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Delayed primary flexor tendon repair in zone II injuries: results of using WALANT and controlled true active motion

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Abstract

Early repair of flexor tendon injuries is ideal, but delays are common. We studied the outcomes of flexor tendon repairs delayed from 5 days to 6 months and carried out under wide-awake local anaesthesia with no tourniquet (WALANT). Twenty-four patients (29 fingers) who underwent primary flexor tendon repair on zone II using a four- to six-strand core suture technique, followed by controlled early active motion therapy. Clinical assessments, including total active motion (TAM) and Disabilities of the Arm, Shoulder and Hand, were made 6, 8 and 12 weeks after operation. All outcomes improved significantly over time. At the final assessment, 93% of fingers showed excellent TAM outcomes. Extension deficit was between 5° and 20° in eight of 26 fingers. The results of this study suggest that delayed primary flexor tendon repair under WALANT can achieve excellent functional outcomes, although longer follow-up is needed for extension deficit recovery.

Level of evidence: IV

Keywords

Delayed repair, early active motion, flexor tendon, functional outcomes, hand surgery, WALANT

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Introduction

Early repair of flexor tendon injuries is highly recommended; however, it may sometimes not be feasible owing to various factors such as the unavailability of a specialist surgeon, associated complex injuries or in missed cases (Tang, 2005). Delayed flexor tendon injuries are not uncommon in our tertiary referral hand surgery clinic, particularly in patients from rural areas where hand surgeons are scarce.

Initially, primary repair is defined as an end-to-end repair conducted within 24 h, with any further delay termed delayed primary repair, which can extend up to 4 weeks after injury, as described by Tang (2019). Despite some studies that suggest there are no adverse effects of delay on outcomes, early repair is generally associated with favourable results (Tang, 2021a). Munz et al. (2021) found that even delays of up to 5 weeks did not significantly affect the outcomes in their study on flexor tendon primary repairs delayed because of restrictions in the COVID-19 pandemic. They emphasized the importance of proper surgical techniques, surgical expertise and early mobilization in achieving positive results. Other studies, including those by Reito and Helkamaa (2020) and Lalonde (2017), have also reported successful outcomes after delayed primary

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repairs, which have often used various anaesthesic methods and postoperative therapy protocols.

Recently, many centres have adopted wide-awake local anaesthesia with no tourniquet (WALANT) for flexor tendon repairs, which provides immediate feedback on the quality and efficiency of the repair while also promoting early active mobilization therapy, which is crucial for successful outcomes (Giesen et al., 2017). We hypothesized that patient outcomes could be satisfactory regardless of the length of the delay when WALANT is used for the primary repair of the flexor tendons. We present the results in patients who underwent delayed primary flexor tendon repair in zone II from 5 days to 6 months after injury, performed under WALANT, followed by controlled early active postoperative treatment.

Methods

This retrospective study was conducted in collaboration with a hand surgery and a hand therapy clinic. The ethics committee approved the study design (record number 2024–147) on 1 February 2024.

We included patients aged $\geq$18 years who underwent primary flexor tendon repair in zone II at least 3 days after injury between June 2021 and July 2023. Flexor tendon injuries to the thumb and wrist were excluded. Patients with concomitant peripheral nerve injuries, fractures of the phalanges or metacarpals, amputations or partial amputations, and arthritis involving the hand were also excluded from the analyses. Patients with concomitant digital nerve and artery injuries were not excluded because digital nerve injuries cause only a sensory deficit and no significant motor deficit (Chan et al., 2006; Rosberg et al., 2003).

Patients who did not comply with the postoperative hand therapy programme or did not complete the assessments were also excluded from the analysis. All patients were operated on under WALANT by two hand surgeons (EA or KÇ) involved in the study. In the postoperative period, a hand therapist (SG) applied a controlled early active movement protocol. The first author (ZE) created the study methodology and assessed patients. Details of the surgical and therapy protocols are provided below.

The age, gender, dominant and injured side of the patients were recorded. The dates of the injury and the surgery were also recorded and used to calculate the delay in surgical repair in terms of the number of days. Injured finger(s) and tendon(s) were noted.

