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Zone 1-2 flexor tendon repair results with WALANT

Yakup Kuzucu[1], Egemen Ayhan[1], Zeynep Tuna[2], Önder Ersan[1]

ABSTRACT

Objective: The aim of this study was to report the outcomes of patients applied with zone 1 and 2 flexor tendon repairs using the with strong core sutures, venting of critical pulleys, intraoperative active movement testing with a wide-awake surgical setting, and early active mobilization approaches.

Patients and Methods: Twenty pulleys impairing excursions during intraoperative active movement were totally vented and up to half of two A2 pulleys were judiciously vented. Therapy started on the third postoperative day. Assessments were performed at the end of the sixth, eighth, and 12th weeks. The Strickland score was calculated for each injured finger and the Disabilities of Arm, Shoulder and Hand (DASH) scale was completed. The Strickland and DASH scores in the consecutive assessments were compared.

Results: Evaluations of 21 fingers of 17 (11 males, six females) patients with a mean age of 30.0±7.9 years were made. There were 17 zone 2 and four zone 1 repairs. One finger (1/21, 4.7%) was operated on again for stiffness (tenolysis) and there was no rupture. The Strickland and DASH scores improved with a statistically significantly at each assessment.

Conclusion: The low tenolysis rates, the absence of ruptures, and improved outcome scores signaled encouragement to follow current flexor tendon repairs.

Key words: *Early active mobilization, flexor tendon, venting of annular pulleys, walant*

Introduction

Flexor tendon surgery and therapy details have evolved significantly over the last decade and outcomes are encouraging with rare or nearly no ruptures, and low tenolysis rates (5-10%) [1-6]. Currently, better outcomes have been reported with lightly tensioned multi-strand repairs, judicious venting of pulleys, and early active movement rehabilitation protocols [1-8]. In addition, a wide-awake local anesthesia no tourniquet (WALANT) technique has been recommended in anesthesia. During tendon repairs, intraoperative active movement with WALANT provides the opportunity to check the gliding of tendons, tension of the repair, and any gap formation. Subsequently, the repair can be tailored according to the intraoperative active movement [1,7,9-12].

Despite the reported better outcomes with the above-mentioned developments, the surgical trends,

Author affiliations : *[1]Department of Orthopedics and Traumatology, University of Health Sciences, Diskapi Yıldırım Beyazıt Training and Research Hospital, Ankara, Turkey [2]Department of Physiotherapy and Rehabilitation, Gazi University, Faculty of Health Sciences, Ankara, Turkey*
Correspondence : *Yakup Kuzucu, MD, Department of Orthopedics and Traumatology, University of Health Sciences, Diskapi Yıldırım Beyazıt Training and Research Hospital, Ankara, Turkey. e-mail: drykuzucu@gmail.com*
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anesthesia types, and rehabilitation methods vary for flexor tendon injury management [13]. In a recent review, Tang JB speculated that not all surgeons actually follow all the rather rapidly updated details of surgical guidelines [14].

The hypothesis of this study was that repair with strong core sutures, judicious venting of critical pulleys, intraoperative active movement testing with WALANT, and early active mobilization would result in encouraging outcomes in flexor tendon zone 1 and 2 injuries.

Patients and Method

Study inclusion criteria were defined as 1) patient acceptance of inclusion in the study, 2) zone 1-2 flexor tendon tears, and 3) full compliance of the patient with the postoperative rehabilitation process. Patients were excluded from the study if they 1) had any condition which constituted a contraindication for WALANT (infection, peripheral vascular disease), 2) did not comply with the postoperative rehabilitation process, 3) had a concomitant bony injury (phalanx-metacarpal fracture), 4) the mechanism of the tissue defect injury was a firearm or crush injury.

A total of 23 fingers of 19 consecutive patients met the study criteria, of which two patients were excluded; one did not attend follow-up examinations and one developed infection in the postoperative period. Of the 21 tendons included for analysis, zone 2 injuries were determined in 17 and zone 1 injuries in four. Flexor pollicis longus (FPL) repair was applied to one and flexor digitorum profundus (FDP) repair to 20. WALANT was applied to all the patients that were operated on.

