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Acute distal biceps tendon repair using cortical button fixation results in excellent short and long-term patient outcome: a single-centre experience of 102 patients

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ABSTRACT

Aims: Acute distal biceps tendon repair reduces fatigue-related pain and minimises loss of forearm supination and elbow flexion strength. We report the short- and long-term outcome following repair using cortical button fixation.

Methods: Between 2010 – 2018, 102 patients (101 males; mean age 43 years) underwent acute (≤6 weeks) distal biceps tendon repair using cortical button fixation. The primary short-term outcome was complications. The primary long-term outcome was the Quick-DASH (Q-DASH). Secondary outcomes included the Oxford Elbow Score (OES), EuroQol-5D-3L (EQ-5D), satisfaction and return to function.

Results: There were eight patients (7.8%) that had a major complication and 34 patients (33.3%) a minor complication. Major complications included re-rupture (n=3, 2.9%), unrecovered nerve injury (n=4, 3.9%) and surgery for heterotopic ossification excision (n=1, 1.0%). Three patients (2.9%) required surgery for a complication. Thirty-three nerve injuries occurred in 31 patients (30.4%). Minor complications included neurapraxia (n=27, 26.5%) and superficial infection (n=7, 6.9%). At a mean follow-up of 5yrs (1–9.8) outcomes were available for 86 patients (84.3%). The median Q-DASH, OES, EQ-5D and satisfaction scores were 1.2 (IQR 0 – 5.1), 48 (IQR, 46 – 48), 0.80 (IQR, 0.72 – 1.0) and 100/100 (IQR, 90 – 100) respectively. A majority of patients returned to sport (82.3%) and employment (97.6%) following surgery. Unrecovered nerve injury was associated with an inferior outcome according to the Q-DASH, OES, EQ-5D, and satisfaction (all $p<0.05$). Multiple linear regression analysis identified an unrecovered nerve injury as strongly associated with an inferior outcome according to the Q-DASH ($p<0.001$) along with infection ($p<0.001$), although re-rupture and further surgery were not ($p > 0.05$).

Conclusions: Acute distal biceps tendon repair using cortical button fixation results in excellent patient reported outcomes and health-related quality of life in the setting in which it was studied. Although rare, unrecovered nerve injury adversely affects outcome.

Keywords: distal biceps tendon; rupture; repair; cortical button; complications; outcomes

INTRODUCTION

Distal biceps tendon rupture predominantly affects males in the fifth decade of life[1]. An epidemiological analysis reported an estimated national incidence of 2.55 per 100,000 patient years[2]. Ruptures commonly occur in the dominant arm and smokers are at 7.5 times greater risk than non-smokers[1]. Whilst acceptable outcomes have been reported with non-operative management[3], some suggest patients have a significant reduction in forearm supination strength and to a lesser extent elbow flexion strength[4], along with fatigue-related discomfort[5] that is problematic for most young active patients.

Operative repair, commonly through either a single- or double-incision, is commonly employed for complete distal biceps tendon ruptures. Grewal *et al* completed one of the very few prospective randomized controlled trials comparing a single versus double-incision technique[6]. Given no significant difference between the groups with respect to patient outcome, apart from a higher incidence of local neurapraxic injury in the single incision group, they concluded that both approaches were effective and the decision as to which to use should be at surgeon discretion. This finding was reinforced by the results of a large systematic review including 494 patients[7]. Operative management has developed since the transosseous suture repair, originally described by Morrey[8], to include a range of techniques that employ a similar principle but with more contemporary implant designs, including biotenodesis screws, bone anchors, bone tunnels and cortical buttons. Cortical button fixation is supported by biomechanical data[9, 10] that demonstrates a significantly higher load to failure when compared with a range of other fixation devices, including those described above. Unfortunately, the complication rate following distal biceps tendon repair is probably higher than expected. A recent systematic review by Amarasooriya *et al* demonstrated a 25% complication rate[11], with 4.6% and 20.4% of patients experiencing a major and minor complication respectively, when reviewing 3091 primary repairs using a variety of surgical approaches and fixation techniques.

Despite the growing use of cortical buttons, data to support current practice is provided by retrospective studies that comprise small patient numbers (n=7 to 60) with short follow-up[3, 12-21]. The aim of this study was to report the patient reported outcome and health related quality of life (HRQoL) following acute distal biceps tendon repair using cortical button fixation in a large single-centre consecutive series of patients. The primary short-term outcome was post-operative complications. The primary long-term outcome was the QuickDASH (Q-DASH) score.