Details of surgical repair

All patients were operated on by one of two hand surgeons (EA or KÇ) with over 5 years of experience. WALANT is the routine method of anaesthesia in primary flexor tendon repair in our hand surgery clinic. However, preoperative preparations for both general anaesthesia and secondary tendon reconstruction were also completed in all patients, should they have become necessary during the operation.

The typical surgical repair method to promote postoperative early active mobilization involved a robust four- to six- strand core suture repair according to the Adelaide technique, resulting in slight bulkiness at the repair site (Ayhan et al., 2021; Francis et al., 2021; Tang et al., 2005). Additionally, we incorporated running and locking peripheral sutures to reinforce and smooth the repair. For core suturing, we used 3–0 or 4–0 polypropylene (Prolene; Ethicon Inc., Somerville, NJ, USA) or polydioxanone (PDS II; Ethicon Inc.) sutures. For peripheral suturing, 5–0 or 6–0 polypropylene (Prolene; Ethicon Inc.) or polydioxanone (PDS II; Ethicon Inc.) sutures were used. After the repair, patients were instructed to flex and extend the fingers actively to assess free tendon gliding and any potential gapping at the repair site (Lalonde and Higgins, 2016; Lalonde and Martin, 2013). If any gapping was observed, we reinforced the repair with additional core sutures, and if there was any constricting pulley hindering smooth tendon gliding, we carefully vented it by 1.5–2 cm.

Details of postoperative therapy

All patients received postoperative hand therapy based on controlled early true active motion principles (Tang, 2021b). The hand was placed in a dorsal blocking splint, and the exercises started after 3–5 days to minimize the work of flexion owing to early oedema (Lalonde and Tang, 2019). Exercise therapy always began with a warm-up of 30–40 passive composite flexion repetitions. Active exercises started with only distal interphalangeal (DIP) flexion within the first week. Patients progressed to DIP and proximal interphalangeal (PIP) flexion in the second week and to a half-fist in the third week. Obtaining a full-unloaded fist was targeted within the fourth week (Tang, 2021b).

After 4 weeks, the splint was gradually removed during the day but worn at night for another 2 weeks. Patients carried out flexor tendon gliding exercises until week 6. Afterwards, the splint was removed entirely, active blocking exercises were begun and patients were encouraged to engage in daily activities while avoiding resisted and heavy tasks for 3 months.

Patients were typically discharged from therapy after 8 weeks and instructed to perform resisted

exercises at home. A visit for a final assessment at week 12 was scheduled at discharge. In this final visit, additional therapy was instructed if necessary (e.g. in the case of any extension deficit).

Clinical assessments

Patients were assessed postoperatively at weeks 6, 8 and 12. The total active motion (TAM) of the injured fingers was measured, and the disability level was assessed using the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire. Total active motion scores were recorded for each injured finger. The injured fingers were also classified according to the Strickland–Glogovac criteria based on the week 12 assessment (Strickland and Glogovac, 1980).

Range of motion assessment. A metal finger goniometer was used to measure the range of motion of the metacarpophalangeal, PIP and DIP joints. Using the Modified Strickland classification, the total extension deficit was subtracted from the sum of the degrees of active flexion of the PIP and DIP joints, divided by 175°, with the result multiplied by 100 to calculate the percentage value. The resulting score was classified as excellent (75–100%), good (50–74%), fair (25–49%) and poor (0–24%) (Strickland, 1985).

Disability level. The DASH questionnaire was used to score the disability level of the patients. The reliability and validity of the Turkish adaptation of the questionnaire were confirmed by Düger et al. (2006). Patients were asked to complete this questionnaire considering their daily life during the previous week at weeks 6, 8 and 12.

Statistical analysis

The normality of the data was assessed using both visual (histograms, Q–Q plots) and statistical methods (Shapiro–Wilk test) and it was seen that all data showed normal distributions. These data are shown as mean (standard deviation). Qualitative variables are presented as percentages and numbers.

Demographic data and DASH scores were analysed based on the number of patients. Information about injuries (such as injured tendon and injury zone) and TAM scores was analysed based on the number of fingers. A repeated measures analysis of variance (ANOVA) was used for changes across three time points (weeks 6, 8 and 12). This test allowed for the assessment of within-subject effects and the identification of significant differences over time. When the p-value of this test was <0.05, to further explore the differences between time points, pairwise comparisons were done using a paired-samples t-test. A Bonferroni correction was applied to adjust for multiple comparisons, and the corrected p-value threshold was set at <0.017. Unless stated otherwise, results were reported as mean (SD). The results are presented as a mean and standard error with a 95% confidence interval.