For WALANT we mixed 1% lidocaine and 1:100,000 epinephrine and 1 ml 8,4% sodium bicarbonate per 10 mg to buffer the acidic effect of lidocaine. If 0.5 mg/1 ml epinephrine is to be used, 50 ml solution should contain 25 ml lidocain %2 + 5 ml %8.4 sodium bicarbonate and should be completed to 50 ml. with 19 ml %0,9 isotonic sodium chloride. Maximum dose is 7 mg/kg. In a patient weighing 70 kg, dose cannot be over 490 mg or 49 mL. In order to prevent necrosis, which may occur with epinephrine, fentolamin was kept ready. Injured extremity was stabilized and patients were prepared for operation after waiting for almost 25-30 minutes to obtain satisfactory homeostatic effect [15,16].

Local anesthesia was injected subcutaneously at the base and middle of the phalanges in the finger. 2 ml was injected into the proximal and middle phalanges. 1 ml was injected into the distal phalanx. In the palmar region, 10-15 ml was injected into the places where dissection is possible. 5-10 ml is given starting from the most proximal area that is likely to be dissected. After injection into the proximal part, it is ensured that the distal parts are blocked by waiting for a few minutes. In order not to increase the compartment pressure in the phalanges, no more than 2 ml is injected per phalanx [11].

For the central suture in the tendon repair, the four-strand core suture technique (cruciate) using 3-0 ethibond was applied. For the epitendinous suture, the locking continuous suture technique with 6-0 prolene was applied. In eight fingers, digital nerve injury was present to which primary repair was performed.

Intraoperatively, the patients were requested to make a full flexion and extension. During the full joint range of movement, the formation of gaps and entrapment of the tendons in the pulleys were assessed (Figure 1). When there was entrapment of the tendons in the pulleys, venting of the pulley was applied.

All the patients were discharged after four to six hours of post-operative circulation monitoring. No patient required hospitalization and no circulation problems developed in any patient.

Post-operative therapy and assessments

Post-operative treatment was performed by a hand therapist according to early active motion principles. Hand therapy was planned with weekly sessions based on the Saint-John protocol. The patients wore a static splint with a dorsal block throughout 24 hours every day for the first four weeks, then night splinting was



Figure 1. Intraoperative active examination following tendon repair.

Table 1. The ASSH TAM evaluation scale.

Grade of MOTION ACHIEVED	FINAL % of NORMAL TAM ACHIEVED
EXCELLENT	No difference between TAM and normal
GOOD	TAM > 75% of normal
FAIR	TAM > 50% of normal
POOR	TAM > 50% of normal

continued in the subsequent two weeks. The wrist was in neutral position, metacarpophalangeal joints were in 40°-50° flexion, and interphalangeal joints were in full extension. Patients were educated about the post-operative follow-up (e.g., elevation and splint use).

The first therapy session was planned on postoperative day three, and composite passive flexion exercises were started after the intensely acute inflammatory phase. Each session started with passive exercises to decrease the flexion work due to swelling in the first 2-3 weeks. Active flexion exercises started with composite (all fingers) DIP flexion after the first week and progressed to full fist in the consecutive weeks. Active composite full flexion was targeted at the end of the 4th week. Starting in the 6th week, patients were instructed to do isolated DIP and PIP flexion exercises in the injured fingers. Scar massage was also applied to patients with excessive scarring. Isolated single finger blocking exercises were started after six weeks. Light daily life activities such as using a mobile phone and computer, eating, and drinking were also allowed after four weeks. The splint was completely removed after six weeks.

Patients were assessed at the end of four, eight, and 12 weeks post-operatively. Functional assessments included range of motion and disability level evaluations. The range of motion in the metacarpophalangeal and interphalangeal joints of the injured fingers was measured using a finger goniometer. The total active motion (TAM) score was calculated for each injured finger and the DASH questionnaire was used to determine the disability level at each assessment. The injured fingers were scored using the TAM scoring system of the American Society for Surgery of the Hand (Table 1) [17]. The time of return to work was also recorded.

In the functional evaluation, the range of movement of each joint of the injured finger was measured with a finger goniometer, and the functional healing percentage of each finger was evaluated with the Strickland formula[18]. At the final evaluation at 12 weeks, the patients were classified using the Strickland values of 75-100 as very good, 50-74 as good, 25-49 as fair, and 0-24 as poor. The disability level of the patients was evaluated with the DASH – Turkish version questionnaire[19]. The time from the operation day to return to work was calculated.

