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The Manchester short splint: A change to splinting practice in the rehabilitation of zone II flexor tendon repairs

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Abstract

Introduction: The results of patients with primary zone II flexor tendon repairs rehabilitated using a traditional forearm-based splint were audited and compared with those who were managed in the Manchester short splint.

Method: The short splint was fabricated to permit maximal wrist flexion and up to 45° of wrist extension with a block to 30° of metacarpophalangeal joint extension. A rehabilitation regimen consisting of early combined passive flexion exercises and active motion was employed. In 2011, 62 patients (76 digits) with a mean age of 34 years (range 14–58) were rehabilitated using the forearm-based splint (group A). In 2012, 40 patients (45 digits) with a mean age of 31 years (range 15–71) were rehabilitated using the Manchester short splint (group B).

Results: Group B had significantly less flexion contracture at their proximal interphalangeal joints than group A at 6 weeks (median 15° versus 28°; $p = 0.003$) and 12 weeks (median 6° versus 18°; $p = 0.024$) postoperatively. At the final review, group B had a significantly greater arc of flexion at their distal interphalangeal joints (median 59° versus 30°; $p < 0.001$) and a greater proportion of patients with excellent/good Strickland's grades. There were three (3.9%) ruptures in group A and two (4.4%) ruptures in group B ($p > 0.999$).

Conclusion: The use of a shorter splint would appear to enhance the outcomes whilst preserving repair integrity.

Keywords

Flexor tendon, rehabilitation, Manchester short splint

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Introduction

The evolution of multi-strand repair techniques has significantly improved the quality and strength of flexor tendon repairs in the hand.[1–4] Despite these advances, postoperative rehabilitation regimens remain largely unchanged and globally diverse. A Cochrane review concluded that there was no firm evidence to define the optimum mobilisation strategy.[5] There is however a considerable amount of supporting literature to suggest that carefully devised rehabilitation regimens are critical to the restoration of tendon glide.[6–8]

Rehabilitation programmes should be customised according to multiple factors including severity of injury, quality of the repair and the patient characteristics.[9] Early active motion of simple primary flexor tendon repair is now accepted practice, provided that the repair is robust and the patient complies with the rehabilitation programme.[8,10,11] When employing an active motion regimen, safety is paramount and the repair must be protected from gapping or rupture by minimising the work of flexion and loading the tendon only within the 'safe zone'.[12,13]

Traditionally, repairs have been protected by the application of a forearm-based dorsal splint with the wrist in a slightly flexed or neutral position and a restriction of hand function for the first 6 weeks following repair.[11,14,15]

Savage examined the influence of wrist position on the forces required to move the interphalangeal joints and concluded that 45° of wrist extension is the optimal position to minimise the work of flexion when utilising

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an active mobilisation regimen.[16] Others have suggested that the forces exerted on flexor tendons are dependent on wrist position[17,18] and that there is increased passive tendon excursion during wrist tenodesis.[19,20] Accordingly, synergistic wrist motion has since been incorporated into some rehabilitation regimens by modification of the splint,[21] but a two-part or a hinged dorsal splint was considered too complex for our patient group.

The need to adhere to these principles has prompted us to develop a shortened version of the forearm-based dorsal splint, which would allow wrist motion during an active rehabilitation regimen. We postulated that by allowing controlled wrist extension we could potentially reduce the work of flexion, promote greater tendon excursion and facilitate interphalangeal joint motion, ultimately resulting in better outcomes. This paper reports the results of a 2-year audit of uncomplicated zone II flexor tendon repairs comparing two groups of patients. The first group in 2011 were rehabilitated using the traditional forearm-based splint and the second group in 2012 using the new dorsal short splint allowing wrist motion.

Method

An audit of patients with uncomplicated primary zone II flexor tendon lacerations was undertaken. All flexor digitorum profundus (FDP) tendons were repaired during consultant-led trauma lists by the same group of hand consultants and specialist trainees, according to the unit's standards of cruciate four-strand repair, double-modified Kessler four-strand repair or Adelaide four-strand repair. The epitendinous suture was a simple continuous pattern. 3/0 Prolene was used for the core suture and 5/0 or 6/0 Prolene for the epitendinous suture. Flexor digitorum superficialis (FDS) tendons were repaired using horizontal mattress sutures. Venting of the pulleys was performed as needed to ensure smooth tendon glide. The results of rehabilitation using a traditional forearm-based splint in 2011 (group A) were compared with those of the newly designed dorsal short splint in 2012 (group B).

