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ORIGINAL ARTICLE

Treatment-related and clinical predictors of extended recovery after fingertip injury: a single-centre experience

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ABSTRACT

Aim To evaluate whether treatment approach and Allen's classification are associated with treatment duration after fingertip injury and to identify predictors of prolonged recovery.
Methods We retrospectively reviewed 91 patients treated for fingertip injuries at Cantonal Hospital Zenica (January 2024 – December 2024). Injuries were classified using Allen's system, and treatment duration was grouped as 7–25, 26–35, or 36–90 days.
Results The cohort was predominantly male (89.0%), with a median age of 47 years (IQR 36–71). Median treatment duration was 24 days (IQR 15–33). Longer treatment duration was associated with exposed distal phalanx ($p = 0.016$), type 2 diabetes mellitus ($p < 0.001$), and treatment approach ($p < 0.001$). In multivariable analysis, osteosynthesis compared with suture (OR 2.95, 95% CI 1.30–12.63) and type 2 diabetes mellitus (OR 3.78, 95% CI 1.22–11.72) were associated with prolonged treatment in exploratory multivariable analysis (36–90 days).
Conclusion Treatment approach and selected comorbidities should be considered alongside injury classification when anticipating recovery duration; however, the findings should be interpreted cautiously because of the limited number of prolonged-treatment events and diabetic patients.

Keywords: finger injuries, postoperative complications, prognosis, surgical procedures

INTRODUCTION

The hand is a highly valuable part of the human body, serving as a critical tool in non-verbal communication, social interaction, and productivity (1). The fingertip, defined anatomically as the portion distal to the insertion of the flexor digitorum superficialis and extensor tendons at the distal phalanx (or interphalangeal joint in the thumb), plays a central role in tactile and sensory function. It consists of pulp, distal phalanx, nail bed, nail plate, germinal matrix, and tendon insertions. The neurovascular supply of the fingertip is derived from digital arteries and nerves, which form a dense anastomotic network near the distal interphalangeal joint (2–5).

Fingertip injuries are the most common type of amputation and can lead to substantial social and economic consequences. Treatment depends on defect orientation, size, and involvement of bone, nail, and tendons. Conservative management is appropriate for soft-tissue defects <1 cm², while larger injuries typically require surgical management, including local or free flaps (6–8). The Allen classification system divides injuries into four types: Type I (pulp only), Type II (pulp and nail), Type III (partial distal phalanx loss), and Type IV (injury proximal to the lunula) (9,10). While the Allen classification is commonly employed to describe the level of fingertip injuries, its utility as a predictor of recovery duration has not been clearly established. Moreover, no studies on this topic have been conducted in Bosnia and Herzegovina.

The aim of this study was to evaluate whether treatment approach and Allen's classification are associated with treatment duration after fingertip injury and to identify predictors of prolonged recovery.

MATERIAL AND METHODS

Subjects and study design

This retrospective study included 91 patients treated at the Department of Plastic and Reconstructive Surgery, Cantonal Hospital Zenica, between 1 January and 31 December 2024.

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The study included patients of both sexes across all age groups, regardless of the mechanism of injury, level of injury according to the Allen classification, or work environment, encompassing both isolated fingertip injuries and those involving one or more fingertips. Patients were excluded if they had associated injuries to other parts of the hand, wrist, or forearm, oblique fingertip amputations, or if only descriptive radiographic (X-ray) images were available without proper image representation, due to the potential for error or bias in monitoring and classification.

Ethical approval was obtained from the Ethics Committee of the Cantonal Hospital Zenica.

Methods

Patient data were extracted using the hospital's electronic system and the protocol of the Department of Plastic and Reconstructive Surgery, Cantonal Hospital Zenica, and included information on age, sex, and mechanism of injury, as well as X-ray images and type of treatment.

Treatment duration was defined as the number of days from the initial injury-related presentation to the date of clinical wound healing (complete epithelialization without the need for dressings), as recorded in the medical charts.

The patient's radiographs were reviewed using the Xero Universal Viewer (Agfa HealthCare, Mortsel, Belgium), and radiological data were collected from the hospital database or from portable media.

The severity of the injury was assessed using Allen's classification, which categorizes fingertip amputations based on the level of tissue loss. Allen Type 1 involves injury limited to the distal fingertip pulp without nail involvement; Type 2 includes loss of the pulp with partial nail bed involvement; Type 3 extends to the distal phalanx, often with significant nail bed loss; and Type 4 represents complete amputation of the distal phalanx including the nail and, in some cases, bone (11,12).