Statistical methods

Data obtained in the study were analyzed statistically using SPSS for Windows v. 20.0 software (Statistical Package for the Social Sciences). Descriptive statistics of the patients (e.g., age) were analyzed according to the number of patients (n:17), and data related to the fingers (e.g., Strickland score) were analyzed according to the number of fingers (n:21). Numerical var-

iables were stated as mean / standard deviation (SD), minimum-maximum values, and categorical variables as number (n) and percentage (%). Conformity of the data to a normal distribution was assessed with the Kolmogorov-Smirnov and the Shapiro-Wilk tests. Differences between two dependent groups of numerical data showing a normal distribution were analyzed with the Paired Samples t-test and those not showing a normal distribution were analyzed with the Wilcoxon test. Data were examined at a 95% confidence interval. A value of $p<0.05$ was accepted as statistically significant.

Results

An evaluation of a total of 21 fingers from 17 patients was made. The patients were comprised of 11 males and six females with a mean age of 30(SD 7.9) years (range, 16-41 years). The time from injury to surgery was calculated as a mean of 14.4(SD 11.7) days (range, 3-40 days) (Table 2). In the 21 fingers, the injury was in zone 2 in 17 of them and in zone 1 in four of the fingers. Digital nerve injury was present in eight fingers. Vascular injury was not observed in any patient. Primary repair was applied to all the tendons. In the intraoperative active movement examination, as the repair area of the tendon was entrapped below the pulley and insufficient tendon sliding was observed, venting was applied to 13 A4, four A3, two A2, and one A5 pulley. In two patients determined to have bowstringing during the active motion examination, pulley reconstruction was performed. In one finger (4.7%) that developed joint stiffness during follow-up, tenolysis was applied. Rupture was not observed in any patient. The mean time of return to work was 49.4(SD 13.6) days (range, 40-90 days). None of the patients had finger necrosis or circulation problems.

A significant increase was observed in the Strickland and DASH score evaluations at six, eight, and 12 weeks. The Strickland value was determined to be 64.1(SD 15.9) at six weeks, 65.1(SD 21.8) at eight weeks, and 84.7(SD 14.6) at 12 weeks. A statistically significant increase was determined in the scores between six and 12 weeks ($p=0.001$), and between eight and 12 weeks ($p=0.001$). The difference in the score between six and eight weeks was not statistically significant ($p=0.807$) (Table 3).

Table 2. Descriptive statistics (Numerical Data).

		Mean / Standard deviation (Minimum-Maximum)
Age(years)*		30.0 (SD 7.9)(16-41)
Time from injury to surgery (days)*		14.4 (SD 11.7) (3-40)
Time of return to work (days)*		49.4 (SD 13.6) (40-90)
Total active motion**		253.0 (SD 16.5) (225-270)
Strickland**	6 weeks	64.1 (SD 15.9) (22.9-85.7)
	8 weeks	65.1 (SD 21.8) (14.3-100)
	12 weeks	84.7 (SD 14.6) (57.14-100)
DASH score*	6 weeks	23.2 (SD 13.6) (3.3-43.3)
	8 weeks	14.8 (SD 8.5) (0.8-35.8)
	12 weeks	6.3 (SD 8.3) (0.8-34.2)

* calculated for 17 patients, ** calculated for 20 fingers

According to the Strickland values of the functional healing results at the final 12-week evaluation, with the exception of one FPL repair, the functional healing results of 20 fingers were evaluated as 15 (75%) being very good and five (25%) as good. The DASH scores were determined as 23.2(SD 13.6) at six weeks, 14.8(SD 8.5) at eight weeks, and 6.3(SD 8.3) at 12 weeks. The changes were observed to be statistically significant between six and eight weeks ($p=0.001$), between eight and 12 weeks ($p=0.001$), and between six and 12 weeks ($p=0.001$). The time of the return to work of the patients was calculated as a mean of 49.4(SD 13.6) days (range, 40-90 days).

