International Journal of Research in Orthopaedics
Alshukaili AH et al. Int J Res Orthop. 2026 Sep;12(5):1493-1497
https://www.ijoro.org

Case Series

DOI: https://dx.doi.org/10.18203/issn.2455-4510.IntJResOrthop20262924

Functional outcomes of two-stage flexor tendon reconstruction in zone 2 of the hand

Ahmed H. Alshukaili[1]*, Gopal Malhotra[2], Patil R. Krishnarao[2]

[1]Department of Orthopedic, Surgery, Khoula Hospital Muscat, Oman
[2]Department of Hand Surgery, Khoula Hospital Muscat, Oman

Received: 13 December 2025
Revised: 03 February 2026
Accepted: 31 March 2026

***Correspondence:**
Dr. Ahmed H. Alshukaili,
E-mail: doctor87ahmed@gmail.com

ABSTRACT

Zone II flexor tendon injuries with delayed presentation or failed primary repair remain among the most challenging conditions in hand surgery due to adhesion formation and compromised pulley systems. Two-stage reconstruction using the Paneva-Holevich technique has demonstrated favorable outcomes internationally; however, data from the Middle Eastern region are scarce. We present a retrospective case series of 21 patients who underwent two-stage flexor tendon reconstruction in zone II at a tertiary referral center in Oman between 2012 and 2020. Functional outcomes were assessed using total active motion (TAM), Adjusted Strickland score, Buck-Gramko rating system, and QuickDASH questionnaire. The mean TAM was 85.4% of the contralateral digit, and the mean Adjusted Strickland score was 82.2%. According to Buck-Gramko criteria, 90.5% achieved excellent outcomes. The mean QuickDASH score was 8.5, indicating minimal disability. Patient satisfaction was 95%, and 85% returned to their previous occupation. Complications requiring reoperation occurred in 28.6% of patients. This case series demonstrates that the Paneva-Holevich technique provides reliable functional restoration in complex Zone II injuries within our population.

Keywords: Flexor tendon injury, Prognostic factors, Staged tendon reconstruction, Outcomes, Paneva-Holevich, Oman

INTRODUCTION

The flexor tendon system, consisting of the flexor digitorum superficialis and flexor digitorum profundus, functions within a fibro-osseous sheath stabilized by annular and cruciate pulleys.[1,2] Zone II, historically described as "no man's land," extends from the distal palmar crease to the insertion of the FDS tendon and is particularly prone to adhesion formation following injury.[3,4]

Although primary repair remains the gold standard for acute injuries, delayed presentation, failed repair, dense scarring, and pulley insufficiency often necessitate staged reconstruction.[5-7] Hunter and Salisbury first described two-stage tendon reconstruction using silicone rod implantation to create a pseudosheath, followed by tendon grafting.[8] Paneva-Holevich later modified this method using a pedicled FDS graft to enhance vascularity and gliding characteristics.[9,10]

Despite substantial literature from Europe and Asia published data from the Arabian Peninsula remain limited.[11-13] Differences in injury patterns, occupational demands, and rehabilitation compliance may influence outcomes. This case series evaluates the functional results, complications, and prognostic variables of the Paneva-Holevich technique in an Omani cohort.

CASE SERIES

This retrospective case series was conducted at Khoula Hospital, Muscat, Oman, between January 2012 and January 2020.

Patients with age ≥8 years, zone II flexor tendon injury, underwent two-stage reconstruction using Paneva-Holevich technique and minimum 6-month follow-up were included from the study.

Patients who had thumb injuries, severe crush injuries with extensive tissue loss and incomplete records were excluded from the study.

Patient characteristics

Twenty-one patients met inclusion criteria. The mean age was 21.3±9.8 years, with male predominance (85.7%). The dominant hand was affected in 61.9%. The little finger was most commonly involved (33.3%). Mean delay to first-stage surgery was 13.8 months. Preoperative prognosis according to Boyes and Stark classification was good in 66.7%, fair in 23.8%, and poor in 9.5%.[19]

Surgical technique

Stage one

Scar excision and adhesion release were performed through a Brunner incision. A silicone Hunter rod was inserted and secured distally to the FDP stump and proximally to the musculotendinous junction. Pulley reconstruction (A2/A4) was performed when required.