Results

Patient demographics and clinical characteristics

A total of 45 patients with delayed primary flexor tendon repairs were found in our records. Twenty-one patients were excluded from the study: one was a foreigner unable to complete the DASH questionnaire, five had thumb injuries, six were non-compliant with the treatment and nine had zone I injuries. The remaining 24 patients (29 injured fingers) were included. Patient age, gender distribution and injury details are shown in Table 1.

Outcomes, deficits and complications

Two patients underwent fractional lengthening of the flexor digitorum profundus muscle owing to excessive tension identified during the intraoperative active flexion–extension test. The delays in surgery for these two patients were 5 weeks and 6 months, respectively. A video demonstrating the fractional lengthening procedure for the patient with a 5-week delay is available in a previous article by two of the authors of this study (Ayhan et al., 2021). In two other patients (without fractional lengthening), the repaired tendon ruptured in the first postoperative week: one was because of non-compliance with splint wear and the other because of early forceful use of the hand. The tendons were re-repaired in these two patients, and postoperative treatment was restarted. The assessment data after the second operation of these two patients were included in the analysis. After 12 weeks, the extension deficit recorded in eight patients ranged from 5 to 20° (Table 2).

The DASH scores and TAM in degrees at weeks 6, 8 and 12 are shown in Table 2, along with the final Strickland–Glogovac criteria. The final TAM values for two fingers were unavailable. The analysis showed a significant difference in both the DASH scores and TAM between consecutive weeks. Further pairwise comparisons revealed significant differences between weeks 6–8, 6–12 and 8–12 (Table 3).

Table 1. Baseline characteristics of the patients.

Demographics and baseline characteristics	
Age (years); mean (SD)	30.4 (7.4)
Gender (*n*)	
Female	10/24
Male	14/24
Dominant side (*n*)	
Right	22/24
Left	2/24
Injured side (*n*)	
Right	14/24
Left	10/24
Dominant hand injured (*n*)	
Yes	12/24
No	12/24
Delay time for repair (days); mean (SD) (range)	27.4 (33.3) (5–180)
Operation day (*n*)	
Within first 7 days	5/24
8–14 days	6/24
15–21 days	2/24
29–35 days	6/24
35 days to 6 months	5/24
Injured finger (*n*)	
Index	6/29
Middle	4/29
Ring	8/29
Little	11/29
Injured tendon (*n*)	
FDP	17/29
FDP+FDS	12/29

FDP, flexor digitorum profundus; FDS, flexor digitorum superficialis; *n*, number of participants; SD, standard deviation.

Table 2. Results of assessment.

Measurement	Value
DASH score: mean (SD)	
6th week	30.4 (16)
8th week	17.4 (10.1)
12th week	8.9 (10.9)
TAM in degrees: mean (SD)	
6th week	196 (28.6)
8th week	224.4 (27.4)
12th week	249.1 (17.7)
Strickland–Glogovac criteria (*n*)	
Excellent	25/27
Good	2/27
Fair	0
Poor	0
Extensor deficit in degrees (missing three fingers):	
Mean (SD): ($f = 26$)	3° (5°)
0° (*f*)	18/26
5° (*f*)	1/26
10° (*f*)	6/26
20° (*f*)	1/26

DASH, Disabilities of the Arm, Shoulder and Hand; *f*, number of fingers; SD, standard deviation; TAM, total active motion.

Discussion

The results of this study show that primary repair of flexor tendons, even when delayed from 5 days to 6 months, can still yield good to excellent outcomes. These promising results were attributed to intraoperative testing of the sutures using the active flexion–extension test and the application of a postoperative early controlled active motion regimen. Our results support the possibility of good results of delayed primary repair when a delay is unavoidable.

Early primary flexor tendon repair within the first 48 hours is generally recommended, although it is not always feasible for various reasons (Giesen et al., 2017). Earlier studies have reported that flexor tendon repair in a well-perfused hand is not an emergency and can be delayed up to 3 weeks in adults (Schneider, 1971). While some prefer surgical repair within 1 week after injury, others suggest that a delay of up to 1 month is acceptable (Sasor et al., 2016). However, there is insufficient high-level evidence to define the optimal timing for early primary tendon repair.