PATIENTS AND METHODS

Study cohort

A retrospective review of our trauma database identified 141 patients with a distal biceps tendon rupture that was clinically or radiologically confirmed at the study centre between 2010 and 2018. Patients were aged 16 years or over at the time of injury. Exclusion criteria included a partial rupture (n=21), surgery more than six weeks after injury i.e., delayed (n=16), and patients who declined surgery (n=2), leaving a total of 102 patients that made up our study cohort (**Figure 1)**. The study was registered and approved under our departmental orthopaedic research database (Scotland (A) Research Ethics Committee 16/SS/0026) and the study was also prospectively registered with the musculoskeletal quality improvement committee.

Patient demographics and injury characteristics

There were 101 males and one female with a mean age of 43.0 years (range, 19 – 67) at the time of injury (**Table 1**). Thirty-two patients (31.4%) had one or more relevant chronic comorbidities and eight patients (7.8%) had previously ruptured the contralateral distal biceps tendon. One patient disclosed taking anabolic steroids at the time of injury. The majority of patients were in regular employment (n=97, 95.1%) and 15 patients (14.7%) were smokers; median of 10 cigarettes per day (range, 3 – 40).

The most common mechanism of injury was heavy lifting (52.0%), followed by sports (35.3%), falls (3.9%) and assault/fight (1.0%). Other mechanisms of injury that could not be easily classified made up 7.8% (n=8) of the cohort and included activities where the elbow was forcefully extended with the hand in supination. The vast majority of patients were right hand dominant (n=94, 92.2%) and the dominant arm was ruptured in 57 cases (55.9%). Associated injuries were rare, with only one patient (1.0%) sustaining an ipsilateral minimally displaced radial head fracture at the time of injury.

Surgical technique

Five fellowship trained consultant Orthopaedic trauma surgeons performed or directly supervised the surgical procedures. The median time interval between injury and surgery was 13 days (range, 1 – 35 days) with repair performed within two weeks in 66 patients (65%), four weeks in 97 patients (95%) and six weeks in the total cohort of 102 patients. Following general anaesthesia and intravenous antibiotics, a high upper limb tourniquet was applied, taking care to ensure that the biceps muscle belly was not trapped above the cuff. A dual incision volar approach was made in the majority of cases (n=84, 82%), including a 2-3cm incision just proximal to the elbow crease to allow retrieval of the ruptured tendon and a further longitudinal incision approximately 4-5cm in length and 2cm distal to the crease to prepare the proximal radius. Other approaches included a single volar incision (n=12, 12%) and an extensile 'lazy S' incision, crossing the elbow crease (n=6, 6%). Careful dissection down, protecting the superficial radial nerve (SRN) and vasculature, allowed exposure of the radial tuberosity. This was performed with the arm in full extension and supination to protect the posterior interosseous nerve (PIN). The radial tuberosity was prepared using a combination of a guide wire/Beath pin and a cannulated 4.5mm drill, with or without a high-speed burr or bone nibblers, in order to create a suitable recess for tendon docking. Fluoroscopy was utilised to confirm location on the tuberosity in a few cases and was surgeon dependant. The retracted proximal end was milked distally and retrieved with care taken to protect the underling neurovascular structures. A whipstitch using either two No. 5 Ethibond (Ethicon, Somerville, New Jersey, USA) or two OrthoCord (Johnson & Johnson, New Brunswick, New Jersey, USA) sutures was performed. These were then secured through a 4mm x 12mm cortical button (Endobutton, Smith & Nephew, Memphis, Tennessee, USA), which was then passed under direct guidance with two peripherally placed sutures using a Beath pin through the radial tuberosity and advanced through the dorsal cortex of the radius. The cortical button was locked off by flipping the device to the transverse position by pulling on the peripheral suture ends. The cortical button was then unable to pass back through the radius. The repair was checked and confirmed clinically, with fluoroscopy used selectively to confirm cortical button position, but this was not routine and again surgeon dependant. Wound closure was performed with a subcuticular technique. Post-operative immobilisation was according to surgeon preference. In a majority of cases (n=78, 76%) an above elbow cast was applied for the first two post-operative weeks, in keeping with the post-operative management described in other studies[16, 17, 19]. The remaining cases were placed into a bulky soft dressing and sling.