Stage two: (4-7 months later)

The rod was replaced with a tendon graft (palmaris longus, FDS slip, or extensor digitorum communis). Distal fixation utilized a modified Kessler technique; proximal fixation used Pulvertaft weave. Tension was adjusted to restore digital cascade.

Rehabilitation protocol

Weeks 0-4: Dorsal blocking splint; passive flexion, active extension, weeks 4-6: Active motion and week 6 onward: Strengthening.

All patients underwent supervised physiotherapy for 12 weeks.

Functional outcomes

Mean TAM wasc85.4%±12.3%, mean adjusted Strickland was 82.2±14.1%, Buck-Gramko ratings were Excellent: 90.5% and good: 9.5%. Mean QuickDASH: 8.5±7.2. the 95% reported satisfaction. The 85% returned to previous occupation (mean 5.2 months).

Complications

Six patients (28.6%) required reoperation: Pulley rupture (2), volar plate contracture (1), symptomatic scar (1), wrist contracture (1) and tenolysis (1)

Complication group showed significantly lower TAM and higher QuickDASH scores ($p<0.01$).

No demographic or graft-type variable significantly influenced outcomes.

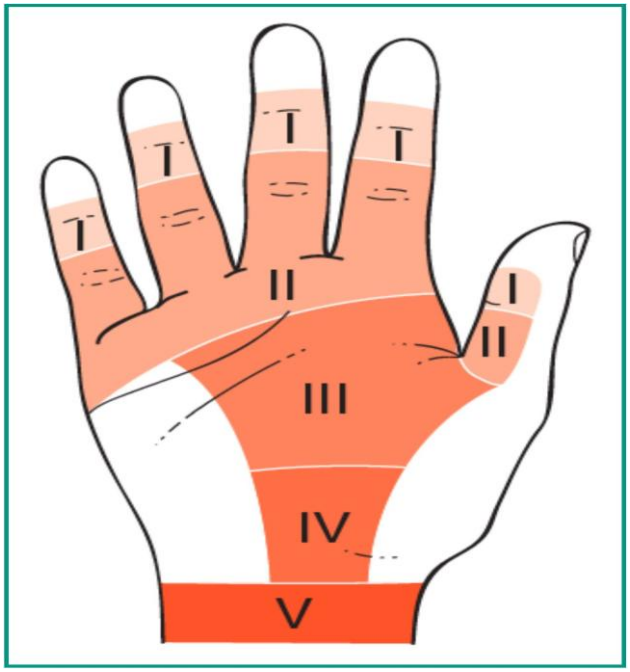

Figure 1: Zones of flexor tendon injuries.

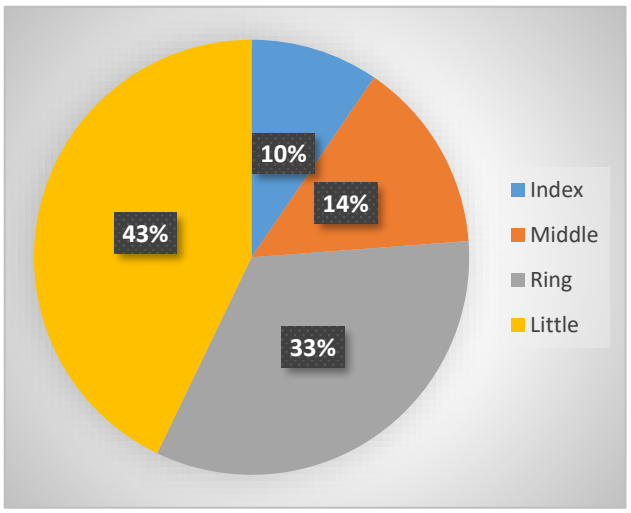

Figure 2: Percentage of finger injuries by location.

