has proved specific to elbow pathology.

We note several limitations in our series. We acknowledge that our cohort includes patients treated by elbow surgeons in a United Kingdom large district general teaching hospital. Consequently, index elbow injuries were often isolated; our results may not apply to other populations, such as those encountered in a major trauma centre.

Post-operative rehabilitation was not entirely consistent amongst our cohort - 10 patients (24%) had inpatient CPM post-operatively early in the series reflecting a trend within the orthopaedic community at that time. More recent research²¹ questioned the benefit of CPM in this setting and post-operative CPM use

became less frequent amongst elbow surgeons; this is reflected within our series.

Finally, a comparative pre-operative OES for our cohort would have enhanced our study.

6. Conclusion

Primary open elbow arthrolysis in post-traumatic stiffness significantly improves elbow ROM in patients that have failed non-operative treatment; with greater gains expected in patients that sustained a more severe elbow injury. Furthermore, we report favourable results in a patient-reported outcome measure.

A 17% risk of recurrence requiring repeat arthrolysis was observed in our cohort and therefore patients should be appropriately counselled upon expected range of movement gain and the importance of rehabilitation to reduce recurrence.

Primary open elbow arthrolysis in post-traumatic stiffness can be performed effectively as a daycase procedure and early mobilisation with active-assisted and active exercises is an effective post-operative rehabilitation strategy.

We recommend that patients presenting to orthopaedic surgeons with post-traumatic elbow stiffness recalcitrant to non-operative treatment should be referred in a timely manner to an elbow surgeon for consideration of open elbow arthrolysis.

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CRediT authorship contribution statement

Alex Murray: Methodology, Investigation, Writing - original draft, Writing - review & editing, Project administration. **Daniel L.J. Morris:** Software, Validation, Formal analysis, Data curation, Writing - review & editing, Visualization. **David I. Clark:** Conceptualization, Supervision.

Declaration of competing interest

The authors have no competing interests to declare.

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