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Functional outcomes following surgical repair of wrist extensor tendons

I.C. Josty, A.H.F. MacQuillan and M.S.C. Murison

Welsh Centre for Burns and Plastic Surgery, Morriston Hospital, Swansea SA6 6NL, UK

SUMMARY. The long term results following the repair of open injuries to extensors carpi radialis longus and brevis and extensor carpi ulnaris have not previously been reported. A retrospective case note review was performed and patients were called back for assessment following surgical repair. Grip strength and pinch strength were reduced by 9.9% ($p = 0.017$) and 11.5% ($p = 0.049$). Wrist movement was also reduced. This demonstrates that the division of these tendons should not be regarded as trivial as they may have long-term adverse effects on wrist function. Information gained from this study may be beneficial in patient education at the time of injury and may provide useful information when preparing medico legal reports.

Keywords: wrist, extensor, tendon, grip strength, pinch strength, functional outcome.

Introduction

Much has been written about repair techniques[1] and functional outcomes in extensor tendon surgery of the digits.[2–4] It is recognised that extensor tendon injuries have often been underestimated, sometimes with an adverse effect on functional outcome. No study to date has looked at the functional outcome following repair of traumatically divided wrist extensor tendons—extensor carpi radialis longus (ECRL), extensor carpi radialis brevis (ECRB) and extensor carpi ulnaris (ECU).

The purpose of this study was to identify epidemiological factors, the surgical repair techniques, splintage and hand therapy, time off work and functional outcomes following injuries to ECRL, ECRB and ECU. With this information it is hoped that we may be able to inform patients more comprehensively about their likely outcome when presenting with such injuries. Information so gained may be used in future audit.

Materials and methods

Subjects were identified from a computer database of all patients who had undergone extensor tendon repair over a 4-year period in our unit. Patient inclusion criteria were those with division of ECRL, and/or ECRB and/or ECU requiring surgical repair, unilateral injury, and patient co-operation with the study. Exclusion criteria were associated open joint or bony injury, flexor tendon injury, digital extensor tendon injury, bilateral injury, previous hand injury and degenerative or inflammatory hand conditions, presence of painful neuroma, and patient unwillingness to participate. All patients had already been discharged from follow up at the time of the study and reached a plateau in their rehabilitation.

Twenty subjects (mean age 32, range 17–59) eligible for inclusion were identified from 1551 patients who had undergone upper limb extensor tendon repairs in the unit.

Epidemiological data and surgical information were obtained by case note review. Functional outcome was assessed by inviting patients to attend a special review clinic. Patients who were willing to participate but who did not attend this clinic were visited and assessed in their own homes. The mean assessment time following repair was 41 months (range 19–64).

Functional testing

Function was assessed by grip and pinch strength measurement and by wrist goniometry.

Grip and pinch strengths were performed using single, factory calibrated, Jamar dynamometer and pinch measuring devices. The third handle setting was used as previous studies have demonstrated that maximal grip strength is attained at this setting.[5,6] Both the dynamometer and pinch device were reset to zero prior to each reading and were read to the nearest increment of the two scale divisions.

The American Society of Hand Therapists[7] recommendation for testing was followed. Subjects were seated comfortably on a chair without armrests. The shoulder was adducted and neutrally rotated, the elbow

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Table 1 Aetiology of tendon division

Mechanism of injury	*Number of subjects*
Glass—Domestic ± alcohol	13
Knife—accidental	3
Knife assault	1
Glass—industrial	1
Sheet steel—industrial	1
Ceramic tile	1

flexed at 90° with the forearm and wrist in neutral position. The same arm position was used for testing both grip and pinch strengths. The pinch device was held between the proximal interphalangeal joint of the index finger and the thumb tip. Before testing, the reason for the study was explained, the method of testing demonstrated and subjects were allowed to practice once with their uninjured hand.

Specific verbal instructions were given in the same tone of voice, "I want you to hold the handle/button and grip/pinch as hard as you can." An opportunity to ask questions was provided. In order to eliminate the effect of hand muscle fatigue, the testing was performed on one hand after another, always starting with the uninjured hand. Two grip/pinch measurements were recorded for each hand and, if the difference was more than 10%, a third reading was taken. Grip strength measurement was followed by pinch strength and the highest value used.

