Outcomes of Fingertip Amputation Reconstruction by Palmar Flap

(A Retrospective Cross-Sectional Study)

Abstract

Introduction: Fingertip injuries are among the most common hand traumas, and the choice of reconstructive technique may influence pain, function, and digital appearance. This study aimed to evaluate the outcome of palmar flap reconstruction for fingertip amputation and assess factors associated with postoperative outcome.

Materials & Methods: Medical records of patients who underwent palmar flap reconstruction from a hospital between 2016 and 2024 were reviewed in a retrospective cross-sectional observational study. Patient-reported outcomes including function, pain, and appearance were measured using a 10-point numeric rating scale. Statistical analysis was performed using the independent t-test, one-way analysis of variance (ANOVA), and Spearman rank correlation.

Results & Discussion: 50 patients with the mean age of 30.14 years with a standard deviation (SD) of 5.58, and 88% being male were studied. All injuries were industrial. The mean scores for appearance, pain, and function were 7.72, 7.72, and 8.26, respectively. No significant differences in outcomes were observed by sex or injured side. Pain scores were higher among patients with three injured fingers (p=0.031). Functional scores were significantly lower in injuries involving the fifth finger (p=0.007). Surgery performed more than 24 hours after injury was associated with higher pain scores (p=0.017), and a borderline trend toward poorer function with increasing surgical delay was observed (p=0.094).

Conclusion: In palmar flap reconstruction for fingertip amputation, the number of injured fingers, involvement of the fifth finger, and surgical delay are key factors associated with lower postoperative outcomes.

Keywords: Finger injuries, traumatic amputation, surgical flaps, hand injuries

Accepted: 40 days before printing

Seyed Hossein Saeed Banadaki, MD[1], Milad Gholizadeh, MD[2], Nima Fathollahzadeh, MD[2], Shahab Sheikhalishahi, MD[3], Hesameddin Jafarinasab, MD[3]

1. Trauma Research Center, Shahid Sadoughi University of Medical Sciences, Yazd, Iran
2. Department of Orthopedic Surgery, Trauma Research Center, Shahid Sadoughi University of Medical Sciences, Yazd, Iran
3. Research Committee, Shahid Sadoughi University of Medical Sciences, Yazd, Iran

Corresponding Author:
Hesameddin Jafarinasab, MD
Email Address:
Jafarinasab1000@gmail.com

Introduction

Fingertip injuries are among the most common injuries of the hand. Owing to the critical role of the fingertip in fine pinch, protective sensation, and the cosmetic integrity of the nail unit, such injuries may be associated with chronic pain, functional impairment, and aesthetic dissatisfaction. These injuries typically occur during the working years and have been reported in both occupational and non-occupational settings. In many reports, the incidence is higher in men, and the consequences may include reduced productivity and absenteeism from work.[1–3]

In fingertip amputations, the goal of treatment is not merely wound closure. Rather, restoration of sensation, provision of durable coverage resistant to shear forces, preservation of finger length and contour, and establishment of an appropriate bed for nail growth are of primary importance. Inadequate management may lead to outcomes such as cold intolerance, pain or bothersome hypersensitivity at the flap or scar site, and functional impairment of the finger. Therefore, the choice of treatment should be guided by the injury pattern, the extent of bone or tendon exposure, the condition of the nail bed, and the patient's functional needs.[4–6]

Despite therapeutic advances, there is still no definitive consensus on the optimal approach for all patients, and the decision between conservative and surgical management should be individualized.

In recent years, semi-occlusive dressing has been introduced as a non-surgical option in selected cases, and recent studies have reported satisfactory healing, patient satisfaction, and certain functional advantages. These findings highlight the need for clearly defined indications and fair comparison between treatment modalities.[6–8]

In cases involving extensive soft tissue loss or exposure of the distal phalanx, reconstruction with a local flap is usually required. The cross-finger flap and the thenar flap are among the commonly used reconstructive techniques, and in addition, the mid-palmar flap has been proposed for certain defect patterns. Despite their advantages, some flap techniques may necessitate a longer period of immobilization, which can influence return to work and patient satisfaction.[6, 9, 10]

From a reconstructive standpoint, in volar fingertip defects, the use of glabrous palmar skin is functionally advantageous due to its similarity in thickness, durability under contact, and quality of coverage. Palmar flaps, by providing a robust and relatively similar tissue to the fingertip pulp, may represent a valuable option for working individuals and those with frequent fingertip contact. In designs based on the mid-palmar region, attention has been paid to its vascular supply from the superficial palmar branch of the radial artery.[10–12]