The mean TAM value of the patients in the final follow-up evaluation at 12 weeks was determined to be 253.00(SD 16.50) (range, 225-270). The TAM values were classified according to the American Society for Surgery of the Hand (ASSH) evaluation scale by comparison with the healthy side, and with the exception of one FPL repair, the TAM classification of 20 fingers was seven (14%) ans excellent and 13 (86%) as good.

Table 3. Comparison of the Strickland and DASH scores at six, eight, and 12 weeks.

	Mean/Standard Deviation			p values		
	6 weeks	8 weeks	12 weeks	6-8	8-12	6-12
Strickland	64.1 (SD 15.9)	65.1 (SD 21.8)	84.7 (SD 14.6)	0.8	0.001*	0.001*
DASH	23.2 (SD 13.6)	14.8 (SD 8.5)	6.3 (SD 8.3)	0.001*	0.001*	0.001*

* p<0.05 statistically significant.

Conclusion

The results of this study demonstrated that flexor tendon repairs with strong core sutures, judicious venting of critical pulleys, intraoperative active movement testing with WALANT, and an early active mobilization protocol resulted in encouraging outcomes in flexor tendon zone 1 and 2 injuries. In previous similar studies where zone 2 tendon repair and a post-operative early active mobilization protocol have been applied, the re-rupture rates have been reported to vary between 2% and 17%. Peck et al. used a two-strand core suture and reported re-rupture at the rate of 17% [20]. Hung et al. reported re-rupture at 8% in repairs made with a two-strand core suture[21]. Al-Qattan et al. applied repair with a six-strand core suture and the re-rupture rate was observed at 2% [22]. Sandow et al. re-rupture occurred at 5% [23] and Moriya et al. a six-strand core suture was applied with a re-rupture rate of 3.9% [6].

The development of re-rupture following tendon repair is related to the surgical technique and the physical therapy protocol applied postoperatively. The mechanical resistance strength of the repair area is important. As seen from the examples in similar studies, as the core suture increases from two-strand to six-strand, the re-rupture rate decreases. A suture with more strands means a more resistant repair area, providing security for early active mobilization. In the current study, the four-strand core suture technique was used and an early active mobilization protocol was applied for post-operative rehabilitation. Re-rupture was not observed in any patient (0%). The most important factor in re-rupture not occurring can be considered to be the patient making active movements after completion of the tendon repair procedure during the operation. This ensured sufficient tendon tension without a gap in the repair area and started early active mobilization in the post-operative period by trusting the repair's tested strength. In addition, swelling of the tendon repair area following intraoperative active movement examination, as insufficient tendon sliding of the tendon was observed because of entrapment below the pulley, pulley venting was applied. Recent studies have emphasized that pulley venting is as important as a strong core suture in starting early active mobilization [8,24-26]. Just as a strong core suture is a precondition for early active mobilization, pulley venting applied when necessary is important for the continuation of repair strength.

DASH scoring is a questionnaire often applied after upper extremity injuries for the evaluation of the disability and functional status of the patient. In studies by Klein [27] and Libberecht et al. [28], DASH scoring was used to evaluate disability and functional status. The mean scores were reported as 10.23 and 8.5, respectively. In the current study, the mean DASH score at 12 weeks post-operatively was found to be 6.3, which was a better result than in previous similar studies. The reason for this was thought to be the application of up-to-date developments. In terms of the current study's approach, the differences from other studies were that a strong slightly swollen repair was made with four strands, the strength of the repair and comfortable movement of the tendon were tested in-

traoperatively with WALANT, any problems such as gap formation or entrapment below the pulley determined during the operation were resolved, and rehabilitation with early active mobilization was preferred. In addition, teamwork was ensured and patients were followed up with closely. Synergy of the surgeon and therapist is important in this respect, and the need for close follow-up of the patients by the hand therapist should be emphasized.