The effect of delay from injury to repair on outcomes also varies across studies. A previous study analysing the outcomes of flexor tendon repairs in 356 fingers found that delayed surgery was a negative predictor of good outcomes (Rigo and Pires, 2018). Earlier experimental studies also indicated that delays in repair could impair tendon function (Tang, 1995) and concluded that the optimal time for tendon repair is at the primary stage. Although delayed tendon repair can be done within 3 weeks to 1 month after injury, the repair is ideally done within the first few days. Reito and Helkamaa (2020) also reported that the risk of complications increases with delays in repair. Despite the widely accepted principle that earlier repair results in optimal outcomes, the ideal timing for flexor tendon primary repair has varied considerably between the previous studies. In contrast to the studies highlighting the adverse effects of delay, some studies have found no detrimental impact of delayed repair on outcomes. Munz et al. (2021) reported on primary flexor tendon repair outcomes delayed owing to COVID-19 pandemic restrictions, including operations done between 3 and 35 days (with a mean delay of 15 days) after the initial injury. They found that the time between injury and surgery was not a significant risk factor for a good outcome and concluded that good outcomes depend on proper surgical methods, the experience of the surgeon and

Table 3. Results of comparisons.

Measurement	Mean (SD)	SE mean	95% CI	*p*-value
DASH score				
6th–8th week ($n=22$)	11.7 (10)	2.1	7.3–16.1	<0.001
6th–12th week ($n=22$)	21.3 (16.4)	3.5	14.1–28.6	<0.001
8th–12th week ($n=21$)	10.3 (9.7)	2.1	5.9–14.8	<0.001
TAM in degrees				
6th–8th week ($f=25$)	−28 (15)	3	−34 to −22	<0.001
6th–12th week ($f=24$)	−54 (25)	5	−64.4 to −44	<0.001
8th–12th week ($f=27$)	−24 (22)	4.3	−33 to −16	<0.001

CI, Confidence interval; DASH, Disabilities of the Arm, Shoulder, and Hand; *f*, number of fingers; *n*, number of participants; SE, standard error; SD, standard deviation; TAM, total active motion.

appropriately applied early mobilization. Similarly, in our study, experienced surgeons used appropriate suture methods. The experienced hand therapists supervised controlled early active motion regimens, contributing to good results even in patients with a delay of up to 6 months. Other studies reporting the outcomes of delayed primary repairs had reported delays ranging from 7 days to 5 weeks (Munz et al., 2021; Reito and Helkamaa, 2020). The results of longer delays have been analysed only in a few individual case reports (Kendrick, 2019; Lalonde, 2017).

Our study used standard methods in all patients enrolled in the analysis. In previous publications, various anaesthesic methods and postoperative therapy protocols have been used. We prefer flexor tendon repair under WALANT, which provides immediate feedback on repair quality and effectiveness. Wide-awake repair offers several advantages over regional or general anaesthesia, including the ability to test the repair intraoperatively by flexing and extending the digit. The surgeon can check for bunching, gapping and triggering, and can revise the repair and vent pulleys to ensure smooth, active motion. Moreover, WALANT encourages early active mobilization therapy, which is crucial for successful outcomes (Rigo and Pires, 2020). As a result, postoperative active movement therapy was applied confidently in our study, which significantly contributed to good to excellent results for TAM.

The extension deficit observed in many patients at the final assessment in our study may be a potential complication. This outcome was not surprising, as the tendon healing process requires several months after repair, and our final results were collected in the twelfth week after operation. We instructed patients with extension deficits to follow a home programme of heating, stretching and tendon gliding exercises but we could not document the extension deficit of the patients beyond this period. Since none of the patients retuned to the clinic complaining of limitation of extension, we believe that improvement was achieved with the home programme.

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Informed consent Written informed consent was obtained from all subjects before the study.

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References

Ayhan E, Tuna Z, Oksuz C. Getting better results in flexor tendon surgery and therapy. Plast Reconstr Surg Glob Open. 2021, 9: e3432.