The use of palmar skin for the repair of digital defects dates back to classic reports. Gatewood introduced this concept in the early decades of the twentieth century, and with subsequent modifications, its application was expanded to distal and fingertip injuries. Thereafter, techniques based on palmar and thenar flaps were refined by various surgeons, and their technical foundations evolved.[13]

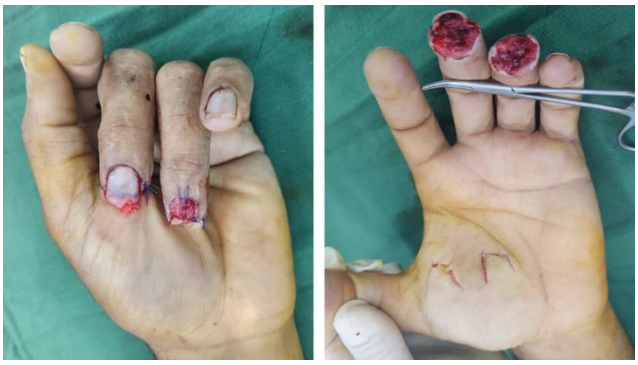
Nevertheless, concerns have been raised regarding complications such as joint stiffness and donor-site scar tenderness. Clinical evidence suggests that a substantial proportion of these issues can be mitigated through optimization of surgical technique, appropriate pedicle design, timely flap division, and early initiation of rehabilitation. Reports on thenar flap rehabilitation and larger case series have also emphasized the importance of structured mobilization to prevent joint stiffness.[10, 14, 15]

In the evaluation of treatment outcomes for fingertip injuries, in addition to objective measures, patient-reported outcomes such as pain, functional performance in daily activities, and satisfaction with appearance are of particular importance. In recent years, comparative studies have demonstrated differences in certain functional and aesthetic outcomes among flap techniques, and recent reviews continue to highlight the role of the thenar flap as a reliable option in fingertip reconstruction.[16, 17]

Given the limited evidence regarding outcomes of fingertip reconstruction using palmar flaps, conducting center-based studies may assist in clinical decision-making, provide more precise patient counseling, and contribute to the refinement of treatment and rehabilitation protocols. The present study aims to evaluate the outcomes of reconstruction in patients with fingertip amputation treated using a palmar flap technique, as well as to analyze the relationship between outcomes and selected clinical factors.[6, 10]

Materials & Methods

This study is a retrospective cross-sectional observational investigation conducted through review of the medical records of all patients with fingertip amputation. The target population consisted of patients who had undergone fingertip reconstruction using a palmar flap at Shahid Sadoughi Hospital in Yazd between 2016 and 2024. The study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.[18, 19]



B A

Figure 1. Intraoperative images of fingertip amputation and reconstruction using a palmar flap. (A) View of the soft tissue defect prior to reconstruction. (B) View after placement and fixation of the flap over the fingertip.

Sampling was performed using a convenience approach in the form of a census of all eligible cases within the specified time frame. Inclusion criteria comprised patients with fingertip amputation who had undergone reconstruction with a palmar flap and had provided informed consent to participate in the study. Exclusion criteria included lack of consent for participation and non-response during follow-up.

Given the retrospective nature of the study, the sample size was determined based on the total number of eligible patients during the 2016 to 2024 period.

Table 1: Baseline patient characteristics, injury pattern, and main outcomes (n = 50 patients, 76 digits)

Variable	Value
Age (years), mean ± standard deviation, range	20 to 40; 30.14 ± 5.58
Sex, n (%)	Male 44 (88); Female 6 (12)
Side of injury, n (%)	Right 30 (60); Left 20 (40)
Mechanism of injury, n (%)	Industrial 50 (100)
Number of digits involved per patient, n (%)	1 digit: 34 (68); 2 digits: 6 (12); 3 digits: 10 (20)
Distribution of injured digits out of 76 digits, n (%)	Digit 1: 3 (3.94); Digit 2: 27 (35.52); Digit 3: 25 (32.89); Digit 4: 13 (17.10); Digit 5: 9 (11.84)
Time to surgery (hours), mean ± standard deviation, range	4 to 168; 33.04 ± 50.93
Appearance score, mean ± standard deviation, min–max	6 to 10; 7.72 ± 1.43
Pain score, mean ± standard deviation, min–max	2 to 9; 7.72 ± 1.36
Function score, mean ± standard deviation, min–max	5 to 10; 8.26 ± 1.45

During the initial extraction phase, approximately 63 records were identified from the hospital archive. After removal of duplicate or irrelevant cases (n=2) and exclusion of records that did not meet the inclusion criteria or had not undergone palmar flap reconstruction (n=4), a number of additional records were excluded due to missing key information (including absence of date or time required to calculate time to surgery, incomplete documentation of the injured finger or side, or lack of valid contact information for follow-up) (n=4). Ultimately, 53 eligible patients remained. Of these, during the final follow-up process, one patient withdrew from participation and two patients were not reachable despite at least three contact attempts. Therefore, 50 patients were included in the final analysis.

