

EARLY RESULTS OF PRIMARY REPAIR IN ZONE II FLEXOR DIGITORUM PROFUNDUS TENDON INJURIES OF THE HAND

*Truong Huu Hanh¹, Nguyen Thanh Tan¹, Pham Hoang Lai², Ngo Thai Hung³,
Tran Quang Son¹, Nguyen Tu Thai Bao¹, Phan Van Tuan¹,
Dao Tien Dat¹, Ho Truong Giang¹, Nguyen Huu Dat^{1*}*

1. Can Tho University of Medicine and Pharmacy

2. Hoa Hao – Medic Can Tho General Hospital

3. 108 Military Central Hospital

**Corresponding author: nhdat@ctump.edu.vn*

Received: 28/02/2025

Reviewed: 22/4/2025

Accepted: 25/6/2025

ABSTRACT

Background: Flexor tendon injuries in the hand are categorized into five zones, each requiring specific surgical repair techniques. Flexor digitorum profundus (FDP) tendon injuries in zone II of the hand present a significant challenge due to the complex anatomy and the risk of adhesion formation. Optimal management remains a subject of ongoing debate, with primary repair often favored for its potential to restore function. This study evaluates the early outcomes of primary repair for FDP tendon injuries in zone II. **Objectives:** To assess the early outcomes of primary flexor digitorum profundus tendon repair in zone II of the hand. **Materials and methods:** A prospective cross-sectional study was conducted on 32 patients (comprising 51 fingers) with zone II flexor digitorum profundus tendon injuries who underwent primary tendon repair at Can Tho Central General Hospital. **Results:** The results were observed in 32 patients (29 males, 3 females), with an average age of 31.31 ± 8.59 . Left-hand injuries accounted for the majority, representing 62.5%. There were 88.2% patients, with injuries affecting both the FDP and FDS (flexor digitorum superficialis) tendons. First phase surgical wound healing rate was 96.9%, tendon re-rupture rate was 6.3%, and there were no report of bleeding or suture exposure. Strickland criteria evaluation at 6 weeks showed 21.6% excellent, 49% good, 19.6% fair, and 9.8% poor outcomes. **Conclusion:** The surgical intervention and rehabilitation regimen for FDP tendon injuries in zone II are considered safe and produce a functionally acceptable outcome.

Keywords: hand injury, zone II, flexor digitorum profundus tendon, primary repair.

I. INTRODUCTION

Zone II flexor digitorum profundus (FDP) tendon injuries, often referred to as "no man's land," pose a significant clinical challenge. This difficulty arises from the region's complex anatomy, which spans from the distal palmar crease to the middle phalanx. The FDP tendon plays a critical role in hand function, particularly in facilitating distal interphalangeal (DIP) joint flexion-an essential movement for grasping and fine motor skills. Diagnosing and treating injuries in this area is complicated by the deep location of the structures and the restricted surgical field, making access particularly challenging. These injuries, commonly resulting from penetrating trauma such as lacerations, often lead to substantial functional impairment.

Primary repair remains the gold standard for treating Zone II FDP tendon injuries, with timely intervention being crucial for achieving the best outcomes. Despite advances in surgical techniques, the risk of complications-such as tendon adhesions, scarring, and restricted tendon

gliding-remains high due to the zone's anatomical complexities. Ongoing debates continue regarding the best approach for repairing flexor tendon injuries in this region [1].

This article demonstrated the outcomes of primary FDP tendon repairs in Zone II, with a focus on functional recovery and complication rates. By analyzing clinical data and evaluating the effectiveness of various surgical techniques, this study aims to enhance the current understanding of managing these complex injuries. The findings could provide valuable insights for refining surgical protocols and optimizing rehabilitation strategies, ultimately improving patient outcomes and restoring hand function more effectively.

II. MATERIALS AND METHODS

This study examined 32 patients with zone II FDP tendon injuries of the hand, who underwent surgery at Can Tho Central General Hospital from April 2023 to February 2025.