Wrist goniometry was performed using a hand-held goniometer. The same seating, shoulder and elbow positioning were used but measurements were taken with the forearm fully pronated. Flexion, extension, radial and ulnar deviation were measured according to the recommendations of the American Society of Hand Therapists.[8] The axis of rotation was taken along the line of the third metacarpal.

Numerical and statistical methods

Predicted pre-injury grip and pinch strengths were calculated using knowledge of the patients' hand dominance, injury laterality and occupation at the time of injury. A previous study[9] showed that there is a grip strength difference of 9.1% and a pinch strength difference of 7.6% between dominant and non-dominant hands in right handed non-manual workers. Similarly, it was shown that grip strength differed by 3.4% and pinch strength differed by 8.9% in light manual workers; no statistically significant differences were found in heavy manual workers. These percentage differences and the uninjured grip/pinch strengths were used to calculate the predicted pre-injury grip and pinch strengths in the subjects. Therefore, each subject acted as their own control. All subjects were right handed.

Pre-injury range of wrist movement was assumed to equal the range in the uninjured side.

The data was analysed using Microsoft Excel and Analyse-It! Software. Normality was assessed using a normal probability plot and the Shapiro–Wilks statistic. A two-tailed paired t-test was used to determine differences between pre and post-injury parameters for normally distributed data, and a Wilcoxon rank test used for non-normally distributed data. A p value <0.05 was taken as being statistically significant.

Table 2 Pre and post-injury grip and pinch strength differences

	Grip	*Pinch*
Mean predicted pre-injury strength (kg)	47.4	8.7
(range)	(22–72)	(7–12.5)
Mean post–injury strength (kg)	42.7	7.7
(range)	(21–76)	(4–14.5)
Mean percentage strength difference	−9.9%	−11.5%
p value (paired t-test)	$p = 0.017$	$p = 0.049$

Results

Epidemiology

1551 patients divided extensor tendons in their hand or forearm and of these 68 required repair of the wrist extensor tendons. 31/68 patients were willing to be reassessed and 11 of these were excluded because of concomitant injury. Of the 37 that were not assessed, one had died and the remainder were either untraceable, had moved from the region or were unwilling to participate in the study.

20 subjects (19 males, 1 female) were suitable for inclusion in this study. 5 patients were seen in the review clinic and 15 in their own homes. 5 were non-manual, 9 were light manual and 6 were heavy manual workers. Most of the injuries occurred in a domestic environment and were due to glass—Table 1.

12 patients injured their right hand and 8 injured their left hand. 7 divided ECRL alone, 6 divided ECU alone and 7 divided both ECRL and ECRB.

Surgical technique

All patients underwent repair under general anaesthetic or brachial plexus block.

Tendons were repaired using a 3/0 or 4/0 polydioxanone modified Kessler core suture and in 8 cases this was supplemented with a 6/0 prolene epitendonous suture. The wrist was splinted in neutral post-operatively for 3 weeks (13 patients). In the other patients the duration of splintage was shortened or prolonged by a week depending on patient compliance or clinic attendance. Physiotherapy was arranged following splint removal. There were no recorded tendon ruptures following repair, and none detectable clinically at the time of follow up. The average time off work was 10.5 weeks (range 0–26 weeks).

Functional results—grip and pinch strength

Grip strength in the injured hand was significantly reduced by a factor of 9.9% compared to the predicted pre-injury grip strength (Table 2).

Table 3 Range of movement comparison between uninjured and injured sides

	Flexion (degrees)	*Extension (degrees)*	*Radial deviation (degrees)*	*Ulnar deviation (degrees)*
Mean uninjured maximum (range)	55.9 (55–77)	63 (50–70)	22.4 (10–35)	34.7 (20–45)
Mean injured maximum (range)	49.1 (10–70)	58.4 (30–70)	19.4 (10–30)	29 (10–50)
Percentage difference	−12%	−7.3%	−13.4%	−16.4%
p value	$p = 0.058$ Paired *t*-test	$p = 0.027$ Wilcoxon test	$p = 0.11$ Paired *t*-test	$p = 0.02$ Paired *t*-test

Pinch strength in the injured hand was significantly reduced by a factor of 11.5% compared to the predicted pre - injury pinch strength (Table 2).

The sample populations of the predicted pre-injury and post-injury strength measurements are shown graphically as box and whisker plots in Figures 1 and 2. The boxplot graph shows a box with the upper border being the 75th centile and the lower the 25th centile. The box contains the median. The upper and lower limits represent the 95th and 5th centiles, respectively, and the crosses represent individual cases outside these limits.

