



Results of Flexor Digitorum Profundus Repair Alone in Rupture of Both Flexor Tendons in Zone II: A Case Series

Mohammad Ali Okhovatpour¹, Mohammadreza Minator Sajjadi¹, Mehran Razavipour¹, Mehrdad Sadighi¹, Reza Zandi¹, Adel Ebrahimpour^{1,*} and Ramin Asgharinejad¹

¹Taleghani Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran

*Corresponding author: Associate Professor of Orthopedics, Taleghani Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran. Email: adel.ebrahimpour@yahoo.com

Received 2018 October 27; Accepted 2018 November 17.

Abstract

Background: Flexor tendon damage makes up a small number of total hand injuries; but management of these injuries often poses a surgical challenge because the results remain unpredictable despite all efforts. The results of flexor tendon repair damage of both deep and superficial injuries, especially in zone II, despite using various methods, still remains poor.

Objectives: This study aimed to assess results of flexor digitorum profundus (FDP) repair with resection of flexor digitorum superficialis (FDS) stump in a setting where both tendons are transected. Lack of human studies for FDP repair alone makes the decision difficult.

Methods: Files of patients, who were referred to the research hospitals with flexor tendon rupture between April 2014 and April 2016 were studied. Patients, who had recent concurrent FDP and FDS rupture in zone II were included. After six months, range of motion (ROM), pinch strength, and disabilities of the arm, shoulder and hand (DASH) score were measured.

Results: Twenty patients were studied; three were excluded due to missing follow-ups. Seventeen patients remained in the study. Thirteen were males and four were females. Ages were between 17 and 55, with mean age of 23.7 years old. According to the DASH score, 13 patients were placed in mild disability group (score one to seven) and four patients showed no disability (score zero).

Conclusions: The results suggest the outcomes of FDP repair alone in zone II is comparable to repairing both tendons.

Keywords: Digits, Flexor Tendon, Tendon Injury, Tendon Repair, Rehabilitation

1. Background

Transection of flexor tendon accounts for less than 1% of hand injuries (1). Terminology of “no man’s land” was first described by Sterling Bunnell to explain zone II flexor injuries in 1948. “No man’s land” is a location outside London used for executions. The mentioned phrase clearly indicates poor treatment outcome even in early repair (2).

One or two slip of flexor digitorum superficialis (FDS) and flexor digitorum profundus (FDP) simultaneous repair is the method of choice among hand surgeons in management of both flexor tendon injuries (3-5). Due to fibroosseous structure of this area, surgical treatment of zone II injuries is often followed by disappointing results (6). Most important complications following zone II tendon repair are re-rupture and joint stiffness (7).

Some animal studies have recently concluded that repair of FDP alone improves both gliding and adhesion formation compared to the current method (8, 9). Despite these results, tendon re-rupture is the major concern for

this repair technique (5, 6, 10). In the literature review a few relevant clinical human studies were found. Due to the lack of clinical human studies, FDP repair alone in setting of zone II both tendon transactions is controversial.

2. Objectives

This study aimed at evaluating results of FDP repair with resection of FDS stump in the setting of both tendon transactions.

3. Methods

The current study was performed in line with the PRO-CESS criteria. Patients with single finger (except thumb) flexor tendon injury in zone II, all with penetrating trauma between April 2014 and April 2016 in our hospitals, were investigated. Patients with recent FDP and FDS rupture were included. The exclusion criteria were crushed hand injury,

bone damages, nerve injuries, and age above 60 or below 12 years old. Patients with history of previous surgery on the same finger and also patients with underlying diseases that affect the hand, such as diabetes mellitus and rheumatoid arthritis, were excluded. All subjects were operated within 10 days of injury.

3.1. Technique

The Bruner’s zigzag incision was employed to expose injured tendons. The FDS proximal stump was resected (at least 3 cm) then FDP was repaired with four strand cruciate technique by use of 3/0 round prolene thread. Suture lines were reinforced by circumferential epitendon simple running technique using the round 6/0 prolene thread.

3.2. Rehabilitation

The post operation period was started with controlled passive motion program with use of dorsal splint (11). Wrist and MP joints were flexed in 30 and 70 degrees, respectively, and interphalangeal joints placed in neutral position within the first three weeks (11). Rehabilitation phase started with passive motion of DIP and PIP joints after the old splint was discontinued and a removable splint was applied after five weeks to prevent hyperextension. Finally, after achievement of full healing, active full range of motion was allowed.