In both groups patients with partial tendon injuries, crush injuries, associated fracture or revascularisation and pre-existing flexion contractures were excluded from this retrospective analysis. Patients who had no recorded outcome due to non-attendance were also excluded. In 2011 all patients who had sustained digital flexor tendon injuries were rehabilitated using the traditional forearm-based splint regardless of patient demographics or injury characteristics. In 2012 the Manchester short splint was only fitted to patients who had complied with their initial appointment arrangements, had followed immediate postoperative instructions, were able to comply with the required weekly attendance for rehabilitation and demonstrated an ability to understand their injuries and the necessity for adherence to a strict rehabilitation regimen. As close monitoring of the short splint was paramount, patients who were unable to adhere to attendance criteria were fitted with a long splint and excluded from the study. This resulted in a reduced number of patients in group B. However, patients in both groups who subsequently did not adhere strictly to the rehabilitation regimen by removing the splint or performing inadvisable activities, such as manual work, but attended for treatment were included. In both groups only those patients with non-complex flexor tendon injuries in one or two digits were included. Digits with single digital nerve injuries were also included. Formal ethics approval was not required but the audit was formally registered and approved by the trust. Patient consent was gained before treatment.

Splint design

The forearm-based dorsal thermoplastic splint immobilises the wrist in neutral position with a 30° metacarpophalangeal (MCP) joint extension block (Figure 1). In contrast, the new dorsal short splint (the Manchester short splint) extends from the proximal wrist crease to the fingertips (Figure 2). The Manchester short splint permits maximal wrist flexion and up to 45° of wrist extension with a block to 30° of MCP joint extension.

Rehabilitation regimen

On the 4th or 5th postoperative day, all patients were seen at the practitioner-led hand therapy clinic for dressing change, wound assessment and formulation of a treatment plan. As oedema plays a significant role in the limitation of motion, especially in the early phase following surgery, the rehabilitation regimen commenced when the initial postoperative oedema had started to subside and gliding resistance was more likely to be reduced.[22,23]

In order to minimise the effects of oedema on joint motion and prevent the tightening of dorsal structures, the exercise sequence prioritised full passive flexion stretching of the interphalangeal joints to maximise passive digital motion prior to the initiation of active motion. This commenced at the first treatment session and continued throughout the rehabilitation regimen. Patients in both groups performed the same passive exercise regimen.

Active flexion exercises were initiated from the distal interphalangeal (DIP) joint to maximise differential glide.[24] Patients were encouraged to perform active flexion exercises carefully to minimise the work of

Figure 1. The traditional forearm-based splint.

Figure 2. The Manchester short splint permits active wrist extension.

flexion within the 'safe zone'[12,13] and were discouraged from performing excessive or forced active flexion at the end range of motion.[25] They were also encouraged to perform active digital extension exercises to minimise the risk of interphalangeal joint flexion contractures (see the Appendix).

Patients in group A performed digital flexion and extension exercises within the forearm-based splint keeping the wrist in a neutral position. In contrast group B, who were rehabilitated using the Manchester short splint, performed active digital flexion exercises with the wrist extended to 45° (Figure 2) and active digital extension exercises with the wrist in maximal flexion (Figure 3). In both groups, volar thermoplastic finger gutter splints were provided for use at night in those patients who, on attendance in the clinic at any stage during the first 6 weeks, demonstrated an inability to achieve full interphalangeal joint extension and had the potential to develop fixed flexion deformities.[26]

All patients were instructed on the safe and light functional use of their hand, excluding only the injured digit rather than exclusion of the whole hand. They were advised to avoid resisted flexion of the affected digit. The patients were instructed to wear their splints full time for a period of 6 weeks, removing it only for hand hygiene purposes. Range of motion of the interphalangeal joints of the injured digit was measured by a clinical specialist hand therapist using a Sammons Preston by Roylan digital goniometer at 6 and 12 weeks postoperatively. Both individual joint range and total joint arc of motion were recorded and Strickland scores calculated.

Patients in both groups were treated by the same members of an experienced team of specialised hand therapists. Follow-up arrangements were the same for each group and all patients were required to attend therapy clinic once weekly for the first 6 weeks. Following removal of the splint, a programme of exercise, soft tissue stretching and night splinting for residual contracture were initiated and patients in both groups were permitted to return to normal activities at 12 weeks.

Statistical analysis

The majority of the variables were not normally distributed, hence non-parametric analyses were employed and accordingly summary values of median and range (minimum, maximum) were presented. Continuous variables between the groups were compared using non-parametric Mann–Whitney U tests and changes between the 6 and 12 weeks data were analysed using pairwise Wilcoxon signed-rank tests. In order to take into account the potential interdependencies of data, the above analyses were restricted to the measurements of a single digit in patients with multiple digit injuries.[27] The most radial finger was chosen arbitrarily in these patients.