Treatment was guided by defect size and bony exposure. Conservative management was used for soft-tissue defects <1 cm² without exposed distal phalanx, whereas larger defects typically required surgical management (6–8). Primary closure was performed when tension-free approximation was feasible after appropriate debridement, while defects > 2 cm^2 or those unsuitable for primary closure were reconstructed using local flaps or skin grafts. The category "flap, graft, or other" included local flap reconstruction, skin grafting, and other soft-tissue reconstructive procedures recorded in the operative notes. In cases of distal phalanx fracture requiring stabilization, osteosynthesis with a Kirschner wire was performed.

Patients were followed for three months after injury. Follow-up evaluation included clinical wound assessment and documentation of complications (infection, necrosis, delayed healing, and need for reintervention).

Statistical analysis

Categorical variables were presented as frequencies and percentages, and continuous variables as median and interquartile range (IQR). The cut-offs were selected to reflect both the empirical distribution of treatment duration (median 24 days; IQR 15–33 days) and clinical interpretability. Specifically, 7–25 days represented shorter-than-median recovery, 26–35 days captured intermediate recovery around the upper quartile, and 36–90 days represented delayed recovery beyond the typical healing window in this cohort. Differences across treatment-duration groups were assessed using Pearson's χ^2 test (or Fisher's exact test when appropriate) for categorical variables and the Kruskal-Wallis test for continuous variables. Univariate and multivariate logistic regression analyses were performed to identify factors associated with prolonged treatment (36–90 days). Because the number of prolonged-treatment events was limited, the multivariable analysis was interpreted as exploratory because of the limited number of prolonged-treatment events and the number of covariates included. Statistical significance was set at $p < 0.05$.

RESULTS

Ninety-one patients were included. Median age was 47 years (IQR 36–71), and 81 (89.0%) were male. Median treatment duration was 24 days (IQR 15–33). Most injuries involved exposed distal phalanx, with 58 of 91 cases (63.7%), and the most frequent treatment categories were flap, graft, or other procedures in 34 of 91 cases (37.4%), followed by suture in 32 of 91 cases (35.2%) and osteosynthesis in 25 of 91 cases (27.5%) (Table 1).

Table 1. Baseline, clinical and treatment data of included patients

Variable	**Cohort (N = 91)**
	Median (IQR)
Age (years)	47 (36–71)
	N (%)
Age categories	
<30 years	17 (18.7)
31–50 years	33 (36.3)
51–60 years	22 (24.2)
61–70 years	14 (15.4)
>70	5 (5.5)
Sex	
Female	10 (11.0)
Male	81 (89.0)
Social status	
Employed	52 (57.1)
Unemployed	11 (12.1)
Retired	21 (23.1)
Aged <18	7 (7.7)
Comorbidities	
Hypertension	16 (17.6)
Diabetes mellitus type 2	5 (5.5)
Other	7 (7.7)
Allen's class	
1	6 (6.6)
2	30 (33.0)
3	29 (31.9)
4	26 (28.6)
Injury mechanism	
Cutting/tearing	60 (65.9)
Contusion	31 (34.1)
Exposed distal phalanx	
Yes	58 (63.7)
No	33 (36.3)
Treatment approach	
Osteosynthesis (internal fixation)	25 (27.5)
Suture	32 (35.2)
Flap, graft, or other	34 (37.4)
Duration of treatment groups	
7–25 days	51 (56.0)
26–35 days	22 (24.2)
36–90 days	18 (19.8)
	Median (IQR)
Duration of treatment (days)	24 (15.0–33.0)