Chan TK, Ho CO, Lee WK, Fung YK, Law YF, Tsang CY. Functional outcome of the hand following flexor tendon repair at the 'no man's land'. J Orthop Surg (Hong Kong). 2006, 14: 178–83.

Düger T, Yakut E, Öksüz Ç et al. Reliability and validity of the Turkish version of the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire. Turk J Physiotherap Rehabil. 2006, 17: 99–107.

Francis EC, Bossut C, O'Donnell M, Eadie P A. Outcomes and rupture rate of the 'Adelaide' four-strand repair for zone 2 flexor tendon injuries over a 10-year period. Eur J Plast Surg. 2021, 44: 231–6.

Giesen T, Calcagni M, Elliot D. Primary flexor tendon repair with early active motion: experience in Europe. Hand Clin. 2017, 33: 465–72.

Kendrick BJL. Case studies on the impact of repair delay in flexor tendon injuries. J Hand Surg Eur. 2019, 44: 423–8.

Lalonde DH. The effect of delay on flexor tendon repair outcomes: individual case reports. Plast Reconstr Surg. 2017, 140: 12–19.

Lalonde DH, Higgins A. Wide awake flexor tendon repair in the finger. Plast Reconstr Surg Glob Open. 2016, 4: e797.

Lalonde DH, Martin AL. Wide-awake flexor tendon repair and early tendon mobilization in zones 1 and 2. Hand Clin. 2013, 29: 207–13.

Lalonde DH, Tang JB. Wide awake flexor tendon repair: contemporary approaches with early active motion. J Hand Surg Am. 2019, 44: 402–10.

Munz M, Hodgson S, Jaggard MK, Ollivere BJ, Kendrick BJL. The impact of COVID-19 on the timing of flexor tendon repairs and clinical outcomes. J Hand Surg Eur. 2021, 46: 354–60.

Reito A, Helkamaa T. Delayed primary repair of flexor tendon injuries: a systematic review. J Plast Surg Hand Surg. 2020, 54: 215–21.

Rigo I, Pires A. Outcomes of delayed flexor tendon repair in 356 fingers: a retrospective study. J Hand Surg Eur. 2018, 43: 540–6.

Rigo I, Pires A. Wide awake local anesthesia no tourniquet (WALANT) in flexor tendon repair: the impact on early mobilization and outcomes. J Hand Surg Am. 2020, 45: 638–45.

Rosberg HE, Carlsson KS, Höjgård S, lındgren B, Lundborg G, Dahlın LB. What determines the costs of repair and rehabilitation of flexor tendon ınjuries in zone II? A multiple regression analysis of data from Southern Sweden.J Hand Surg Br. 2003, 28: 106–12.

Sasor SE, Hendrickson MA, Breidenbach WC. Delayed primary flexor tendon repair: a review of the literature and our experience. Hand Clin. 2016, 32: 339–48.

Schneider LH. Flexor tendon repair in the digital sheath: a comparison of results of immediate and delayed repair. J Bone Joint Surg Am. 1971, 53: 1041–48.

Strickland JW. Results of flexor tendon surgery in zone II. Hand Clin. 1985, 1: 167–79.

Strickland JW, Glogovac SV. Digital function following flexor tendon repair in Zone II: a comparison of immobilization and controlled passive motion techniques. J Hand Surg Am. 1980, 5: 537–43.

Tang JB. The effect of delayed repair on the functional outcomes of flexor tendon injuries: an experimental study. J Hand Surg Am. 1995, 20: 533–9.

Tang JB. Flexor tendon injuries: principles of treatment and rehabilitation. J Hand Surg. 2005, 30: 1185–200.

Tang JB. Tendon injuries across the world: treatment, outcomes, and future directions. Hand Clin. 2019, 35: 233–42.

Tang JB. Recent developments in flexor tendon surgery and hand therapy. J Hand Surg Eur. 2021a, 46: 254–61.

Tang JB. Rehabilitation after flexor tendon repair and others: a safe and efficient protocol. J Hand Surg Eur. 2021b, 46: 813–7.

Tang JB, Zhang Y, Cao Y, Xie RG. Core suture purchase affects strength of tendon repairs. J Hand Surg Am. 2005, 30: 1262–6.