Rupture rates between the groups (categorical data) were compared using Fisher's exact tests. Analyses based on patient level and digit level were both performed for completeness. All analyses used the conventional two-sided 5% significance level and this was set at $p < 0.05$.

Figure 3. The Manchester short splint permits full wrist flexion.

Results

In 2011, 62 patients (76 digits) who sustained complete zone II lacerations of FDP with or without concomitant FDS injuries were included in the audit. There were 42 (68%) males and 20 (32%) females, with a mean age of 34 years (range 14–58). All tendon lacerations were repaired between 0 and 13 days from the time of injury (mean 3 days). They were rehabilitated using the forearm-based splint (group A).

In 2012, 40 patients (45 digits) with comparable injuries were rehabilitated using the Manchester short splint (group B). There were 30 (75%) males and 10 (25%) females, with a mean age of 31 years (range 15–71). All tendons were repaired between 0 and 8 days from the time of injury (mean 2 days).

At 12 weeks, 24 out of 62 (39%) patients in group A and 12 out of 40 (30%) patients in group B did not attend for measurement and defaulted from further follow-up. These patients did attend for the 6-week evaluation and their results are included in the study. The range of motion of the PIP and DIP joints and the differences between the two groups are summarised in Table 1.

Table 1. Range of motion of the PIP and DIP joints at 6 and 12 weeks.

			n	2011 Forearm-based splint Median (range)	n	2012 Manchester short splint Median (range)	*p*-value
PIP joints	6 weeks	Extension deficit	59	28 (0, 60)	38	15 (0, 50)	0.003
		Flexion	59	75 (30, 96)	38	78 (36, 102)	0.475
		Total arc	59	43 (0, 96)	38	61 (5, 102)	0.010
	12 weeks	Extension deficit	40	18 (0, 50)	28	6 (0, 28)	0.024
		Flexion	40	86 (45, 102)	28	86 (34, 104)	0.916
		Total arc	40	73 (14, 102)	28	77 (9, 104)	0.197
DIP joints	6 weeks	Extension deficit	59	10 (0, 40)	38	0 (0, 25)	0.041
		Flexion	59	35 (0, 95)	38	34 (0, 75)	0.714
		Total arc	59	22 (0, 85)	38	26 (0, 75)	0.199
	12 weeks	Extension deficit	38	0 (0, 20)	28	0 (0, 18)	0.115
		Flexion	38	33 (0, 70)	28	59 (12, 83)	<0.001
		Total arc	38	30 (0, 70)	28	59 (5, 83)	<0.001

At 6 weeks following surgery the patients in group B who were managed in the Manchester short splint demonstrated a statistically significantly reduced extension deficit at both the PIP joint (median difference = 13°, p = 0.003) and the DIP joint (median difference = 10°, p = 0.041) than those in group A who used the traditional splint. Although the difference in individual PIP joint or DIP joint flexion was not statistically significant by use of the Manchester short splint, the total arc of flexion for the PIP joint was found to be statistically significant (median difference = 18°, p = 0.010).

At 12 weeks postoperatively patients in group B continued to demonstrate reduced extension deficit at the PIP joint (median difference = 12°, p = 0.024) but improvements in the total arc of flexion were not significant compared to group A. At 12 weeks patients in both groups demonstrated no difference in DIP joint extension deficit but at this stage improvements in the flexion of the DIP joint (median difference = 26°, p = <0.001) and the arc of flexion (median difference 21°, p = <0.001) were significant. Outcomes of the patients according to the original Strickland's grading system[28] at 12 weeks postoperatively are summarised in Table 2.

There were three ruptures in group A and two ruptures in group B but there were no significant differences between the groups on Fisher's exact test (p > 0.999). The three ruptures in group A occurred at week 1, 8 and 10, respectively. The cause of rupture of the first patient was not known; the second case was felt to be due to early snagging of the repair on the A2 pulley and the third case ruptured during a road traffic accident. In group B, the two ruptures occurred at weeks 3 and 6, respectively. The first case was complicated by a wound infection while the second patient did not comply with the instructions and apparently had removed the splint himself by the 2nd week of rehabilitation.

Table 2. Comparison of early outcome using Strickland's grading.

	2011 Traditional forearm-based splint (%)	2012 Manchester short splint (%)
Strickland's grading at 6 weeks		
Excellent	1	5
Good	7	5
Fair	22	39
Poor	70	51
Strickland's grading at 12 weeks		
Excellent	6	22
Good	23	27
Fair	38	32
Poor	33	19

Discussion

We compared the outcomes of patients with uncomplicated zone II flexor tendon repairs who had been rehabilitated using either the traditional forearm-based splint or the Manchester short splint. It demonstrated similar rupture rates between the two groups comparable to published levels using four-strand repair techniques[3] and indicated that the use of a shorter splint appears to be safe for the rehabilitation of these injuries.