Table 2. Distribution of observed variables among treatment duration groups

Variable		Treatment duration groups			Test statistic*	*p*
		7–25 days (N = 51)	26–35 days (N = 22)	36–90 days (N = 18)		
Baseline patients' data		N%				
Sex	Female	7 (13.7)	3 (13.6)	0 (0.0)	2.779	0.250
	Male	44 (86.3)	19 (86.4)	18 (100.0)		
Age categories	<30 years	11 (21.6)	4 (18.2)	2 (11.1)	14.645	0.066
	31–50 years	12 (23.5)	14 (63.6)	7 (38.9)		
	51–60 years	15 (29.4)	1 (4.5)	6 (33.3)		
	61–70 years	9 (17.6)	2 (9.1)	3 (16.7)		
	>70	4 (7.8)	1 (4.5)	0 (0.0)		
Social status	Employed	27 (52.9)	12 (54.5)	13 (72.2)	6.006	0.423
	Unemployed	7 (13.7)	4 (18.2)	0 (0.0)		
	Retired	12 (23.5)	4 (18.2)	5 (27.8)		
	Aged <18	5 (9.8)	2 (9.1)	0 (0.0)		
Comorbidities						
Hypertension		11 (21.6)	3 (13.6)	2 (11.1)	1.316	0.518
DM2		0 (0.0)	0 (0.0)	5 (27.8)	21.461	<0.001
Other		4 (7.8)	2 (9.1)	2 (11.1)	0.180	0.914
Clinical findings						
Allen's classes	1	5 (9.8)	1 (4.5)	0 (0.0)	7.760	0.256
	2	20 (39.2)	4 (18.2)	6 (33.3)		
	3	12 (23.5)	11 (50.0)	6 (33.3)		
	4	14 (27.5)	6 (27.3)	6 (33.3)		
Injury mechanism	Cutting/tearing	34 (66.7)	15 (68.2)	11 (61.1)	0.248	0.883
	Contusion	17 (33.3)	7 (31.8)	7 (38.9)		
Exposed distal phalanx	Yes	26 (51.0)	17 (77.3)	15 (83.3)	8.325	0.016
	No	25 (49.0)	5 (22.7)	3 (16.7)		
Treatment-related data						
Treatment approach	Osteosynthesis (internal fixation)	7 (13.7)	13 (59.1)	5 (27.8)	20.195	<0.001
	Suture	23 (45.1)	6 (27.3)	3 (16.7)		
	Flap, graft, or other	21 (41.2)	3 (13.6)	10 (55.6)		

DM2, diabetes mellitus type 2; *, Pearson's χ^2 test or Fisher's exact test was used as appropriate.

Among the variables compared across treatment-duration groups, three showed statistically significant differences (Table 2). Type 2 diabetes mellitus was observed only in the 36–90-day group, with no cases in the 7–25-day group, no cases in the 26–35-day group, and 5 of 18 cases (27.8%) in the 36–90-day group ($p < 0.001$). Distal phalanx exposure became more frequent with longer treatment duration, occurring in 26 of 51 cases (51.0%) in the 7–25-day group, 17 of 22 cases (77.3%) in the 26–35-day group, and 15 of 18 cases (83.3%) in the 36–90-day group ($\chi^2 = 8.325$, $p = 0.016$). Treatment approach also differed significantly across the groups ($\chi^2 = 20.195$, $p < 0.001$). Other baseline and clinical variables did not differ significantly among the treatment-duration groups.

In univariate analyses (Table 3), DM2 (OR = 2.95, 95% CI: 1.10–7.90, $p = 0.032$), exposed distal phalanx (OR = 3.79, 95% CI: 1.49–9.61, $p = 0.005$), and osteosynthesis versus suture (OR = 4.13, 95% CI: 1.48–11.49, $p = 0.006$) were associated with prolonged treatment (36–90 days). In the multivariate model adjusting for age, sex, social status, hypertension, Allen class, mechanism, and exposed distal phalanx, DM2 (OR = 3.78, 95% CI: 1.22–11.72, $p = 0.021$) and osteosynthesis (OR = 2.95, 95% CI: 1.30–12.63, $p = 0.011$) remained independent predictors of prolonged treatment in this exploratory model, whereas exposed distal phalanx lost significance (OR = 2.53, 95% CI: 0.39–16.19, $p = 0.328$). All other covariates, including age categories, sex, social status, hypertension, other comorbidities, Allen's classification, and contusion mechanism, were not significantly associated with prolonged treatment in either analysis (all $p > 0.05$).

DISCUSSION

This single-centre study examined factors associated with prolonged recovery after fingertip injury and, to our knowledge, represents the first report from Bosnia and Herzegovina addressing this question. In our cohort, recovery duration was influenced more by treatment approach and selected clinical factors than by Allen's anatomical classification alone.

The main aims in fingertip injury management remain pain-free coverage, durable sensibility, and an acceptable appearance. While distal interphalangeal joint motion may not fully return, this is often well tolerated, and recovery is more meaningfully captured by functional scores and two-point discrimination targets (13). Given that fingertip injuries are common across age groups and represent a frequent form of distal digital amputation (14), practical predictors of recovery time are important for counselling and planning return to activity.