Post-operatively, patients were reviewed in the outpatient clinic two weeks after surgery for removal of cast (when used), wound care and clinical examination. Radiographs were performed at the discretion of the treating surgeon (**Figure 2)**. Routine physical therapy consisted of six weeks of active range of motion but no lifting of heavy objects, followed by up to twelve weeks of biceps hammer curls using incremental weight. Patients were discharged from clinic following satisfactory review of complications and engagement with physical therapy.

Short-term outcome

Patients were followed up routinely at a mean of 4.1 months (range, 2.0 – 55.5) following surgery. The primary short-term outcome was complications following surgery, both major and minor. In keeping with previous literature[22, 23], major complications included (1) re-rupture, (2) deep infection requiring operative intervention, (3) vascular injury, (4) unrecovered nerve injury, (5) symptomatic heterotopic ossification (HO) requiring further surgery and (6) complex regional pain syndrome (CRPS). Minor complications included (1) neurapraxia, (2) superficial infection not requiring surgical intervention and (3) symptomatic HO without repeated surgical intervention[23].

Long-term outcome

Patient reported outcome data was gathered via a structured telephone interview, conducted by two of the authors (THC and BJK). The primary long-term outcome was the Quick-DASH (Q-DASH)[24], which has been validated for completion over the telephone[25]. Secondary outcome measures included the Oxford Elbow Score (OES)[26], and EuroQol-5D-3L (EQ-5D)[27]. Patients were also asked the following questions and instructed to answer using a scale of 0-100, with a score of 100 representing the best possible outcome. "How would you rate the average pain in your elbow over the last four weeks?" "How would you rate your general health over the last four weeks?" "How would you rate your overall satisfaction with the treatment outcome?" Where applicable, data on return to function, including work and sport were recorded. Complications and any further surgeries were also confirmed.

Statistical methods

Data was analysed using IBM SPSS software version 24.0 (Armonk, NY: IBM Corp). The Shapiro Wilk test was used to assess data normality. Categorical binary data were analysed using either the chi-square test (all observed frequencies in each cell > 5) or the Fisher's exact test (one cell had an observed frequency of ≤ 5). Comparison of continuous data between three or more groups, including nerve injury group was performed using the Kruskal-Wallis test. Spearman correlation was used to measure the strength of association between two continuous variables. Factors associated with long-term outcome according to the Q-DASH score were identified through univariate analysis. To limit the number of variables included in the model in view of the sample size, only variables that showed a trend towards significance ($p < 0.1$) or were significantly associated ($p < 0.05$) with the Q-DASH score on univariate analysis were included in a multiple linear regression model using enter methodology. Two-tailed p-values were reported, and statistical significance was set at p-values of less than 0.05.

RESULTS

Short-term outcomes - complications

Eight patients (7.8%) had a major complication and 34 patients (33.3%) a minor complication. Major complications included four cases (3.9%) of unrecovered nerve injury (Table 2), three cases (2.9%) of re-rupture, and one patient (1.0%) required further surgery for excision of symptomatic HO (**Figure 3**). No patients experienced deep infection requiring operative intervention, vascular injury or CRPS. Minor complications included 27 cases (26.5%) of neurapraxia (Table 2) and seven cases (6.9%) of superficial infection not requiring surgical intervention. There were no cases of conservatively managed symptomatic HO. Timing between injury and surgical repair was not associated with the development of post-operative complications (p=0.175). There was no difference in complication rates following immobilisation in either an above elbow plaster or bulky bandage and sling post-operatively (p=0.117).

Re-ruptures and further surgeries

The mean age of the three patients that re-ruptured was 42.7 years (range, 38 – 46) and the mean time from surgical repair to re-rupture was 13 months (range, 3 – 24). Two cases of re-rupture were the result of further trauma; one patient restrained a forklift truck three months post-surgery, and the second patient was lifting a heavy box 12 months after surgery. The third patient recalled no specific traumatic episode but reported progressive muscle fatigue over a two-year period whilst working as a mechanic. A clinical re-rupture was diagnosed but the patient elected not to undergo revision surgery as symptoms were controlled. Three patients (2.9%) required further surgery; two of the re-ruptures at three and 12 months following primary repair, and one other patient for excision of heterotopic ossification, which was significantly limiting forearm rotation four months following acute repair.