Inappropriate resisted functional activity, placing too much stress on a repair is a major cause of rupture following a flexor tendon repair.[29] Published studies and our personal clinical experience reveal that patients will use their injured hands for functional activities, despite instructions to the contrary, both during the early stages of healing and within the 6 weeks of protective splintage.[30,31] Recognising this tendency, 'safe use' of the hand has been our policy throughout the reported period. Exception is made to this advice in the presence of multiple digit injuries. It is recognised that in allowing restricted use of the hand some stress on the repair site is inevitable due to the common muscle belly of FDP. However, as the affected digit is excluded during function this stress is confined to simultaneous active motion. The shorter splint also facilitates functional activity by permitting wrist extension.

A combination of wound pain, oedema and the resting posture of the digits can lead to early loss of active extension at the interphalangeal joints. Deep lacerations breaching the joints are especially problematic and the resultant scar formation can exacerbate the limitation in range of motion. Rehabilitation regimens should therefore be designed to prevent these flexion deformities from developing by early recognition and intervention. The most notable finding of this study was the reduction in the degree of extension loss at the PIP joints in those patients who wore the Manchester short splint compared to the group who wore the forearm-based splint. The working hypothesis is that wrist flexion, which is permissible within the short splint, facilitates relaxation of the flexor tendons while, at the same time, augmenting active digital extension by the extensor tenodesis effect.

There was however no significant difference in the degree of active flexion achievable at the PIP joints between the groups. Although the total arc of motion was significantly better in the short splint group (at 6 weeks), this appears to have been achieved by preventing extension loss, rather than by a gain in flexion.

By 12 weeks, the arc of PIP joint motion became comparable but the extension deficit remained significantly less in the short splint group. Regardless of the splint designs, the range of digital flexion is likely to be limited by other factors such as the extent of postoperative oedema and joint stiffness early in the rehabilitation phase.[22,23]

At the final review the most noteworthy finding was a significantly greater gain in the arc of flexion at the DIP joint for those patients treated with the short splint. This is also reflected in the greater proportion of patients achieving good to excellent Strickland's grades in the short splint group. Strickland's method of evaluating outcome[28] was not originally designed to be used before rehabilitation or scar maturation is complete and therefore the results presented in this study cannot be compared to other published studies or viewed as final.

There were a number of limitations to the study and the authors acknowledge that there are inherent potential biases using comparison of historical cohorts. For example, despite having clear unit protocols for the surgical management of the flexor tendon injury we cannot rule out some variability between different surgeons in handling of the sheath and venting of pulleys. Another significant limitation may be that in both groups strict compliance with the exercise regimen and splint wearing cannot be guaranteed. There was also an element of bias in patient selection for the short splint which may have influenced the outcomes although non-compliant patients who wore the short splint were included. The study was further limited by the reduced numbers of patients who did not attend for measurement at 12 weeks and defaulted from further follow-up.

Despite these limitations, the study reports a number of factors with regard to surgery, patient demographics and injury types which were comparable.

The authors recognise that a prospective randomised controlled trial is now desirable given the apparent findings of benefit from the use of the Manchester short splint.

Conclusion

The Manchester short splint permits wrist motion which facilitates interphalangeal joint extension and flexion. This appears to enhance the digital arc of flexion in the early phase leading to improvements in DIP joint flexion and differential glide. This demonstrates improved outcomes whilst preserving repair integrity. The Manchester short splint appears to be a safe and innovative development in the rehabilitation of primary flexor tendon repairs in zone II.

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Conflict of interest

None declared.

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Appendix

The rehabilitation regimen using the Manchester short splint

- Attend outpatient clinic at 4–5 days post-operatively
- Theatre dressing removed and wound check
- Protective dorsal splint applied to be worn for 6 weeks
- Prioritise restoration of full passive digital flexion
- Initiate early active motion from the DIP joint within the ‘safe zone’ following robust repair with the wrist in 45° extension. Promote differential glide
- Discourage full range of active motion
- Encourage active digital extension exercises with the wrist in flexion
- Apply digital extension splints to be worn at night in the event of early loss of extension or joint injury
- Perform safe, functional activity
- Remove splint at 6 weeks and progress light functional activity
- At 6 weeks commence stretching and splinting of residual flexion deformity or tight scarring
- Apply a night extension splint as appropriate
- Return to normal activity between 10 and 12 weeks