3.3. Follow Up

Following the surgery, all patients were visited weekly during the first three weeks and also in the fifth week, and second, fourth, and sixth month.

After six months range of motion (ROM), pinch strength and disabilities of the arm, shoulder, and hand (DASH) score was measured (12). Range of motion was evaluated by the total active motion (TAM) system recommended by the American Society for Surgery of the Hand (ASSH) (Table 1).

Table 1. TAM Evaluation System for ASSH^a

Score	Percentage
Excellent	Normal
Good	> 75
Fair	50 - 75
Poor	< 50
Worse	< pre-op

Abbreviations: ASSH, American Society for Surgery of the Hand; TAM, total active motion.

^aTAM = total active flexion - total extension deficit (metacarpo-phalangeal joint, inter-phalangeal joints), % = TAM of the injured finger/TAM of contra lateral finger.

Tip pinch strength was measured using a Saehan Hydraulic Hand Evaluation kit by measuring the strength between the pulp of involved finger and the pulp of thumb.

3.4. Ethics

All patients participating in the study signed a consent letter and advantages and disadvantages of this surgical technique were described before the surgery.

3.5. Statistical Analysis

The SPSS 22 statistical program was used.

4. Results

Twenty patients were studied yet three patients were excluded due to missing follow-ups. Seventeen patients remained in the study. Thirteen were males and four were females. Ages were between 17 and 55, with mean age of 23.7 years. Seven patients had dominant hand injury and for the rest, the non-dominant hand was involved.

The TAM results in 17 fingers with FDS excision and FDP repair is shown in Table 2.

Table 2. TAM Results in 17 Patients After Six Months

TAM Result	No. (%)
Excellent	3 (18)
Good	13 (76)
Fair	1 (6)
Poor	-

Abbreviation: TAM, total active motion.

The average tip pinch strength as a percentage of the contra lateral finger was 79%, measured by Saehan Hydraulic Hand Evaluation kit.

According to the DASH score, 13 patients were placed in the mild disability group (score one to seven) and four patients showed no disability (score zero) (Table 3).

Table 3. DASH Score Results After Six Months

Disability	Score	No. (%)
Sever	15 - 21	0 (0)
Moderate	8 - 14	0 (0)
Mild	1 - 7	13 (76)
None	0	4 (24)

Abbreviation: DASH, disabilities of the arm, shoulder and hand.

There was no progress to swan neck deformities and rupture in any of participating patients.

5. Discussion

There is a long history in treatment of zone II flexor tendon transection, which was started by Bunnell's "no man's land" that was challenged by Verdan, who made it "some man's land" by publishing early repair results (13).

Repair of both FDS and FDP tendons is the best way to improve functional and clinical results (11, 14).

Repair of both tendons helps FDP tendon to glide smoothly through tendon sheath and provides adequate blood supply for tendon healing (15). Complications, such as adhesion formation and re-rupture, can be limited with meticulous exposure, repair of the sheath, and atraumatic tendon stitching (16, 17).

Despite these progresses in surgical techniques, repair or resect of FDS in both tendon tear is still controversial (18).

Lister et al. reported that 75% of patients with both tendon repairs in no man's land attained excellent or good results according to the TAM system, while those with FDS excision showed only 42.9% excellent or good results (19).

In a study coordinated by Nielsen and Jensen better results with both tendons repair versus isolated FDP repair with resection of FDS were achieved (20).

Tsuge et al. excised the FDS when it was damaged completely, giving excellent or good results in 24 out of 34 patients, using the White's criteria (21).

In another study designed by Tang et al. comparing both tendons repair and FDP isolated repair in zone II, results were not significantly different (22).

In the study of 17 fingers with FDS excision, TAM results were excellent in three fingers (18%), good in 13 fingers (76%), and fair in one finger (6%). Tip pinch strength and DASH score is comparable to previous studies with both tendons repair technique. Denize et al. reported that when both tendons are repaired, TAM is excellent in 4%, good in 68%, fair in 23%, and poor in 5% of patients. Tip pinch strength improved by 76% compared to the uninjured hand. The DASH score was reported as 76% mild disability and 24% no disability, similar to the current study (23).

It seems that in addition to motion, tip pinch is also an important factor in hand function that researchers have paid less attention to. According to acceptable outcomes in treatment of both tendon rupture in zone II with FDP alone repair, it seems that further studies should focus on designing randomized clinical trials (RCT) to compare results of these two techniques and clarify the controversy.