Table 1: Boyes and Stark prognostic classification according to preoperative clinical status.

Stages	Preoperative injuries	Our cases
1	Simple wound	10
2	Extensive wound	3
3	Assoiated joint injury	7
4	Associated nerve injury	1
5	Multiple combined problems	0

Table 2: Results after zone 2 flexor tendon reconstruction.

Results	Buck-Gramko rating		TAM		Adjusted Strickland rating	
	Score	N (digits)	Score	N (digits)	Score	N (digits)
Excellent	14-15	19	>150	18	75-100	17
Good	11-13	2	125-149	3	50-74	4
Satisfaction	7-10	0	90-124	0	25-49	0
Poor	0-6	0	<90	0	0-24	0

DISCUSSION

Zone II flexor tendon injuries remain among the most technically demanding conditions in hand surgery due to the confined fibro-osseous sheath, high risk of adhesion formation, and frequent pulley compromise.[1-4] When primary repair fails or presentation is delayed, two-stage reconstruction remains the most reliable salvage option.[5-7] This case series demonstrates that the Paneva-Holevich modification provides excellent functional recovery within our population, with a mean TAM of 85.4% and mean Adjusted Strickland score of 82.2%.

Comparison with International Literature

Our results compare favorably with previously published series. Beris et al reported a mean Strickland score of 73% in 22 patients undergoing staged reconstruction using a silicone rod and pedicled intrasynovial graft.[12] Naam reported excellent or good results in 82% of cases using a pedicled FDS graft.[21] Similarly, Darlis et al documented satisfactory outcomes in pediatric populations.[20]

The 100% excellent/good rate in our cohort according to Buck-Gramko criteria slightly exceeds the 82-90% range reported in most international series.[20,21] While caution is warranted given sample size, this finding may reflect strict adherence to a standardized rehabilitation protocol and meticulous pulley reconstruction during stage one.

Functional and patient-reported outcomes

Modern hand surgery increasingly emphasizes patient-reported outcome measures in addition to objective range-of-motion data.[22,23] Our mean QuickDASH score of 8.5 indicates minimal residual disability and correlates with the high satisfaction rate (95%) and return-to-work rate (85%). These findings highlight that staged reconstruction can restore not only motion but meaningful functional independence. In a young, predominantly working-age population such as ours, restoration of grip function and occupational capacity is particularly critical. Average return-to-work time of 5.2 months aligns with reported timelines in comparable series.[24,25]

Complications and secondary procedures

Overall complication rate of 28.6% falls within expected range of 15-35% for staged flexor tendon reconstruction.[24,25] Pulley rupture and adhesion formation remain the most frequent causes of reoperation in literature.[26] Importantly, in our series, all complications were surgically addressed with acceptable secondary outcomes.

The significantly lower TAM and higher QuickDASH scores in complication subgroup confirm that secondary procedures meaningfully affect short-term functional recovery. However, even in these patients, eventual functional improvement was achievable, underscoring importance of close postoperative monitoring.

Prognostic factors

Unlike Djerbi et al who identified injury severity and smoking as negative predictors, we found no statistically significant association between demographic variables, graft type, or dominance and final outcome.[27] This may suggest that surgical technique and structured rehabilitation exert a stronger influence than baseline demographic factors. However, the relatively small cohort limits the statistical power to detect subtle associations.

Technical considerations

The Paneva-Holevich technique offers theoretical advantages over free tendon grafting, including improved vascularity and smoother gliding due to intrasynovial characteristics of the pedicled FDS graft.[9-12] Careful tension adjustment during stage two remains critical to avoid flexion contracture or lag.