Initially, eligible patient records from 2016 to 2024 were retrieved from the hospital archive. Demographic data and injury-related information were extracted, including age, sex, side of injury, number of the injured digit, number of digits involved per patient, and the time interval between injury occurrence and surgical intervention. The mechanism of injury was also recorded for descriptive purposes. In cases where a variable was incomplete in some records, analyses related to that variable were conducted based on the number of valid observations, and the denominators were clearly reported in the results. However, records lacking key information required for study inclusion or final follow-up were excluded during the screening stage.

After identification, patients were enrolled in the study based on the inclusion and exclusion criteria. Informed consent was obtained from all participants. Pain and functional outcomes were assessed using a 10-point Likert scale, where a score of 1 indicated minimal pain and a score of 10 indicated maximal pain.[20] For assessment of appearance and aesthetics, a single fixed evaluator rated the outcomes using the same 10-point Likert scale.

Outcome evaluation, including pain, function, and appearance, was conducted at the final follow-up. Final follow-up was defined as the last recorded patient visit after completion of treatment and wound healing, and in cases involving a two-stage flap, after pedicle division. The duration of follow-up was calculated as the time interval between the date of surgery and the date of final follow-up, at which outcomes were recorded. Throughout the manuscript, “postoperative pain” refers to the pain score at the time of final follow-up.

Surgical Technique and Postoperative Care Surgical procedures were performed by the center’s surgical team, including attending surgeons with participation of orthopedic residents. In cases where a resident was the primary operator, key steps were carried out under the direct supervision of a senior surgeon. In most cases, anesthesia was achieved using regional anesthesia in the form of a digital nerve block, and the type of anesthesia was recorded based on medical documentation.

At the study center, fingertip reconstruction with a palmar flap was performed as a pedicled flap harvested from glabrous hand skin. The flap design was determined based on the location of the defect and the involved digit. The flap was elevated as a full-thickness flap with an adequate layer of subcutaneous tissue to preserve its vascularity. After debridement and preparation of the recipient site, the flap was secured over the defect without tension. When necessary, the finger was immobilized in an appropriate position to avoid pressure on the pedicle (Figure 1).

Postoperatively, patients were monitored for signs of flap vascular compromise and were instructed on wound care. Short-term immobilization was applied to protect the flap, and a rehabilitation and mobilization program was initiated after ensuring flap stability and initial wound healing. Typically, in the early postoperative days, the limb was maintained in an elevated position, and a short-term protective splint (approximately 7 to 10 days) was used to safeguard

the flap. During this period, active mobilization of the shoulder, elbow, wrist, and uninvolved digits was initiated from the first day, and gentle active movement of the free joints of the involved digit was gradually started according to patient tolerance. After splint removal and adequate wound healing, and in cases of two-stage flaps, following pedicle division (usually around 10–15 days after the first stage), active and passive range-of-motion exercises of the involved finger were initiated under the supervision of a hand therapist. These were subsequently progressed in a stepwise manner with stretching exercises, edema control, and later functional strengthening. After complete wound closure, patients were instructed in scar care and desensitization techniques, including scar massage and a gradual desensitization program.[20] The timing of pedicle division in two-stage flaps was determined based on the surgeon's judgment and the status of healing.

Outcome measures included functional score, pain score, and appearance/aesthetic score, which were recorded using a data collection form specifically designed for this study and based on a numerical scale ranging from 0 to 10. Pain was assessed using a numerical rating scale from 0 (no pain) to 10 (worst imaginable pain). In addition, variables extracted from the medical records were used both for descriptive purposes and to examine the association between selected factors and outcomes, including sex, side of injury, number of digits involved, digit number, and time interval to surgery. The study was conducted after approval by the institutional research council and with authorization from the university ethics committee and was conducted in accordance with the Declaration of Helsinki.[21] Patient information was treated as confidential and analyzed in a coded format.

Data were entered and analyzed using the Statistical Package for the Social Sciences (SPSS), version 26. Quantitative variables were reported as mean and standard deviation, while qualitative variables were presented as frequency and percentage. The independent samples t-test was used to compare mean outcomes between two groups, and one-way analysis of variance (ANOVA) was applied for comparisons among more than two groups.