Nerve injuries

Documentation of nerve associated complications was divided into anatomical distributions (**Table 2**), which included the posterior interosseous nerve (PIN), lateral antebrachial cutaneous nerve (LABCN), superficial branch of radial nerve (SRN) and median nerve (MN). Thirty-three nerve injuries occurred in 31 patients (30.4%), of which two patients experienced a combined injury to both the SRN and MN. Following a period of simple observation, recovery of nerve function was recorded in 27 of the 33 injuries (81.8%) at a mean of 17.6 weeks (range, 6 – 36). There were six cases (18.2%) of persistent nerve related complications in four patients. One patient had ongoing SRN dysesthesia, which did not improve following observation. The second patient had significant denervation injury of the MN confirmed on nerve conduction studies resulting in poor motor function and reduced sensation. The third and fourth patients had a combined nerve injury and had residual paraesthesia in both the SRN and MN distributions, but normal motor function. Two of the patients with a median nerve injury had their surgery performed through the described two incision volar approach and one had an extensile ‘lazy S’ incision.

Long-term outcomes

Long-term outcome scores were collected from 86 patients (84.3% follow-up) at a mean follow up of 4.7 years (range, 1 – 9.8 years). The median Q-DASH score (primary long-term outcome measure) was 1.2 (IQR 0 – 5.1). The median OES and the median EQ-5D score were 48 (IQR, 46 – 48) and 0.80 (IQR, 0.72 – 1.0) respectively (**Table 3**). Of the 83 patients employed before their injury, 81 (97.5%) reported returning to work after a mean of 6.7 weeks (range, 0.0 – 32.0) following surgery. Of the 62 patients that played sport before their injury, 51 (82.3%)

returned to sport after a mean of 22.3 weeks (range, 3 – 130). The median satisfaction score was 100/100 (IQR, 90 – 100).

Factors associated with long-term outcome (QDASH)

To assess the impact of nerve related complications on patient long-term outcome, the 86 patients with completed long-term outcome scores were divided into three groups; (1) no nerve injury (n=60, 69.7%), (2) recovered neurapraxic injury (n=22, 25.6%) and (3) unrecovered nerve injury (n=4, 4.7%). Patients in group 3 reported significantly inferior outcomes ($p < 0.05$) across all measures apart from pain compared with those patients in groups 1 and 2 (**Table 3**). There was no statistical significance (all $p > 0.05$) between outcome scores reported by patients in group 1 and 2, indicating that patients who sustain a recovered neurapraxic injury have a comparable outcome in the longer term to those who do not sustain a nerve related complication.

Factors associated with the long-term Q-DASH score were determined through univariate analysis, which identified four variables that showed a trend towards association of a poorer (higher) Q-DASH (all $p<0.1$; **Table 4**). On multiple linear regression analysis an unrecovered nerve injury ($p<0.001$; B=42.3) and post-operative infection ($p<0.001$; B=13.9) were associated with an inferior long-term outcome, but re-rupture ($p=0.440$) and requirement for further surgery ($p=0.652$) were not ($R^2 = 0.586$).

DISCUSSION

This study is the largest single-centre consecutive series in the literature that documents both the short and long-term outcomes following acute surgical management of patients with an acute distal biceps tendon rupture using cortical button fixation. The results of this study suggest that surgery yields excellent long-term patients reported outcomes, HRQoL and patient satisfaction for the majority of cases, in the setting and using the technique described. The factor most strongly associated with a poorer patient reported outcome in the longer term is an unrecovered nerve injury, with the difference seen on multivariate analysis greater than the MCID for the QDASH. Although rare, the damaging effect of a permanent nerve injury must be fully considered when surgeons and patients are contemplating surgical repair of these injuries.

Cortical button fixation devices are widely recognised as an effective treatment option for distal biceps tendon repair. However, there are few studies demonstrating the longer-term outcomes. Other single-centre studies employing cortical button fixation alone present smaller cohorts ranging from 7 to 60 patients[3, 12-21], with a follow-up range of eight months to a maximum of 3.7 years[12, 13, 19, 21, 28-30]. The long-term primary outcome measure in the current study was the Q-DASH, with our scores comparable to the findings of others. Huynh *et al*[21], Greenberg[31], and Gupta *et al*[13], reported mean DASH scores of 7.9, 8.6 and 0, respectively. However, the sample size was small in the latter two studies and the mean age was 27.4 years in the study by Gupta *et al*[13], which is approximately 15 years younger than the mean age in our study, with ours more in keeping with the published epidemiology of these injuries.