The quality of tendon healing was evaluated using the Strickland formula, measuring the active movements of the injured finger. These two questionnaires have been used in similar studies of tendon injuries. In a study by Libberecht et al., the results were 54% as very good and 29% as good [28]. In a study by Klein, the zone 2 functional results were reported as 53% being very good, 42% as good, and the zone 1 results were 29% as very good and 43% as good [27]. Functional results were stated to be 56% as very good and 26% as good in a study 2018, Giesen et al. reported results of 67% as very good and 22% as good[3]. In the current study, with the exclusion of one FPL, the results of the final follow-up Strickland evaluation of 20 tendons were 75% as very good and 25% as good. No fair or poor results were seen in the evaluation of any patient. Compared to previous studies, better results were obtained in the current series. This was attributed to the safe initiation of early active mobilization as a result of sufficient intraoperative control of the strength of the tendon repair.

In the final follow-up examination at the end of 12 weeks, the TAM values were calculated and the tendon repair and functional outcome success were examined evaluated according to the ASSH classification. With this method of evaluation of the tendon repair outcome, reported results of 11% as excellent and 57% as good[28]. In similar studies, the mean TAM value was reported as 230° [6] and as 219° [3]. In the current study, the mean TAM value was determined to be 253°. With the exclusion of one FPL repair, the results of 20 fingers in the TAM classification according to AASH were 14% as excellent and 86% as good. No patients were classified as fair or poor. The results of the current study were seen to be better than those of previous studies, which was attributed to the application of the WALANT method enabling intraoperative checking of the tendon repair, sufficient tendon sliding, and the physiotherapy being regularly monitored by a single experienced physiotherapist.

Before the 90s, it was believed that the use of epinephrine could cause finger necrosis. Last two decade, large series reporting the safe injection of finger epinephrine have been published in which phentolamine rescue has never been necessary [29-31].

There were some limitations to this study, primarily the relatively low number of patients. The main reason for this was the inclusion of only patients with injuries in a specific region of the flexor tendon. However, that there was no re-rupture in the early post-operative period and the time of the return to work was a mean of 49 days with the start of early active movement, suggests that the results of the utilized method were sufficient. Other limitations of the study were the lack of long-term results and a control group for comparison of tendon injury repairs in similar regions under general or regional anesthesia (RIVA, block).

As no motor block is created in WALANT, it allows intraoperative active movement. With the implementation of intraoperative active movement, the problems of tension in the tendon repair, the presence of a gap, tendon sliding, and the need for pulley venting or pulley reconstruction can be resolved. When the surgeon is sure of the repair, early active mobilization can be started with a clear mind. Although the WALANT method includes the important advantage of intraoperative active movement after flexor tendon repairs, there is a need for prospective studies comparing flexor tendon repair results with different anesthesia techniques.

Conflict of interest statement

The authors have no conflicts of interest to declare.