In cases where assumptions of normality were not met, corresponding non-parametric tests were employed. In addition, appropriate correlation methods, based on data distribution, were used to assess the relationship between time from injury to surgery and outcomes. A p-value of less than 0.05 was considered statistically significant. In the presence of missing data for certain variables, the number of valid cases for each analysis was reported, and analyses were conducted based on available data.

Results

Over the 8-year period, 63 records were identified. After removal of duplicate or irrelevant cases (n=2), exclusion of records that did not meet the inclusion criteria or had undergone non-palmar reconstruction (n=4), and elimination of records with incomplete key information (n=4), a total of 53 eligible patients remained. Of these, 1 patient withdrew and 2 patients were not reachable, resulting in 50 patients included in the final analysis.

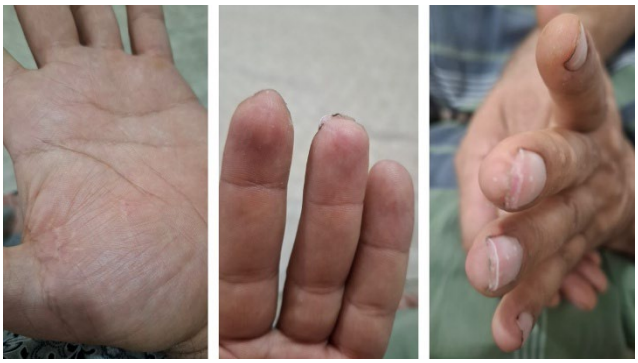


Figure 1. Intraoperative images of fingertip amputation and reconstruction using a palmar flap. (A) View of the soft tissue defect prior to reconstruction. (B) View after placement and fixation of the flap over the fingertip.

The mean age of patients was 30.14 years (standard deviation: 5.58), with an age range of 20 to 40 years. A total of 44 patients (88%) were male and 6 (12%) were female. Thirty patients (60%) had injuries to the right hand and 20 patients (40%) to the left hand.

Regarding the number of involved digits, 34 patients (68%) had single-digit injuries, 6 patients (12%) had involvement of two digits, and 10 patients (20%) had injuries involving three digits. In total, 76 injured digits were recorded in the sample, with the highest frequency observed in the second and third digits.

The time interval from injury to surgical intervention ranged from 4 to 168 hours, with a mean of 33.04 hours (standard deviation: 50.93). Outcome scores for appearance, pain, and function were recorded at final follow-up using a 0 to 10 Likert scale. For the pain index, higher scores indicated greater pain.

The mean duration of follow-up from the time of surgery to outcome assessment was 14.8 months (standard deviation: 7.2; range: 6 to 36 months), with

a minimum follow-up period of 6 months. These findings are summarized in Table 1.

Table 2. Summary of Statistical Tests and Main Results

Comparison or Explanatory Variable	Outcome	Statistical Test	P-value	Conclusion
Sex (male vs. female)	Appearance	Independent t-test	0.317	No significant difference
	Pain	Independent t-test	0.395	No significant difference
	Function	Independent t-test	0.187	No significant difference
Side of injury (right vs. left)	Appearance	Independent t-test	0.354	No significant difference
	Pain	Independent t-test	0.723	No significant difference
	Function	Independent t-test	0.861	No significant difference
Number of affected fingers (1, 2, 3)	Pain	One-way ANOVA	0.031	Three-finger group had higher pain scores
	Appearance	One-way ANOVA	>0.05	No significant difference
	Function	One-way ANOVA	>0.05	No significant difference
Finger number	Function (finger 5)	t-test	0.007	Lower function
	Finger 1	t-test	0.092	Borderline association
Time to surgery (<24 vs. >24 hours)	Pain	Independent t-test	0.017	Delay >24 hours associated with higher pain
	Appearance and function	Independent t-test	>0.05	No significant association
Time to surgery (hours)	Appearance and pain	Spearman correlation	>0.05	No significant association
	Function	Spearman correlation	0.094	Borderline trend toward poorer function with longer delay

In the analytical assessment, no statistically significant differences were observed between men and women in terms of appearance and pain scores. The corresponding p-values were 0.395 and 0.317, respectively. Likewise, no significant difference was found in functional scores between the two groups, with a reported p-value of 0.187. Therefore, in the present sample, sex was not associated with significant variation in any of the three primary study outcomes.