5.1. Conclusions

The current results suggest that FDP alone repair technique in zone II is comparable with both tendons repair

method in benefits and complications, yet further studies, such as RCTs on patients, are needed to determine the superior surgical technique.

Footnotes

Conflict of Interests: It is not declared by the author.

Ethical Considerations: Code: IR.SBMU.RETECH.REC.1396.506.

Funding/Support: It is not declared by the author.

Patient Consent: All patients participating in the study signed a consent letter and advantages and disadvantages of this surgical technique were described before the surgery.

References

- Hill C, Riaz M, Mozzam A, Brennen MD. A regional audit of hand and wrist injuries. A study of 4873 injuries. *J Hand Surg Br.* 1998;23(2):196-200. doi: [10.1016/S0266-7681\(98\)80174-5](https://doi.org/10.1016/S0266-7681(98)80174-5). [PubMed: 9607659].
- Brand PW. Paralytic claw hand; with special reference to paralysis in leprosy and treatment by the sublimis transfer of Stiles and Bunnell. *J Bone Joint Surg Br.* 1958;40-B(4):618-32. doi: [10.1302/0301-620X.40B4.618](https://doi.org/10.1302/0301-620X.40B4.618). [PubMed: 13610974].
- Kleinert HE, Schepel S, Gill T. Flexor tendon injuries. *Surg Clin North Am.* 1981;61(2):267-86. doi: [10.1016/S0039-6109\(16\)42381-9](https://doi.org/10.1016/S0039-6109(16)42381-9). [PubMed: 723323].
- Kleinert HE. Report of the committee on tendon injuries. *J Hand Surg Am.* 1989;14(2 Pt 2):3816. doi: [10.1016/S0363-5023\(83\)80275-5](https://doi.org/10.1016/S0363-5023(83)80275-5). [PubMed: 2659655].
- Kotwal PP, Ansari MT. Zone 2 flexor tendon injuries: Venturing into the no man's land. *Indian J Orthop.* 2012;46(6):608-15. doi: [10.4103/0019-5413.104183](https://doi.org/10.4103/0019-5413.104183). [PubMed: 23325961]. [PubMed Central: PMC3543876].
- Paillard PJ, Amadio PC, Zhao C, Zobitz ME, An KN. Pulley plasty versus resection of one slip of the flexor digitorum superficialis after repair of both flexor tendons in zone II: A biomechanical study. *J Bone Joint Surg Am.* 2002;84-A(11):2039-45. doi: [10.2106/00004623-200211000-00020](https://doi.org/10.2106/00004623-200211000-00020). [PubMed: 12429767].
- Pike JM, Gelberman RH. Zone II combined flexor digitorum superficialis and flexor digitorum profundus repair distal to the A2 pulley. *J Hand Surg Am.* 2010;35(9):1523-7. doi: [10.1016/j.jhsa.2010.06.024](https://doi.org/10.1016/j.jhsa.2010.06.024). [PubMed: 20807631]. [PubMed Central: PMC2935297].
- Xu Y, Tang JB. Effects of superficialis tendon repairs on lacerated profundus tendons within or proximal to the A2 pulley: An in vivo study in chickens. *J Hand Surg Am.* 2003;28(6):994-1001. doi: [10.1016/S0363-5023\(03\)00428-3](https://doi.org/10.1016/S0363-5023(03)00428-3). [PubMed: 14642516].
- Tang JB, Xie RG, Cao Y, Ke ZS, Xu Y. A2 pulley incision or one slip of the superficialis improves flexor tendon repairs. *Clin Orthop Relat Res.* 2007;456:121-7. doi: [10.1097/01.blo.0000246564.96208.b0](https://doi.org/10.1097/01.blo.0000246564.96208.b0). [PubMed: 17065841].
- Zhao C, Amadio PC, Zobitz ME, An KN. Resection of the flexor digitorum superficialis reduces gliding resistance after zone II flexor digitorum profundus repair in vitro. *J Hand Surg Am.* 2002;27(2):316-21. doi: [10.1053/jhsu.2002.31729](https://doi.org/10.1053/jhsu.2002.31729). [PubMed: 11901391].
- Strickland JW. Development of flexor tendon surgery: Twenty-five years of progress. *J Hand Surg Am.* 2000;25(2):214-35. doi: [10.1053/jhsu.2000.jhsu25a0214](https://doi.org/10.1053/jhsu.2000.jhsu25a0214). [PubMed: 10722813].