The vast majority of complications reported in our series were minor (n=34, 33.3%) and nerve-related (n=27, 26.5%). The second largest single-centre series to date included 60 patients with comparable demographics and treatment protocol to our study[21]. The rate of persistent LABCN paraesthesia reported in our study is lower than the 11.7% (n=7) reported by Huynh *et al*, with all nerve complications in this distribution recovering spontaneously. Huynh *et al* carried out radiographic assessment and diagnosed 34 patients (56.7%) with HO, although no patient required further surgery for this, and three patients (5%) experienced a re-rupture. Our rate of HO is much lower (1%) and explained by the fact that we did not routinely perform post-operative radiographs unless there was clinical concern. It is likely that the true incidence is higher than 1% but in the absence of symptoms, this may be of limited clinical significance as has been previously described[19]. Post-operatively the majority of patients in the current study were placed into an above elbow plaster for two weeks. Appreciating the study is not of adequate size, we did not detect a statistically significant difference in any patient reported outcome or rate of complications compared with immobilisation in a bulky bandage. This may suggest that a plaster may not be routinely required.

Neurapraxic injury to the SRN and LABCN were most common in our series, with all injuries to the LABCN and 16/19 SRN injuries recovering spontaneously. At first impression, this rate sounds high, but is in keeping with previously published work. Ford *et al* published a large multi-centre retrospective review of 970 patients, operated on by 73 surgeons[23]. The overall 'major' complication rate was 7.5% and 'minor' complication rate was 21.5%, resulting in a total complication rate of 29%. Most minor complications were an injury to the LABCN and SRN injury predominantly in the anterior/volar incision group, consistent with our study. A recent multi-centre cohort study analysed complications in 784 distal biceps tendon repairs[32]. This study included a heterogenous patient group with four different types of fixation. A single anterior incision was used in 639 patients and the complication rate in this sub-group was 38.1% and nerve injury accounted for 30.2% of this overall rate, both very much in keeping with the findings of our study.

There were three patients (3%) in our series who had a median nerve injury, which is higher than the published rate of 0.3% in a recent systematic review[11]. Two patients were left with persistent sensory impairment and one with both sensory impairment and motor deficit. In the latter case, the tendon had retracted proximally and was adhered to the median nerve. During tendon mobilisation, over-aggressive traction on the nerve resulted in injury. Whilst both motor and sensory function partially improved, by six months the nerve conduction studies demonstrated severe denervation and the nerve was not explored. This serves as a reminder of the importance of adequate exposure, careful soft tissue handling and meticulous dissection of local structures, particularly if there are concerns regarding adherence against the injured tendon. We reported only one case (1%) of transient PIN injury, which fortunately fully recovered. In contrast, previous studies have published injury rates of 2-5%[6, 23, 30, 33]. One key finding of our study relates to the longer-term impact of an unrecovered nerve injury on patient outcome, albeit the vast majority of nerve complications recovered spontaneously. Although Lang *et al* have previously demonstrated significantly poorer DASH scores in those patients that experienced a complication[28], we believe this study is the first determine this relationship between unrecovered nerve injury and longer-term outcome.

The infection rate previously published by Dunphy *et al*[32] was only 1.3%, with our rate of superficial infection requiring oral antibiotics 6.9%. In our series, however, the majority of antibiotics were prescribed in primary care and importantly no patient required either intravenous antibiotics or surgical intervention for wound complications. Our re-rupture rate of 2.9% is comparable to other studies that specifically assessed cortical button fixation; 1.9%-5%[21, 23, 29, 32]. Cusick *et al* published a low failure rate of 1.2% in 168 patients[30]. However, in their series, the cortical button was supplemented with an interference screw. As the follow-up was limited to eight months, this study may have missed some re-ruptures presenting beyond this period, as two of the three re-ruptures in our series occurred after the first post-operative year.

With regards to return to work, most of our study cohort that were employed prior to their injury returned to work after a mean period of almost seven weeks following surgery. A recent systematic review reported on data from 1270 patients with a mean age of 45 years[34]. The group included a heterogenous mix of injuries (acute/chronic, full/partial thickness), surgical approaches and repair techniques, with only a quarter of patients undergoing cortical button fixation. In keeping with the results of this series, a significant proportion of patients (89%) were able to return to work after surgery. The pooled mean period between surgery and return with no restrictions was 14 weeks, which is twice the duration reported in the current study, but we recorded return to work in any capacity, which may have taken into account modification of duties to facilitate an earlier return. Despite this, it is reassuring to note that a high percentage of patients return to employment given the high incidence of males of working age sustaining this injury.