Subsequently, outcomes were compared based on the side of injury using the independent samples t-test. The results indicated no significant difference in appearance scores between right- and left-hand injuries (Figure 2), with a p-value of 0.354. Similarly, no significant difference was observed in pain scores (p=0.723). Finally, functional scores also did not differ significantly between the two sides (p = 0.861). These findings suggest that, within the context of this study, the side of involvement had no significant effect on patient-reported outcomes.

The association between the number of involved digits and postoperative outcomes was evaluated using one-way analysis of variance. In this analysis, pain scores showed a statistically significant difference across groups, with a p-value of 0.031. Specifically, patients with involvement of three digits reported higher pain levels. In contrast, appearance and functional scores did not differ significantly among patients with one-, two-, or three-digit involvement, with p-values greater than 0.05 for both outcomes. These results indicate that the number of involved digits appears to be more closely related to increased postoperative pain rather than to changes in appearance or function.

In the analysis stratified by digit number, involvement of the fifth digit was associated with a significant reduction in functional score (p=0.007). Moreover, in the evaluation of postoperative pain for the first digit, the p-value was 0.092, which lies in a borderline range and may suggest a potential trend, although it does not meet the conventional threshold for statistical significance ($p<0.05$). No significant effects were observed for the other digits.

The effect of time to surgery was examined at two levels. First, patients were categorized into two groups based on delay to surgery, less than 24 hours and more than 24 hours, and compared using the independent samples t-test. The results demonstrated that a delay of more than 24 hours was significantly associated with increased postoperative pain at final follow-up (p=0.017). In contrast, no significant differences were found between the two groups in terms of appearance or functional scores, with p-values greater than 0.05 in both cases. All outcomes were recorded at the final follow-up after completion of reconstruction.

In the next step, to assess the continuous relationship between delay in hours and outcomes, Spearman's

rank correlation coefficient was applied. This analysis showed no significant association between delay and either appearance or pain ($p>0.05$). However, for functional outcome, the p-value was 0.094, indicating a borderline trend toward decreased function with increasing surgical delay. Although this finding did not reach statistical significance, it may have clinical relevance and warrants further investigation in larger samples with control for potential confounders. Overall, the results of the statistical analyses are summarized in Table 2.

Discussion

The findings of this study indicate that reconstruction of fingertip amputation using a palmar flap, in a population predominantly affected by industrial injury mechanisms, is generally associated with relatively favorable functional and aesthetic outcomes. At the same time, three distinct clinical patterns emerged as factors associated with outcomes: increased pain in multi-digit injuries, reduced function in cases involving the fifth digit, and an association between a delay of more than 24 hours to surgery and increased postoperative pain. These findings can be interpreted within the framework of the primary goals of fingertip injury management, namely achieving a painless digit, preserving length, and providing protective sensation along with durable coverage.[4, 6, 21]

From an epidemiological perspective, the predominance of male patients and occupational context is consistent with previously reported patterns in traumatic hand injuries and digital amputations.[2] In the present study, all cases were attributed to industrial mechanisms, which underscores, in terms of hand emergency service planning, the necessity of streamlined pathways for rapid assessment, decision-making, and rehabilitation. This is particularly important because such patients typically require a quicker return to work and more durable fingertip coverage.[3]

Palmar flaps, utilizing glabrous skin from the palm, theoretically offer the potential to create a functional and relatively stable fingertip due to their tolerance to contact, resistance to shear forces, and relative compatibility with the pulp.[4, 11] In case series and technical reports, mid-palmar–based approaches have been introduced as practical options for certain defect patterns, particularly in the long fingers.[10] Furthermore, more recent studies on flaps based on the superficial palmar branch of the radial artery have reported clinical efficacy and soft tissue coverage capability in the distal finger region, indicating that the use of palmar tissue remains an active and evolving area in distal fingertip reconstruction.[22]

In the analysis of the present study, pain was significantly greater in patients with injuries involving three digits. Clinically, multi-digit injuries are often associated with higher energy trauma, greater extent of soft tissue damage, and increased psychological burden, all of which can complicate the rehabilitation process. This observation is consistent with evidence from studies on patterns of digital amputation; for example, in a large study focusing on patient-reported outcomes, injury patterns involving three or more digits were found to have particular significance in terms of patient-centered outcomes.[23] From a practical standpoint, the present finding may imply the need for closer pain monitoring, patient education and expectation management, and the design of rehabilitation and pain control programs tailored to the severity of injury.[4, 6]