2.1. Materials

Inclusion criteria:

- Patients are at least 16 years old.
- Patients had flexor digitorum profundus (FDP) tendon injuries in Zone II of the hand.
- Patients who underwent primary tendon repair within 24 hours of injury.

Exclusion criteria:

- Patients with pre-existing paralysis or deformities in the affected hand.
- Patients had co-existing injuries: skin defects, extensor tendon injuries.
- Patients who have undergone previous tendon repairs in the affected hand or those with a history of tendon dysfunction due to prior surgeries.

2.2. Methods

- **Research design:** prospective cross-sectional study.
- **Sample size:** n = 32 patients.
- **Research content:**

Patient's general characteristics: gender, age, occupation.

Characteristics of injuries: causes, injury-surgery interval, affected hand, number of injured fingers, type of injured tendon.

Treatment outcomes: post-operative complications, range of motion recovery results at 6 weeks were assessed by the original Strickland criteria.

Surgical method: tendon repairs were performed within the first 24 hours post-injury. The FDP tendon was repaired using modified Kessler 4-strand core suture technique, reinforced by a continuous circumferential epitendon suture. The FDS tendon was not repaired.

Postoperative rehabilitation: Postoperatively, patients were immobilized with dorsal splint. All patients followed rehabilitation protocol that included active extension, passive flexion, and the technique of controlled passive extension and flexion.

Range of motion recovery results at 6 weeks was assessed by the original Strickland criteria [2]. PIP and DIP range of motion (ROM) = [(active flexion PIP + DIP) - (extension deficit PIP + DIP)] / 175° x 100%. Four categories were used to classify ROM: Poor (less than 90°), Fair (90°-124°), Good (125°-149°), and Excellent (greater than 150°). These categories correspond to less than 50%, 50-69%, 70-84%, and 85-100% of normal ROM, respectively. One hundred percent of the normal range of motion is achieved when the PIP joint attains 110° of flexion and 0° of extension, and the DIP joint attains 65° of flexion and 0° of extension, yielding a combined total flexion of 175° and total extension of 0°.

- **Data analysis:** The results are presented in mean \pm SD and percentages. Data was evaluated based on the descriptive statistics. Data was then put to statistical analysis using SPSS 26.0.

- **Ethics approval:** The Institutional Review Board at Can Tho University of Medicine and Pharmacy sanctioned the ethical approval for this study (Approval No. 23.129.HV-ĐHYDCT, dated March 20, 2023). The collected data is solely intended for research purposes. All information pertaining to research subjects will be maintained in strict confidentiality and anonymized.

III. RESULTS

3.1. Characteristics of patients

Table 1. Characteristics of patients

Characteristics		Percentage
Age		31.31 \pm 8.59 (18-46)
Gender	Male	29 (90.6%)
	Female	3 (9.4%)
Occupation	Intellectual	3 (9.4%)
	Worker	9 (28.1%)
	Farmer	12 (37.5%)
	Other	8 (25%)

In our study of 32 patients, number of patients were male 29 (90.6%) as compared to female 3 (9.4%). The male-to-female ratio was approximately 9.67:1. The age of the patients ranged from 18 years to 46 years with the average age being 31.31 \pm 8.59 years. The most prevalent occupation among the individuals in this dataset is farmer, with 37.5% representation.

3.2. Characteristics of injuries

Domestic accidents were the most prevalent cause, affecting 18 patients, which represented 56.3% of the total. Occupational accidents were the least frequent cause, with only 5 patients (15.6%). Violence still accounted for a substantial portion of cases, affecting 9 patients (28.1%).

Table 2. Injury - surgery interval

	Time	No. of Patients	Percentage
Injury - surgery interval	\leq 12 hrs	29	90.6%
	>12 hrs	3	9.4%

A significant majority of patients (29, or 90.6%) underwent surgery within 12 hours of their injury, with only a small fraction of patients (3, or 9.4%) undergoing surgery after 12 hours. The shortest time interval between injury and surgery was 3 hours, while the longest interval was 21 hours.