Additionally, consistent pulley reconstruction at stage one likely contributed to the favorable outcomes observed. Preservation or reconstruction of A2 and A4 pulleys remains essential to prevent bowstringing and optimize biomechanical efficiency.[1,3]

Strengths

Use of multiple validated functional scoring systems, inclusion of patient-reported outcome measures, standardized surgical technique by experienced hand surgeons, structured rehabilitation protocol and regional data from an underreported geographic area

Limitations

Limitations were retrospective design, single-center experience, small sample size, mean follow-up of 9

months may not capture long-term degenerative changes and lack of baseline preoperative PROMs.

Despite these limitations, this series contributes valuable regional evidence supporting staged reconstruction in delayed zone II injuries.

CONCLUSION

Two-stage flexor tendon reconstruction using the Paneva-Holevich technique remains a reliable and reproducible strategy for complex zone II injuries. In this case series, excellent objective and patient-reported outcomes were achieved with acceptable complication rates. The technique continues to be a valuable option in settings where delayed presentation and failed primary repair are common.

Recommendations

Future research should focus on prospective multicenter studies with larger sample sizes and longer follow-up durations to better define prognostic factors. Incorporation of baseline patient-reported outcome measures would strengthen longitudinal assessment. Exploration of wide-awake local anesthesia techniques may further optimize intraoperative graft tensioning and potentially improve outcomes. Development of standardized regional rehabilitation protocols may enhance consistency of postoperative recovery.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: Not required

REFERENCES

1. Tang JB. Flexor tendon repair: recent changes and current methods. J Hand Surg Eur. 2015;40(9):853-63.
2. Strickland JW. Flexor tendon injuries: I. Foundations of treatment. J Am Acad Orthop Surg. 1995;3(1):44-54.
3. Freilich AM, Chhabra AB. Secondary flexor tendon reconstruction: a review. J Hand Surg Am. 2007;32(9):1436-42.
4. Momeni A, Grauel E, Chang J. Complications after flexor tendon injuries. Hand Clin. 2010;26(2):179-89.
5. Samora JB, Klinefelter RD. Flexor tendon reconstruction. J Am Acad Orthop Surg. 2016;24(1):9-19.
6. Langer MF, Wieskötter B, Oeckenpöhler S. Staged flexor tendon reconstruction: indications and results. Handchir Mikrochir Plast Chir. 2019;51(3):174-81.
7. Chesney A, Chauhan A, Kattan A. Systematic review of flexor tendon rehabilitation protocols in zone II of the hand. Plast Reconstr Surg. 2021;147(2):449-59.
8. Hunter JM, Salisbury RE. Flexor-tendon reconstruction in severely damaged hands. J Bone Joint Surg Am. 1971;53(5):829-58.
9. Paneva-Holevich E. Two-stage reconstruction of the flexor tendons. Int Orthop. 1982;6(2):133-8.
10. O'Shea K, Wolfe SW. Two-stage reconstruction with the modified Paneva-Holevich technique. Hand Clin. 2013;29(2):223-33.
11. Beris AE, Darlis NA, Korompilias AV. Two-stage flexor tendon reconstruction in zone II using a silicone rod and a pedicled intrasynovial graft. J Hand Surg Am. 2003;28(4):652-60.
12. Beris AE, Lykissas MG, Korompilias AV. Two-stage flexor tendon reconstruction in zone II using a silicone rod and a pedicled intrasynovial graft: long-term results. J Hand Surg Eur. 2011;36(4):304-11.
13. Al-Qattan MM, Al-Zahrani K. Flexor tendon injuries in the hand: factors influencing results in Saudi Arabia. Saudi Med J. 2009;30(1):78-82.
14. Ibrahim AM, Kim PS, Rabie AN. A systematic review of flexor tendon rehabilitation protocols. Plast Reconstr Surg Glob Open. 2015;3(11):e557.
15. American Society for Surgery of the Hand. Clinical Assessment Committee: Clinical Assessment Recommendations. 2nd ed. ASSH. 1992.
16. 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(6):537-43.
17. Buck-Gramcko D. A new method for evaluation of results in flexor tendon repair. Handchirurgie. 1976;8(2):65-9.
18. Gummesson C, Ward MM, Atroshi I. The shortened disabilities of the arm, shoulder and hand questionnaire (QuickDASH): validity and reliability based on responses within the full-length DASH. BMC Musculoskelet Disord. 2006;7:44.
19. Boyes JH, Stark HH. Flexor-tendon grafts in the fingers and thumb: a study of factors influencing results in 1000 cases. J Bone Joint Surg Am. 1971;53(7):1332-42.
20. Darlis NA, Beris AE, Korompilias AV. Two-stage flexor tendon reconstruction in zone 2 of the hand in children. J Pediatr Orthop. 2005;25(3):382-6.
21. Naam NH. Staged flexor tendon reconstruction using pedicled tendon graft from the flexor digitorum superficialis. J Hand Surg Am. 1997;22(2):323-7.
22. Walbeehm ET, Duraku LS, Jupiter JB. Patient-reported outcome measures in hand surgery. J Hand Surg Eur. 2015;40(8):771-5.
23. Shauver MJ, Chung KC. The minimal clinically important difference of the Michigan Hand Outcomes Questionnaire. J Hand Surg Am. 2009;34(3):509-14.
24. Soucacos PN, Beris AE, Malizos KN. Two-stage treatment of flexor tendon ruptures: silicon rod complications analyzed in 109 digits. Acta Orthop Scand. 1997;68(275):48-51.
25. Frakking TG, Depuydt KP, Kon M. Retrospective outcome analysis of staged flexor tendon reconstruction. J Hand Surg Br. 2000;25(2):168-74.
26. Tang JB, Zhou X, Pan ZJ. Strong digital flexor tendon repair, extension-flexion test, and early active flexion:

experience in 300 tendons. Hand Clin. 2017;33(3):455-63.
27. Djerbi I, Chammas M, Mirous MP. Prognostic factors in two-stage flexor tendon reconstruction: is it possible to predict surgical failure? Orthop Traumatol Surg Res. 2016;102(1):53-9.
28. Dy CJ, Hernandez-Soria A, Ma Y, Timothy RR, Aaron D. Complications after flexor tendon repair: a systematic review and meta-analysis. J Hand Surg Am. 2012;37(3):543-51.
29. Kotwal PP, Varshney A, Soral A. Comparison of outcomes of tendon repair in zone II flexor tendon injuries under wide-awake anesthesia versus general anesthesia. J Hand Surg Asian Pac. 2019;24(2):166-71.
30. Higgins A, Lalonde DH. Wide-awake flexor tendon repair: current trends. Plast Reconstr Surg. 2017;140(4):734e-6e.
31. Tang JB, Amadio PC, Boyer MI, Robert S, Chunfeng Z, Michael S, et al. Current practice of primary flexor tendon repair: a global view. Hand Clin. 2013;29(2):179-89.
32. Trumble TE, Vedder NB, Seiler JG. Zone-II flexor tendon repair: a randomized prospective trial of active place-and-hold therapy compared with passive motion therapy. J Bone Joint Surg Am. 2010;92(6):1381-9.
33. Chesney A, Chauhan A, Kattan A, Forough F, Achilleas T. Systematic review of flexor tendon rehabilitation protocols in zone II of the hand. Plast Reconstr Surg. 2021;147(2):449-59.
34. Schreuders TA, Roebroeck ME, Jaquet JB, Steven ERH, Henk JS. Measuring the strength of the intrinsic muscles of the hand in patients with ulnar and median nerve injuries: reliability of the Rotterdam Intrinsic Hand Myometer. J Hand Surg Am. 2004;29(2):318-24.
35. Groth GN. Pyramid of progressive force exercises to the injured flexor tendon. J Hand Ther. 2004;17(1):31-42.
36. Evans RB. Managing the injured tendon: current concepts. J Hand Ther. 2012;25(2):220-33.

Cite this article as: Alshukaili AH, Malhotra G, Krishnarao PR. Functional outcomes of two-stage flexor tendon reconstruction in zone 2 of the hand. Int J Res Orthop 2026;12:1493-7.