A significant reduction in functional scores was observed in cases involving the fifth digit. This finding may have several explanations. Functionally, the fifth digit plays an important role in power grip and ulnar coordination of the hand, and any persistent pain, shortening, sensitivity, or limitation of motion may become more evident in daily activities and manual tasks. On the other hand, the number of fifth-digit cases in this study was limited, and the results may have been influenced by characteristics of the injury pattern, the extent of pulp loss, or concomitant nail bed injury. Comparative reports on flap techniques have also noted differences in functional outcomes, rates of contracture, and nail deformities, suggesting that the final outcome may depend on the technique, defect pattern, and rehabilitation.[16, 17] In future studies, the use of more standardized outcome assessment tools, such as the Fingertip Injury Outcome Score, may help to more precisely delineate the role of the involved digit and the severity of injury.[24]

Another key finding was that a delay of more than 24 hours to surgery was associated with a significant increase in postoperative pain. From a physiological perspective, delayed wound cleansing, debridement, and establishment of stable coverage may lead to increased inflammation, edema, stimulation of nerve endings, and in some cases infection or scar sensitivity, ultimately exacerbating the pain experience.[4, 6] However, it should be noted that the relationship between time to surgery and outcomes is not consistent across studies. For instance, in a recent study on traumatic finger injuries leading to amputation, increased time to surgery was not significantly associated with a higher risk of

complications or the need for reintervention.[25] These discrepancies may be attributed to differences in injury type, outcome definitions, treatment protocols, and the timing and method of pain assessment. In the present study, in addition to the two-group comparison, Spearman rank correlation analysis also showed a trend approaching statistical significance toward decreased function with increasing delay, which may support the hypothesis of a temporal effect on rehabilitation, although a larger sample size is required for definitive conclusions.

In this study, no significant differences were observed in aesthetic, pain, or functional scores between men and women, nor between the right and left sides. From a methodological standpoint, the small number of female patients may have reduced the statistical power to detect true differences. Moreover, in industrial injuries, factors such as type of exposure, trauma severity, and rehabilitation protocols may be more influential than variables such as sex or laterality.[2, 3]

In contrast to pain and function, the variables examined did not provide a clear explanation for variations in aesthetic outcomes. This likely reflects the multifactorial nature of fingertip appearance. Factors such as nail quality and nail bed condition, amputation angle, nail plate deformity, and scar quality are important determinants, and if not recorded in a structured manner, the ability to conduct precise analysis is reduced.[26] In addition, comparative studies of flap techniques have reported differences in rates of nail deformity and contracture, suggesting that appearance may depend more on the type of defect and surgical technique than solely on sex or laterality.[17] Furthermore, long-term reports on neurovascular flaps have identified complaints such as cold intolerance and nail deformity as being partly dependent on the nature of the initial injury, reinforcing the importance of detailed documentation of wound characteristics and nail bed status.[27]

Conclusion

In recent years, conservative management using semi-occlusive dressings has been introduced as an option in selected cases, and several recent studies and reviews have reported favorable outcomes, reduced donor-site morbidity, and acceptable tissue regeneration.[7, 8] Nevertheless, in occupational populations requiring durable coverage, or in cases where bone exposure or the need for immediate coverage is present, local flap techniques continue to play a central role.[4, 6] In addition, data on homodigital neurovascular flaps and techniques based on digital arterial branches have demonstrated that stable coverage with acceptable sensory recovery can be achieved, although this often comes at the cost of increased technical complexity and a higher requirement for surgical expertise.[28]

Among the strengths of this study are the use of real-world patient data and the simultaneous evaluation of multiple clinical factors within a population with a uniform injury mechanism. However, several important limitations should be acknowledged. First, the study is single-center with a relatively limited sample size, which may increase the risk of type II error in some subgroup analyses. Second, outcome assessment was performed using a researcher-developed numerical scale, and standardized validated international instruments such as FIOS were not employed.[24] Third, aesthetic outcomes were evaluated by a single observer; although this reduces interobserver variability, it may still introduce observer bias. Fourth, objective measurements such as two-point discrimination testing, assessment of protective sensation, and range of motion parameters were not recorded, despite the fact that sensory recovery is considered one of the key advantages reported in neurovascular techniques.[28, 29] Finally, if the exact timing of postoperative assessments and the duration of follow-up are not consistently documented, interpretation of pain and functional outcomes becomes more challenging.

Based on the findings of this study, patients with multi-digit injuries should be initially anticipated to experience greater pain and a more challenging rehabilitation course, and therefore pain management and rehabilitation protocols should be proactively tailored. In cases involving the fifth digit, particular attention to functional training, targeted rehabilitation, and monitoring of return-to-work status is recommended. Furthermore, from a practical standpoint, the results of this study support the design of referral pathways and surgical planning strategies aimed at minimizing delay, particularly within the first 24 hours after injury. Future studies are recommended to adopt multicenter designs with larger sample sizes, precise documentation of injury patterns based on standardized classifications, objective assessment of sensory and motor function, and the use of validated outcome measures such as FIOS, in order to more accurately estimate the independent effect of each variable.