Return to sport of any level is poorly defined in the literature following biceps tendon surgery. In our series 82% returned to sport on average at just over 5 months following surgery. D'Alessandro *et al* study included just 10 patients, 8 of whom were classed as bodybuilders/weightlifters with a mean age of 40 years[35]. All 10 patients returned to full unlimited activity with no evidence of re-rupture, but the duration of recovery was not clearly defined. More recently, Pagani *et al* reviewed 25 cases of distal biceps tendon repair in professional National Football League (NFL) players[36]. Twenty-one players (84%) returned to sport but had significantly shorter post-injury careers following surgery, with most players retiring after just two seasons. Poyser *et al* collected mid-term outcome data from 31 patients of their initial series of 50 patients who underwent either suture anchor or cortical button fixation[17]. The authors reported that all 31 patients were able to return to sport, employment and playing of musical instruments, but do not state the time period between surgery and recommencement. Despite the lower proportion of patients in our study returning to sport after injury, we believe we are the first authors to define a mean recovery period, which can be used to inform patients and guide rehabilitation.

Given the rate of complications associated with surgery described throughout the literature above, some surgeons advocate the use of primary non-operative management. Legg *et al*, compared nonoperative vs. cortical button fixation in a retrospective cohort study including 47 patients[3]. The Q-DASH score in the cortical button group was 6.3 compared with 14.1 in the nonoperative group, potentially lending support to surgical fixation, but this difference is less than the defined MCID for the Q-DASH[37]. This study is limited by the difference in group sizes (40 patients in the cortical button group) and the mean age difference between groups of 12 years, although the mean age of the cortical button group was similar to that in the current study and in the literature. Whilst surgical repair of distal biceps tendon ruptures is generally safe, it is clear from the results of this current study that major complications do happen. In the event of a significant nerve injury, we have reported that patient outcome is considerably inferior to uncomplicated surgery and would most realistically be poorer than primary non-operative management. Taking this into consideration, future adequately powered randomized controlled trials would be helpful in assessing the clinical benefit of fixation over conservative treatment.

The main strengths of this study are the inclusion of a large number of consecutive patients, as well as the duration and retention (84%) for long-term follow-up. We employed a standardised technique using a cortical button device, using a volar approach. Limitations include the retrospective nature of the study and lack of objective measurements of patient function including a formal range of motion and strength assessment, as performed in other studies[15, 19, 31]. This was not practically possible as patients were not reviewed in person at the outpatient clinic, but the positive outcome scores would suggest very few are experiencing significant functional limitations. For the same reason we are unable to report our rates of radiographic HO, the clinical significance of which is debated. Our reported complication rate may be lower than the true incidence as we were dependent on the accuracy of reporting at the time of clinical review. However, our complication rate is comparable than those reported in recent literature[11] and patients were asked to confirm if they had experienced any complications on telephone review. Given the length of follow-up, patient recall of specific dates that they returned to work and sport are likely estimates. More accurate data on return to function would be best collected prospectively in future studies.

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TABLES

Table 1: Patient demographics and mechanism of injury for study cohort (n=102)

Demographic/Injury Characteristic	Total
Number of patients	102
Mean age at surgery (years)	43.0 (19 – 67)
Sex (n, %)	
- Male	101 (99.0%)
- Female	1 (1.0%)
Hand dominance (n, %)	
- Right	94 (92.1%)
- Left	8 (7.9%)
Injured side (n, %)	
- Right	61 (59.8%)
- Left	41 (40.2%)
Smoker at injury (n, %)	
- Yes	15 (14.7%)
- No	87 (85.3%)
Mechanism of injury (n, %)	
- Heavy lifting	53 (52.0%)
- Sports	36 (35.3%)
- Fall	4 (3.9%)
- Assault/fight	1 (1.0%)
- Other	8 (7.8%)

Table 2: Nerve injury by distribution and recovery.

Nerve region	Total number (n, %)	Number resolved (n)	Number unresolved (n)
Nerve injury (n=31*)			
- PIN	1 (3.0)	1	0
- LABCN	10 (30.3)	10	0
- SRN	19 (57.6)	16	3
- MN	3 (9.1%)	0	3
Total	33 (100)	27 (81.8)	6 (18.2)

* number of patients, PIN = posterior interosseous nerve, LABCN = lateral antebrachial cutaneous nerve, SRN = superficial radial nerve, MN = median nerve

Table 3: Long-term outcome measures collected including total cohort, neurapraxic and unrecovered nerve injury group. (All median and IQR).