Table 3. Characteristics of affected hands and fingers

		No. of Patients	Percentage
Side of injury	Right hand	11	34.4%
	Left hand	20	62.5%
	Both hand	1	3.1%
Number of injured fingers	1	21	65.6%
	2	6	18.8%

		No. of Patients	Percentage
	3	3	9.4%
	4	1	3.1%
	5	1	3.1%

There were 26 right-handed patients, making up 81.3% of the total sample. Left-hand injuries predominated, affecting 62.5% of patients (20 individuals), while right-hand injuries accounted for 34.4% (11 patients). Bilateral injuries were rare, observed in only 3.1% of cases (1 patient).

The number of injured fingers ranged from a minimum of 1 to a maximum of 5. The majority of patients (65.6%, 21 individuals) experienced isolated finger injuries, 6 patients had two-digit, 3 had three-digit, and 1 had four-digit injuries. In one case, a patient suffered injuries to both hands, affecting a total of five fingers: the left middle digit and the right index, middle, ring, and small digits.

Table 4. Characteristics of injured tendons

Type of injured tendons	No. of Fingers	Percentage
FDP + FDS injuries	45	88.2%
Isolated FDP injuries	6	11.8%
Total	51	100%

Combined FDP and FDS tendon injuries affected 45 fingers (88.2%), while isolated FDP injuries were observed in 6 fingers (11.8%).

3.3. Treatment outcomes

Table 5. Post-operative complications

Complications	No. of Patients	Percentage
Infection	1	3.1%
Exposed tendon suture beneath the skin	0	0%
Bleeding	0	0%
Re-ruptured tendon	2	6.3%

There were 31 patients who showed no signs of infection and experienced primary healing, while 1 patient required debridement and secondary healing due to infection. None of the patients had exposed tendon suture beneath the skin or suffered from bleeding. Two patients had tendon re-ruptures.

Table 6. Functional outcome at 6 weeks according to the original Strickland criteria

Results	No. of fingers	Percentage
Excellent	11	21.6%
Good	25	49%
Fair	10	19.6%
Poor	5	9.8%
Total	51	100%

The majority of fingers achieved excellent or good results, with 11 fingers (21.6%) showing excellent outcomes and 25 fingers (49%) showing good outcomes. Fair results were observed in 10 fingers (19.6%), while poor results were the least common, affecting only 5 fingers (9.8%).

IV. DISCUSSION

4.1. Characteristics of patients

In our study, the mean age of patients was 31.31 ± 8.59 years, of which 29 (90.6%) were male. Chan T.K. *et al.* presented an average age of 32.5 (17-51), whereas Natal-Albelo E.J. *et al.* found an average age of 38.6 ± 13.1 [4], [5]. Flexor tendon injuries are one of the most common hand injuries, especially in young men and at work [3].

We observed that the most prevalent category among the participants was non-highly educated individuals (workers and farmers) with 65.6%. In Starnes T. *et al.*'s study, it was found that 62% of the patients had not graduated from university, while only 29% of the participants were manual workers [6]. These differences indicate a social dependency within our study group. This trend is due to the greater vulnerability of less-educated individuals and manual workers to occupational injuries [1].

4.2. Characteristics of injuries

We found that domestic accidents were the most common cause, while occupational accidents were the least common. In contrast, Benameur H. *et al.* reported that injuries were mainly due to armed robbery (57%), workplace accidents (21.5%), and domestic accidents (21.5%) [7]. These differences may reflect variations in social factors.

All of patients underwent emergency surgery upon admission. A total of 90.6% of patients received early surgery within 12 hours, a significantly higher percentage compared to the 9.4% who had surgery after 12 hours. Time of the repair has a significant effect on the Strickland scores. Surgery performed within the first 24 hours following the injury gave better results [8].