Acknowledgement

The authors would like to thank the staff of Seyed Al-Shohada Hospital, Yazd, and the patients who cooperated during the follow-up process of this study.

Conflict of interest

The authors declare that there is no conflict of interest related to this study.

References

1 Conn JM, Annest JL, Ryan GW, Budnitz DS. Non-work-related finger amputations in the United States, 2001-2002. Ann Emerg Med. 2005 Jun;45(6):630-5. doi: 10.1016/j.annemergmed.2004.10.012. PMID: 15940097.

2. Daniel B.C. Reid, Kalpit N. Shah, Adam E.M. Eltorai, Christopher C. Got, Alan H. Daniels. Epidemiology of Finger Amputations in the United States From 1997 to 2016, Journal of Hand Surgery Global Online. 2019;1(2):45-51. DOI 10.1016/j.jhsg.2019.02.001.

3. Sorock GS, Lombardi DA, Hauser RB, Eisen EA, Herrick RF, Mittleman MA. Acute traumatic occupational hand injuries: type, location, and severity. J Occup Environ Med. 2002 Apr;44(4):345-51. doi: 10.1097/00043764-200204000-00015. PMID: 11977421.

4. Tang JB, Elliot D, Adani R, Saint-Cyr M, Stang F. Repair and reconstruction of thumb and finger tip injuries: a global view. Clin Plast Surg. 2014 Jul;41(3):325-59. doi: 10.1016/j.cps.2014.04.004. PMID: 24996458.

5. Peterson SL, Peterson EL, Wheatley MJ. Management of fingertip amputations. J Hand Surg Am. 2014 Oct;39(10):2093-101. doi: 10.1016/j.jhsa.2014.04.025. PMID: 25257490.

6. Lee DH, Mignemi ME, Crosby SN. Fingertip injuries: an update on management. J Am Acad Orthop Surg. 2013 Dec;21(12):756-66. doi: 10.5435/JAAOS-21-12-756. PMID: 24292932.

7. Pastor T, Hermann P, Haug L, Gueorguiev B, Pastor T, Vögelin E. Semi-occlusive dressing therapy versus surgical treatment in fingertip amputation injuries: a clinical study. Eur J Trauma Emerg Surg. 2023 Jun;49(3):1441-1447. doi: 10.1007/s00068-022-02193-6. Epub 2022 Dec 10. PMID: 36495343; PMCID: PMC10229690.

8. Esmaeil A, Al-Naseem AO, Lari A, Prada C. Semi-occlusive dressings for the management of fingertip amputations: A systematic review. J Hand Microsurg. 2025 Mar 1;17(3):100241. doi: 10.1016/j.jham.2025.100241. PMID: 40182737; PMCID: PMC11964534.

9. Rabarin F, Saint Cast Y, Jeudy J, Fouque PA, Cesari B, Bigorre N, Petit A, Raimbeau G. Cross-finger flap for reconstruction of fingertip amputations: Long-term results. Orthop Traumatol Surg Res. 2016 Jun;102(4 Suppl):S225-8. doi: 10.1016/j.otsr.2016.03.006. Epub 2016 Mar 28. PMID: 27033841.

10. Garg R, Shah S, Uppal S, Mittal RK, Thakur B, Rafique S. Modified mid palmar flap for middle finger tip injuries: A review of 12 cases. Journal of Orthopedics, Traumatology and Rehabilitation. 2019;11(1):27-30. DOI: 10.4103/jotr.jotr_9_19

11. Orbay JL, Rosen JG, Khouri RK, Indriago I. The glabrous palmar flap: the new free or reversed pedicled palmar fasciocutaneous flap for volar hand reconstruction. Tech Hand Up Extrem Surg. 2009 Sep;13(3):145-50. doi: 10.1097/BTH.0b013e3181ac9183. PMID: 19730044.

12. FUSCO EM. Fingertip reconstruction with palmar skin flaps. Am J Surg. 1954 Apr;87(4):608-11. doi: 10.1016/0002-9610(54)90423-7. PMID: 13138803.

13. Gatewood G. A plastic repair of finger defects without hospitalization. J JAMA. 1926;87(18):1479. Doi: 10.1001/jama.1926.92680180002013a

14. Barbato BD, Guelmi K, Romano SJ, Mitz V, Lemerle JP. Thenar flap rehabilitated: a review of 20 cases. Ann Plast Surg. 1996 Aug;37(2):135-9. doi: 10.1097/00000637-199608000-00003. PMID: 8863971.