Outcome measure	Total Group (IQR)	Group 1 No nerve injury (IQR)	Group 2 Nerve injury recovered (IQR)	Group 3 Nerve injury not recovered (IQR)	p-value †
Patients	86	60	22	4	
Q-DASH	1.2	0.0	2.3	47.8	0.005*
	(0 – 5.1)	(0 – 4.5)	(0 – 9.1)	(14.2 – 83.0)	
OES	48.0	48.0	48.0	17	0.004*
	(46.0 – 48.0)	(46.0 – 48.0)	(46.8 – 48)	(11 – 27.25)	
EQ-5D	0.80	0.80	0.825	0.17	0.010*
	(0.72 – 1.00)	(0.70 – 1.00)	(0.73 – 1.00)	(0.11 – 0.60)	
Health /100	80.0	80.0	85.0	67.5	0.028*
	(75.0 – 90.0)	(75.0 – 90.0)	(80.0 – 93.5)	(38.8 – 73.8)	
Pain /100	90.0	90.0	97.5	45.0	0.056
	(63.8 – 100)	(61.3 – 100)	(77.5 – 100)	(20.0 – 85.0)	
Satisfaction	100	100	98.0	18.0	0.024*
/100	(90.0 – 100)	(95.0 – 100)	(90 – 100)	(10 – 81.3)	

Q-DASH = QuickDASH, OES = Oxford Elbow Score, EQ-5D = EuroQol-5D
† Kruskal-Wallis test, * $p < 0.05$

Table 4: Univariate analysis identifying factors associated with long-term outcome according to the Q-DASH score.

Variable	p-value
Demographics & injury characteristics	
- Age at surgery (years)	0.305 †
- Gender	n/a
- Co-morbidities	0.104 §
- Smoker	0.314 §
- Previous rupture	0.214 §
- Dominant arm injured	0.719 §
- Sports related mechanism	0.860 §
Peri-operative	
- Time to surgery (days)	0.917 †
- Incision type	0.478 ø
- Cast vs sling post-operatively	0.894 ø
- Infection	**0.044 §**
- Re-rupture	**0.034 §**
- Unrecovered nerve injury*	**0.002 §**
- Further surgery	**0.065 §**

† Spearman correlation, § Mann-Whitney U test, ø Kruskal-Wallis test

*Direct comparison of unrecovered nerve injury (n=4) *vs* no nerve injury + recovered nerve injury (n=82)

FIGURES

Figure 1: STROBE study flowchart demonstrating selection and flow of patients.