12. Hudak PL, Amadio PC, Bombardier C. Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand) [corrected]. The Upper Extremity Collaborative Group (UECG). *Am J Ind Med*. 1996;**29**(6):602-8. doi: [10.1002/\(SICI\)1097-0274\(199606\)29:6<602::AID-AJIM4>3.0.CO;2-L](https://doi.org/10.1002/(SICI)1097-0274(199606)29:6<602::AID-AJIM4>3.0.CO;2-L). [PubMed: [8773720](https://pubmed.ncbi.nlm.nih.gov/8773720/)].
13. Kleinert HE, Spokevicius S, Papas NH. History of flexor tendon repair. *J Hand Surg Am*. 1995;**20**(3 Pt 2):S46-52. doi: [10.1016/S0363-5023\(95\)80169-3](https://doi.org/10.1016/S0363-5023(95)80169-3). [PubMed: [7642949](https://pubmed.ncbi.nlm.nih.gov/7642949/)].
14. Libberecht K, Lafaire C, Van Hee R. Evaluation and functional assessment of flexor tendon repair in the hand. *Acta Chir Belg*. 2006;**106**(5):560-5. doi: [10.1080/00015458.2006.11679952](https://doi.org/10.1080/00015458.2006.11679952). [PubMed: [17168270](https://pubmed.ncbi.nlm.nih.gov/17168270/)].
15. Tang JB. Flexor tendon repair in zone 2C. *J Hand Surg Br*. 1994;**19**(1):72-5. doi: [10.1016/0266-7681\(94\)90054-X](https://doi.org/10.1016/0266-7681(94)90054-X). [PubMed: [8169485](https://pubmed.ncbi.nlm.nih.gov/8169485/)].
16. Bunnell S. *Surgery of the hand*. Philadelphia: JB Lippincott; 1956. p. 86-98.
17. Dy CJ, Hernandez-Soria A, Ma Y, Roberts TR, Daluiski A. Complications after flexor tendon repair: A systematic review and meta-analysis. *J Hand Surg Am*. 2012;**37**(3):543-551. doi: [10.1016/j.jhsa.2011.11.006](https://doi.org/10.1016/j.jhsa.2011.11.006). [PubMed: [22317947](https://pubmed.ncbi.nlm.nih.gov/22317947/)].
18. Henry M. Zone II: Repair or resect the flexor digitorum superficialis? *J Hand Surg Am*. 2011;**36**(6):1073-4. quiz 1075. doi: [10.1016/j.jhsa.2011.02.015](https://doi.org/10.1016/j.jhsa.2011.02.015). [PubMed: [21514745](https://pubmed.ncbi.nlm.nih.gov/21514745/)].
19. Lister GD, Kleinert HE, Kutz JE, Atasoy E. Primary flexor tendon repair followed by immediate controlled mobilization. *J Hand Surg Am*. 1977;**2**(6):441-51. doi: [10.1016/S0363-5023\(77\)80025-7](https://doi.org/10.1016/S0363-5023(77)80025-7). [PubMed: [336675](https://pubmed.ncbi.nlm.nih.gov/336675/)].
20. Nielsen AB, Jensen PO. Primary flexor tendon repair in "no man's land". *J Hand Surg Br*. 1984;**9**(3):279-81. [PubMed: [6392457](https://pubmed.ncbi.nlm.nih.gov/6392457/)].
21. Tsuge K, Yoshikazu I, Matsuishi Y. Repair of flexor tendons by intratendinous tendon suture. *J Hand Surg Am*. 1977;**2**(6):436-40. doi: [10.1016/S0363-5023\(77\)80024-5](https://doi.org/10.1016/S0363-5023(77)80024-5). [PubMed: [336674](https://pubmed.ncbi.nlm.nih.gov/336674/)].
22. Tang JB, Xu Y, Chen F. Impact of flexor digitorum superficialis on gliding function of the flexor digitorum profundus according to regions in zone II. *J Hand Surg Am*. 2003;**28**(5):838-44. doi: [10.1016/S0363-5023\(03\)00300-9](https://doi.org/10.1016/S0363-5023(03)00300-9). [PubMed: [14507516](https://pubmed.ncbi.nlm.nih.gov/14507516/)].
23. Deniz E, Ayse K, Sehim K, Mehmet D, Aysun S, Süreyya E. Postoperative management of flexor tendon repair in zone 2. *J Phys Ther Sci*. 2000;**12**(1):63-6. doi: [10.1589/jpts.12.63](https://doi.org/10.1589/jpts.12.63).