Functional results—range of movement

All subjects had a full range of digital excursion and pronation/supination in both the uninjured and the injured forearms. Analysis of the different components of wrist movement showed statistically significant reduction in ulnar deviation and extension but not in flexion and radial deviation (Table 3).

Assessment of combined flexion/extension range and combined radial/ulnar deviation was performed. Analysis showed a mean loss of 11.4 degrees in the flexion/extension plane ($p = 0.022$) and a mean loss of 8.7 degrees in the radial/ulnar plane ($p = 0.0008$). This is shown in Figure 3.

Discussion

Extensor tendon injuries form a significant proportion of the workload in most hand surgery units. However, wrist extensor injuries are rare in comparison to all extensor injuries of the hand and forearm (68/1551 = 4.4%). Most of these injuries are sustained whilst punching glass which we know does not discriminate between one tendon and another. Consequently, isolated wrist extensor tendon injuries are even more rare, as demonstrated by the relatively small sample size. We specifically wanted to look at the effect of division and repair of the wrist extensor tendons which is why the patients with digital tendon injuries were excluded. Some of our study group had also injured and underwent repair of brachioradialis ($n = 2$) and the sensory branches of the radial nerve ($n = 6$). None of the patients who underwent repair of the sensory branches of the radial nerve had symptoms of a painful neuroma. These subjects were included, as we had no evidence to suggest that division of these structures affects grip/pinch strength measurement or wrist movement.

Patients with hand injuries may be less than compliant with therapy and follow up and it may be argued that patients who are willing to participate in the study may not be a truly representative sample. However, our study group comprised those who were willing to attend for review and those who were ‘chased‘ for follow-up, thus helping to reduce this possible bias. The majority of the injuries were sustained in the domestic setting

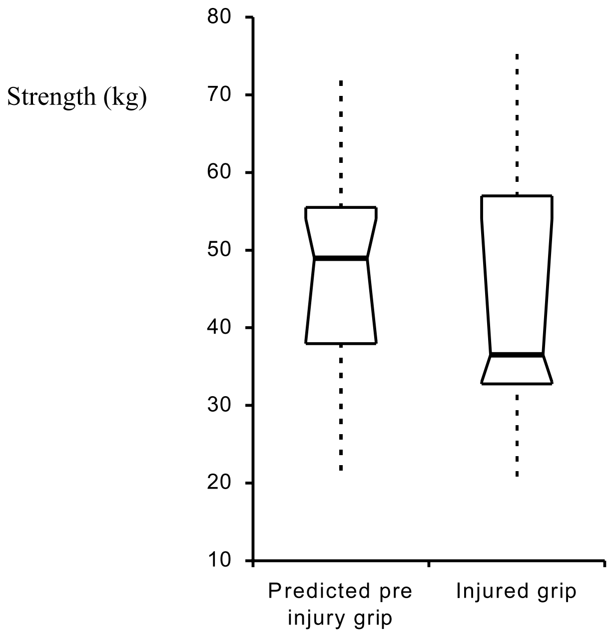

Figure 1—Box plot of grip strength populations.

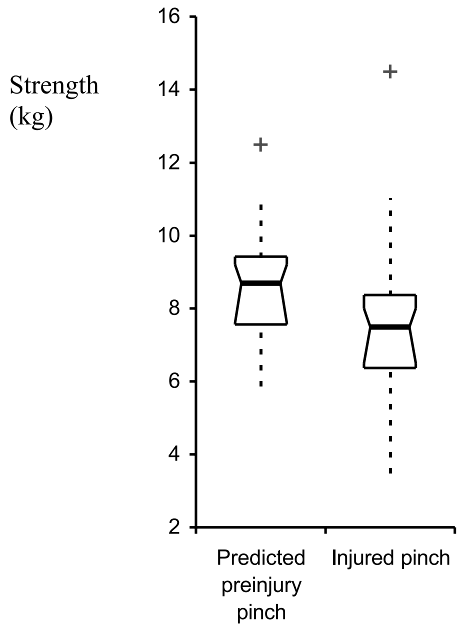

Figure 2—Boxplot of pinch strength populations.