Our study included 26 right-handed patients (81.3%), with 34.4% sustaining injuries to their right hand and 62.5% to their left hand. One patient (3.1%) sustained injuries to both hands (due to a fall from a height, with both hands instinctively grabbing onto a sharp metal roofing). Thus, the non-dominant hand was more often injured, which aligns with Chan T.K. *et al.*'s study, where only 4 of 16 right-handed patients injured their right hand [4]. Nevertheless, our findings differed from the study by Benameur H. *et al.*, where 33 patients had right-hand injuries, and 9 had left-hand injuries (of which 36 patients were right-handed and 6 were left-handed) [7]. This discrepancy can likely be attributed to the fact that the dominant hand is typically the one used for grasping tools in daily activities. Consequently, the dominant hand is less likely to sustain injuries during work-related activities. But in fights, people use their main hand to protect themselves, so it gets hurt more often.

In terms of the involved digits, our study found that 21 patients (65.6%) had single-digit injuries, while 11 patients (34.4%) had multiple-digit injuries. Similarly, Güntürk Ö.B. *et al.* reported that 70.8% of patients had one finger injured, and 29.2% had injuries to two or more fingers [8]. This is likely due to common causes of injuries, like domestic or work accidents, where patients often instinctively pull their hand back, injuring only one finger.

The vast majority of injured fingers (88.2%, 45 fingers) presented with both FDP and FDS tendon injuries, with only 11.8% (6 fingers) showing isolated FDP injuries. Similar to our findings, Benameur H. *et al.* found that in their study of 42 fingers (42 patients), combined tendon injuries were predominant, with 33 cases (78.6%), while isolated FDP injuries accounted for 9 cases (21.4%) [7].

4.3. Treatment outcomes

In a study, Mohammadhoseini P. *et al.* performed on 34 patients, the infection rate was 11.8% (4 patients), while in another study of Güntürk Ö.B. *et al.* on 89 patients, the rate of infection was reported 0% [3], [8]. The infection rate in our study was 3.1%, caused by significant soft tissue damage from a sugarcane juice machine. Preoperative condition played a role in wound healing. No complications, like bleeding or visible sutures under the skin, occurred due to the surgeon's skillful tendon suturing and hemostasis techniques.

Repairing zone II flexor tendons remains challenging due to the high risk of rupture, despite advances in techniques [9]. The tensile strength of a flexor repaired tendon is at its weakest after approximately one week, and most ruptures occur during the first 3 weeks [10]. In our research, tendon rupture was in 2 cases (6.3%) at the third week post-surgery. This rate is comparable to the 8.8% reported in Mohammadhoseini P. *et al.*'s study and higher than the 2.3% rate reported in the study of Güntürk Ö.B. *et al.* [3], [8]. Natal-Albelo E.J. *et al.* reported an 8% rupture rate in Hispanic patients undergoing FDS excision [5]. Several studies have emerged comparing two-strand and four-strand sutures. These studies demonstrated the superiority of more than two strands, which would promote early mobilization with less risk of rupture during the healing phase [7].

The tendon accommodations of both FDP and FDS tendons in a tight fibro-osseous tunnel is a key risk factor for poor surgical outcomes in zone II flexor tendon injuries. [11]. To minimize the bulk of the repaired tendon and aid gliding, some surgeons prefer excising the FDS tendon and repairing only the FDP, while others repair both [11], [12]. At 6 weeks, 70.6% of patients had excellent or good outcomes, while 29.4% had fair or poor results. Gadallah A. *et al.* found that at 6 weeks, 76% of patients who had both tendons repaired had good results, compared to 40% for those with only the FDP repaired [1]. Post-repair rehabilitation should encourage early mobilization. There is no unanimity on the type of protocol, but the recommended principles are early active mobilization, avoiding adhesions, and promoting joint flexibility [7]. The increase in Strickland scores from 6 to 12 weeks highlights the importance of follow-up and rehabilitation lasting up to 3 months to assess range of motion improvements [1].

V. CONCLUSION

Hand wounds in zone II present ongoing challenges due to various prognostic factors. Sutures with more than two strands have shown effectiveness, providing a balance of ease, speed, and strength for early rehabilitation. Future studies with larger sample sizes and long-term follow-up are needed to evaluate the long-term outcomes.