15. Melone CP Jr, Beasley RW, Carstens JH Jr. The thenar flap--An analysis of its use in 150 cases. J Hand Surg Am. 1982 May;7(3):291-7. doi: 10.1016/s0363-5023(82)80182-2. PMID: 7086099.

16. Huded V, Gautam G. Thenar Flap: A Workhorse Flap for Fingertip Injuries. Cureus. 2025 Aug 23;17(8):e90785. doi: 10.7759/cureus.90785. PMID: 40988782; PMCID: PMC12451407.

17. Kuwahara Y, Hara T, Kurahashi T, Kitami T, Tatebe M. Comparing clinical and aesthetic outcomes of cross-finger and homodigital reverse digital artery island flap for fingertip injuries: A single-center retrospective cohort study. J Plast Reconstr Aesthet Surg. 2024 Aug;95:411-418. doi: 10.1016/j.bjps.2024.03.019. Epub 2024 Apr 22. PMID: 38734540.

18. Cuschieri S. The STROBE guidelines. Saudi J Anaesth. 2019 Apr;13(Suppl 1):S31-S34. doi: 10.4103/sja.SJA_543_18. PMID: 30930717; PMCID: PMC6398292.

19. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP; STROBE Initiative. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. J Clin Epidemiol. 2008 Apr;61(4):344-9. doi: 10.1016/j.jclinepi.2007.11.008. PMID: 18313558.

20. Fassler PR. Fingertip Injuries: Evaluation and Treatment. J Am Acad Orthop Surg. 1996 Jan;4(1):84-92. doi: 10.5435/00124635-199603000-00003. PMID: 10795040.

21. World Medical Association. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. JAMA. 2013 Nov 27;310(20):2191-4. doi: 10.1001/jama.2013.281053. PMID: 24141714.

22. Zhao W, Song KX, Ma BD, Liu YT. Clinical application of the free superficial palmar branch of radial artery flap for soft-tissue reconstruction of distal digital injury. J Orthop Surg Res. 2024 Sep 9;19(1):553. doi: 10.1186/s13018-024-05041-y. PMID: 39252052; PMCID: PMC11382396.

23. Chung KC, Yoon AP, Malay S, Shauver MJ, Wang L, Kaur S; FRANCHISE Group. Patient-Reported and Functional Outcomes After Revision Amputation and Replantation of Digit Amputations: The FRANCHISE Multicenter International Retrospective Cohort Study. JAMA Surg. 2019 Jul 1;154(7):637-646. doi: 10.1001/jamasurg.2019.0418. PMID: 30994871; PMCID: PMC6583841.

24. Jerome JTJ, Malshikare VA. Fingertip Injuries Outcome Score. Plast Reconstr Surg Glob Open. 2022 Jun 16;10(6):e4386. doi: 10.1097/GOX.0000000000004386. PMID: 35733925; PMCID: PMC9203073.

25. Ash M, Wang J, Menon A, Brown C, Ghareeb P. Time to Amputation After Traumatic Digital Injury Does Not Affect Complication Rates: A Retrospective Multi-Institutional Analysis. Hand (N Y). 2026 Feb;21(2):218-222. doi: 10.1177/15589447241302360. Epub 2024 Dec 17. PMID: 39690829; PMCID: PMC11653370.

26. Tos P, Crosio A, Adani R. Fingertip injuries and their reconstruction, focusing on nails. Hand Surg Rehabil. 2024 Apr;43S:101675. doi: 10.1016/j.hansur.2024.101675. Epub 2024 Mar 1. PMID: 38432516.

27. Foucher G, Delaere O, Citron N, Molderez A. Long-term outcome of neurovascular palmar advancement flaps for distal thumb injuries. Br J Plast Surg. 1999 Jan;52(1):64-8. doi: 10.1054/bjps.1997.3005. PMID: 10343593.

28. Kim KS, Yoo SI, Kim DY, Lee SY, Cho BH. Fingertip reconstruction using a volar flap based on the transverse palmar branch of the digital artery. Ann Plast Surg. 2001 Sep;47(3):263-8. doi: 10.1097/00000637-200109000-00008. PMID: 11562030.

29. O'Brien B. Neurovascular island pedicle flaps for terminal amputations and digital scars. Br J Plast Surg. 1968 Jul;21(3):258-61. doi: 10.1016/s0007-1226(68)80033-5. PMID: 4877607.