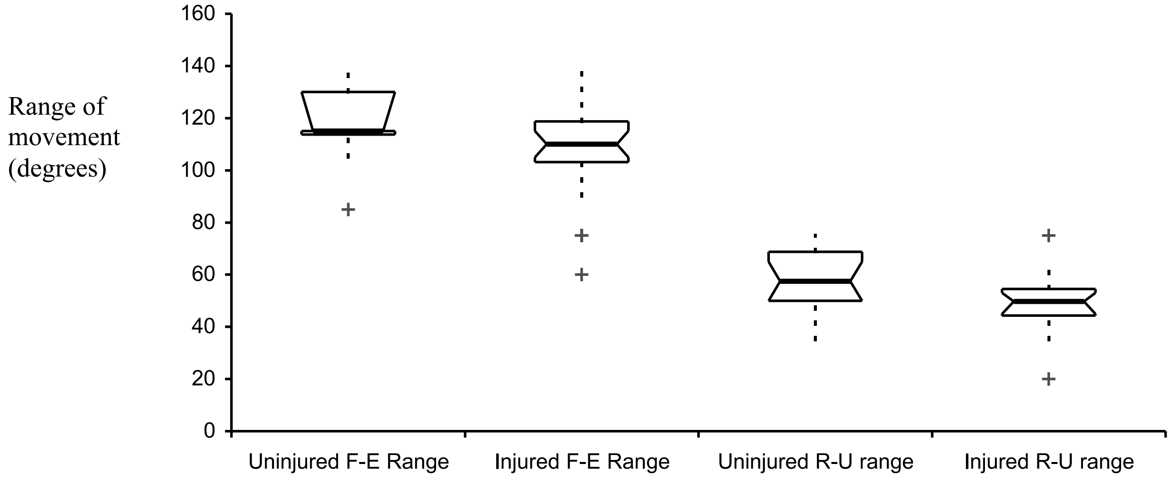

Figure 3—Boxplot comparing flexion/extension and radial/ulnar deviation between uninjured and injured sides.

and were removed from the possible bias of any ongoing medicolegal claim; only one subject was involved in a claim at the time of the study.

We calculated the predicted pre-injury grip/pinch strengths and compared these to the post-injury results. On the basis of their study, Armstrong and Oldham[10] conclude that it is "virtually impossible to estimate accurately from the opposite hand what the strength of an injured hand would have been before the injury". However, no allowance was made for their subjects' occupations or sporting activities in the analysis of their data. In addition, they used a cylindrical dynamometer and recognise that differences between studies may be due in part to differences in equipment and testing positions. However, analysis of our data using the uninjured side as a direct comparison without correction for occupation still showed statistically significant reductions in grip strength measurements following injury.

Wrist movement was assessed using a simple goniometer, as it is cheap, portable, and easy to use. Although the accuracy and reliability of electrogoniometry has been established[11] this technique was not used in our study as we wanted to use a low-cost technique which could be easily reproduced in the patient's home and in the clinic/medical reporting setting. One disadvantage of our method was that we were unable to document the range of circumduction in our subjects.

The data demonstrates significant reductions in grip and pinch strength and in wrist movement following repair of extensor wrist motors. A linear relationship exists between tendon excursion and wrist motion.[12] We propose that the injury, surgical repair and adhesion formation decreased the effective tendon excursion, resulting in reduced movement and grip/pinch strength. Patients noticed reduced grip strength in the injured wrist as it affected daily activities. However, the statistical reduction in wrist movement was outside the functional range and was not clinically significant to the patients.

We believe that this is the first review of outcomes following such injuries. Closed avulsion injuries of ECRL and ECRB and their subsequent outcome have been previously reported;[13] some cases regained full function and strength and others lost some grip strength and passive range of movement.

Although these are uncommon injuries it is important to know their likely functional outcome. This information may be useful for patient education following injury and repair, and as a bench mark in audit and medicolegal reports.

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The Authors

I. C. Josty, BSc, FRCS (Plast), Specialist Registrar, Welsh Centre for Burns and Plastic Surgery, Morriston Hospital, Swansea SA6 6NL, UK
A. H. F. MacQuillan MRCS, RAFT research fellow, Mount Vernon Hospital, Northwood, Middlesex, UK

M. S. C. Murison, FRCS (Plast), Consultant Hand and Plastic Surgeon, Welsh Centre for Burns and Plastic Surgery, Morriston Hospital, Swansea SA6 6NL, UK

Correspondence to I. C. Josty

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