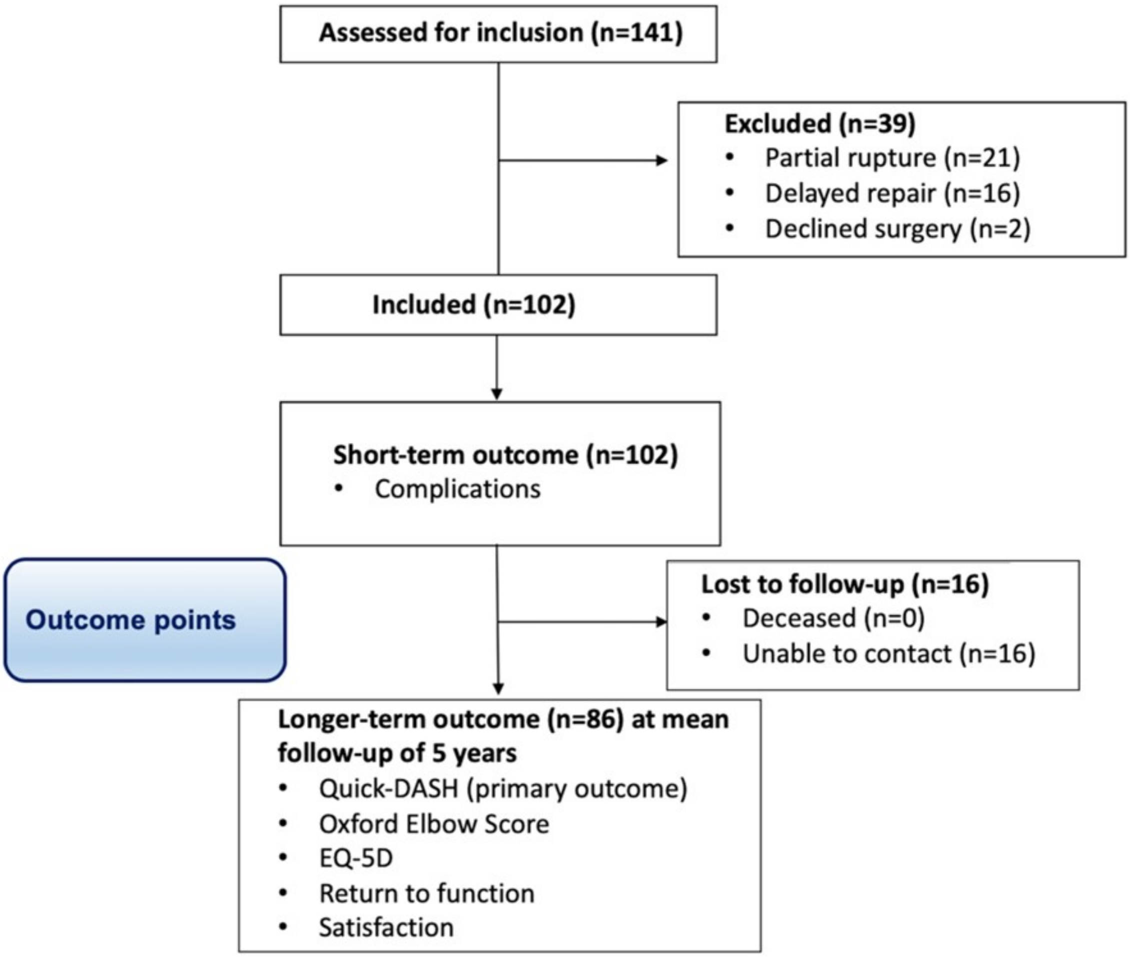

Figure 2: Anteroposterior (A) and lateral radiographs (B) taken at the two-week post-operative outpatient clinic to ensure satisfactory cortical button placement.

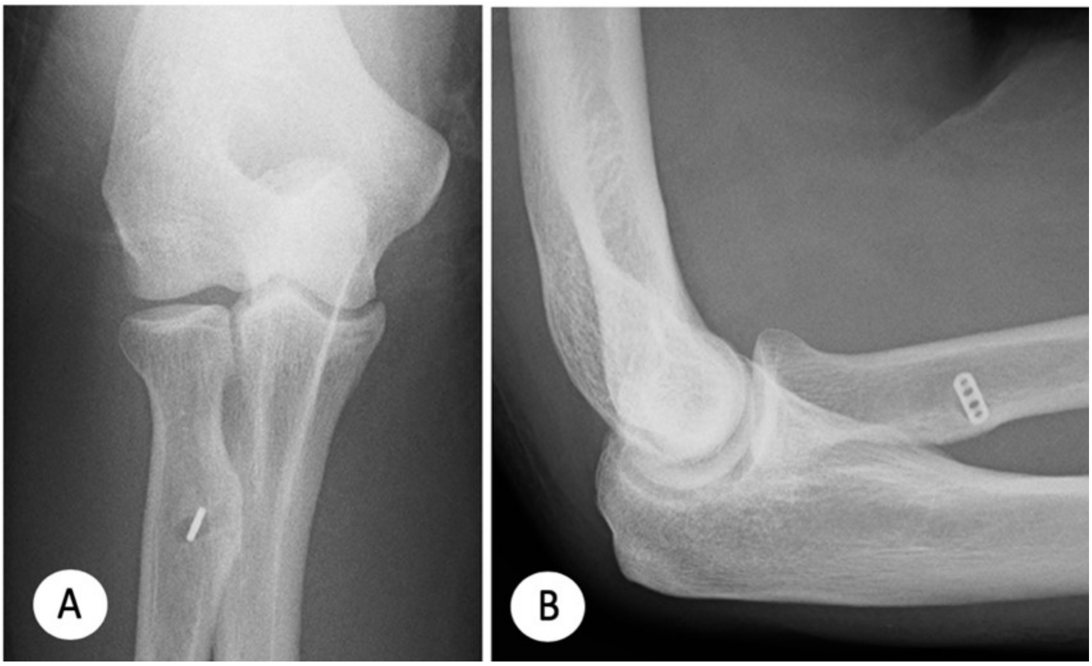

Figure 3: Lateral radiograph demonstrating symptomatic heterotopic ossification four months following primary repair requiring surgical excision.