References

1. Tang JB. Flexor Tendon Injuries. Clin Plast Surg 2019;46:295-306.
2. Tang JB, Zhou X, Pan ZJ, Qing J, Gong KT, Chen J. Strong Digital Flexor Tendon Repair, Extension-Flexion Test, and Early Active Flexion: Experience in 300 Tendons. Hand Clin 2017;33: 455-63.
3. Giesen T, Reissner L, Besmens I, Politikou O, Calcagni M. Flexor tendon repair in the hand with the M-Tang technique (without peripheral sutures), pulley division, and early active motion. J Hand Surg Eur 2018;43:474-9.
4. Zhou X, Li XR, Qing J, Jia XF, Chen J. Outcomes of the six-strand M-Tang repair for zone 2 primary flexor tendon repair in 54 fingers. J Hand Surg Eur 2017;42:462-8.
5. Pan ZJ, Xu YF, Pan L, Chen J. Zone 2 flexor tendon repairs using a tensioned strong core suture, sparse peripheral stitches and early active motion: results in 60 fingers. J Hand Surg Eur 2019;44:361-6.
6. Moriya K, Yoshizu T, Tsubokawa N, Narisawa H, Matsuzawa S, Maki Y. Outcomes of flexor tendon repairs in zone 2 subzones with early active mobilization. J Hand Surg Eur 2017;42:896-902.
7. Tang JB. New developments are improving flexor tendon repair. Plast Reconstr Surg 2018;141: 1427-37.
8. Tang JB. Release of the A4 pulley to facilitate zone II flexor tendon repair. J Hand Surg Am 2014;39:2300-7.
9. Lalonde D, Higgins A. Wide Awake Flexor Tendon Repair in the Finger. Plast Reconstr Surg Glob Open 2016;4:e797.
10. Lalonde D. Wide-awake flexor tendon repair. Plast Reconstr Surg 2009;123:623-5.
11. Lalonde DH, Martin AL. Wide-awake flexor tendon repair and early tendon mobilization in zones 1 and 2. Hand Clin 2013;29:207-13.
12. Khor WS, Langer MF, Wong R, Zhou R, Peck F, Wong JK. Improving Outcomes in Tendon Repair: A Critical Look at the Evidence for Flexor Tendon Repair and Rehabilitation. Plast Reconstr Surg 2016;138:1045e-58e.
13. Unsal SS, Yildirim T, Armangil M. Comparison of surgical trends in zone 2 flexor tendon repair between Turkish and international surgeons. Acta Orthop Traumatol Turc 2019;53:474-7.
14. Tang JB. Recent evolutions in flexor tendon repairs and rehabilitation. J Hand Surg Eur Vol 2018;43:469-73.
15. Lalonde DH, Wong A. Dosage of local anesthesia in wide awake hand surgery. J Hand Surg Am 2013;38:2025–8.
16. Ayhan E, Ozdemir E, Gumusoglu E, Cevik K, Eskandari MM. The rise of wide awake hand surgery - Contribution from Turkey. Hand Microsurg 2018;7:125-34.
17. Kleinert HE, Verdan C. Report of the Committee on Tendon Injuries (International Federation of Societies for Surgery of the Hand). J Hand Surg Am 1983;8:794–8.
18. Strickland JW. Results of flexor tendon surgery in zone II. Hand Clin 1985;1:167–9.
19. Düger T, Yakut E, Öksüz Ç, Yörükan S, Bilgütay BS, Ayhan Ç, et al. [Kol, Omuz ve El sorunları (Disabilities of the Arm,Shoulder and Hand - DASH) Anketi Türkçe uyarlamasının güvenirliği ve geçerliği][Article in Turkish]. Türk Fiz ve Rehabil Derg 2006;17:99-107.
20. Peck FH, Kennedy SM, Watson JS, Lees VC. An evaluation of the influence of practitioner-led hand clinics on rupture rates following primary tendon repair in the hand. J Plast Surg Br 2004;57:45–9.
21. Hung LK, Pang KW, Yeung PL, Cheung L, Wong JM, Chan P. Active mobilisation after flexor tendon repair: comparison of results following injuries in zone 2 and other zones. J Orthop Surg (Hong Kong)2005;13:158-63.
22. Al-Qattan MM, Al-Turaiki TM. Flexor tendon repair in zone 2 using a six-strand "figure of eight"

suture. J Hand Surg Eur 2009;34:322–8.
23. Sandow MJ, McMahon M. Active mobilisation following single cross grasp four-strand flexor tenorrhaphy (Adelaide repair). J Hand Surg Eur 2011;36:467–75.
24. Tang JB. Tendon surgery of the hand. Elsevier Saunders, Philadelphia, 2012:88–97.
25. Elliot D. Tendon surgery of the hand. Elsevier Saunders, Philadelphia, 2012:125–32.
26. Elliot D. Tendon surgery of the hand. Elsevier Saunders, Philadelphia 2012:98–103.
27. Klein L. Early active motion flexor tendon protocol using one splint. J Hand Ther 2003;16:199-206.
28. Libberecht K, Lafaire C, Van Hee R. Evaluation and functional assessment of flexor tendon repair in the hand. Acta Chir Belg 2006;106:560–5.
29. Lalonde D, Bell M, Benoit P, Sparkes G, Denkler K, Chang P. A multicenter prospective study of 3,110 consecutive cases of elective epinephrine use in the fingers and hand: the Dalhousie Project clinical phase. J Hand Surg Am 2005;30:1061–7.
30. Chowdhry S, Seidenstricker L, Cooney DS, Hazani R, Wilhelmi BJ. Do not use epinephrine in digital blocks: myth or truth? Part II. A retrospective review of 1111 cases. Plast Reconstr Surg 2010;126:2031–4.
31. Fitzcharles-Bowe C, Denkler K, Lalonde D. Finger injection with high-dose (1:1000) epinephrine: does it cause finger necrosis and should it be treated? Hand 2007;2:5–11.

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