REFERENCES

1. Gadallah A., Etman A., Abelhalim M. Flexor Digitorum Superficialis Tendon Injuries in Zone II: To Repair or Not. *The Egyptian Journal of Plastic and Reconstructive Surgery*. 2023. 47(4), 319-325. doi: 10.21608/ejprs.2023.319998
2. Strickland J.W. and Glogovac S.V. Digital function following flexor tendon repair in zone II: A comparison of immobilization and controlled passive motion techniques. *The Journal of hand surgery*. 1980. 5(6), 537-543. doi: 10.1016/s0363-5023(80)80101-8
3. Mohammadhoseini P., Mohammadi S.M., Mousavi Nia N. Short-Term and Long-Term Therapeutic Results of Deep Flexor Tendon Repair in Zone II in Patients Referred to Imam

- Khomeini Hospital, Ahvaz, Southern Iran. *World J Plast Surg*. 2024. 13(1), 82-86. doi: 10.61186/wjps.13.1.82
4. Chan T.K., Ho C.O., Lee W.K., Fung Y.K., Law Y.F., Tsang C.Y. Functional outcome of the hand following flexor tendon repair at the 'no man's land'. *J Orthop Surg (Hong Kong)*. 2006 Aug. 14(2), 178-83, doi: 10.1177/230949900601400214.
 5. Natal-Albelo E.J., Olivella G., Paralicci-Márquez G.U., Rivera L., Echegaray G., Ramírez N., Foy-Parrilla C.A. Functional and Disability Assessment Among Hispanics With Zone 2 Flexor Tendon Injuries: Comparative Study Between Flexor Digitorum Superficialis Repair and Flexor Digitorum Superficialis Excision. *JAAOS: Global Research and Reviews*. 2020 Sep. 4(9):e20.00081. doi: 10.5435/JAAOSGlobal-D-20-00081.
 6. Starnes T., Saunders R.J. and Means K.R. Clinical outcomes of zone II flexor tendon repair depending on mechanism of injury. *The Journal of hand surgery*. 2012. 37(12), 2532-2540
 7. Benameur H., Bensaleh S., Chagou A., Jaafar A., Chahbouni M. Comparison of Modified Kessler and McLarney Techniques in Zone II Flexor Tendon Repair. *Cureus*. 2022. 14(9):e29364. doi: 10.7759/cureus.29364.
 8. Güntürk Ö.B., Kayalar M., Kaplan İ., Uludağ A., Özaksar K., Keleşoğlu B. Results of 4-strand modified Kessler core suture and epitendinous interlocking suture followed by modified Kleinert protocol for flexor tendon repairs in Zone 2. *Acta Orthop Traumatol Turc*. 2018. 52(5), 382-386. doi: 10.1016/j.aott.2018.06.003.
 9. Heydari M.B., Porhesam Y., Karimi Rouzbahani A., Mahmoudvand G., Mahmoudvand H. Comparison of Six-strand and Four-strand Techniques on the Repair of Injured Deep Flexor Tendons of Zone II of the Hand: A Randomized Controlled Clinical Trial. *World Journal of Plastic Surgery*. 2023. 12(2), 34-40. doi: 10.52547/wjps.12.2.34.
 10. Adolfsson L., Soderberg G., Larsson M., Karlander L.E. The effects of a shortened postoperative mobilization programme after flexor tendon repair in zone 2. *Journal of Hand Surgery*. 1996. 21(1), 67-71. doi:10.1016/S0266-7681(96)80016-7.
 11. Dy C.J., Daluiski A. Update on zone II flexor tendon injuries. *Journal of the American Academy of Orthopaedic Surgeons*. 2014. 22(12), 791-799. doi: 10.5435/JAAOS-22-12-791.
 12. Tang J.B., Xie R.G., Cao Y., Ke Z.S., Xu Y. A2 pulley incision or one slip of the superficialis improves flexor tendon repairs. *Clinical Orthopaedics and Related Research*. 2007. 456, 121-127. doi: 10.1097/01.blo.0000246564.96208.b0.
-