Although the Allen classification is useful for describing injury level, it does not reflect key determinants of healing and rehabilitation, including defect configuration, exposed bone, and the reconstructive method selected. Our results support an approach in which treatment is tailored to the clinical presentation

Table 3. Prediction of prolonged treatment of fingertip injury (36–90 days) based on univariate and multivariate regression analysis

Variable		Univariate regression analysis		Multivariate regression analysis	
		OR (95% CI)	*p*	OR (95% CI)	*p*
Sex	Female	referent category			
	Male	2.34 (0.59–9.27)	0.225	1.58 (0.29–8.63)	0.598
Age categories	<30 years	referent category			
	31–50 years	2.23 (0.70–7.03)	0.172	0.98 (0.18–5.29)	0.980
	51–60 years	1.03 (0.27–3.91)	0.969	0.61 (0.09–4.18)	0.617
	61–70 years	1.08 (0.25–4.65)	0.919	0.22 (0.01–3.42)	0.281
	>70	0.40 (0.04–4.30)	0.448	0.06 (0.00–1.66)	0.097
Social status	Employed	referent category			
	Unemployed	0.48 (0.13–1.72)	0.259	0.36 (0.08–1.76)	0.208
	Retired	0.84 (0.31–2.26)	0.728	3.18 (0.57–17.79)	0.188
	Aged <18	0.36 (0.07–1.91)	0.229	0.34 (0.03–3.32)	0.351
Hypertension*		0.52 (0.17–1.61)	0.256	0.77 (0.18–3.25)	0.719
DM2*		2.95 (1.10–7.90)	0.032	3.78 (1.22–11.72)	0.021
Allen's classes	1	referent category			
	2	2.96 (0.31–28.38)	0.345	1.60 (0.13–19.15)	0.712
	3	6.37 (0.68–59.26)	0.103	1.92 (0.16–23.34)	0.610
	4	4.78 (0.50–45.67)	0.174	1.86 (0.14–24.61)	0.636
Mechanism of injury	Cutting/tearing	referent category			
	Contusion	1.13 (0.49–2.62)	0.769	1.26 (0.44–3.62)	0.671
Exposed distal phalanx		3.79 (1.49–9.61)	0.005	2.53 (0.39–16.19)	0.328
Treatment approach	Osteosynthesis (internal fixation)	4.13 (1.48–11.49)	0.006	2.95 (1.30–12.63)	0.011
	Suture	referent category			
	Flap, graft, or other	2.04 (0.72–5.73)	0.177	0.94 (0.14–6.40)	0.948

DM2, diabetes mellitus type 2; OR, odds ratio; CI, confidence interval; * referent category: No.

and functional needs rather than guided by classification alone (15). Patient-related factors, particularly work demands and comorbidities, may further shape recovery trajectories (16,17).

In our cohort, treatment duration most commonly ranged from 7 to 25 days, which is consistent with published data on fingertip amputation treatment protocols (18). Type 2 diabetes mellitus occurred only among patients with the longest treatment duration, which is biologically plausible given impaired wound healing and increased infection susceptibility in diabetes (19,20). However, this finding should be interpreted cautiously because only five patients had type 2 diabetes mellitus, all of whom were in the prolonged-treatment group. In addition, the need for osteosynthesis was associated with prolonged recovery, likely reflecting greater injury complexity and the added requirements of bone stabilization and postoperative protection.

Limitations of this study include the retrospective single-centre design with a moderate sample size, which may limit generalizability. The number of prolonged-treatment events was limited, and only five patients had type 2 DM; therefore, the regression findings should be considered exploratory and interpreted with caution. Follow-up was limited to three months, and longer-term functional, sensory, and patient-reported outcomes were not evaluated.

CONCLUSION

In conclusion, Allen classification remains useful for anatomical description, but in this cohort it was not independently associated with prolonged treatment duration. Prolonged recovery appeared to be more closely related to operative requirements, particularly osteosynthesis, and patient factors such as type 2 diabetes mellitus. Given the limited number of prolonged-treatment events and diabetic patients, these findings should be interpreted as exploratory and confirmed in larger studies.

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CONFLICTS OF INTEREST

None to declare.

ETHICS STATEMENT

The study protocol was reviewed and approved by the Ethical Committee of Cantonal Hospital Zenica (approval number: 00-03-35-76-12/25). The requirement for written informed consent was waived.

DATA AVAILABILITY STATEMENT

The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

AUTHOR CONTRIBUTIONS (CRediT)

Conceptualization: A.A., E.B.; **Data curation:** E.B.; **Formal analysis:** A.A., E.B., A.K., S.K.; **Investigation:** A.A., E.B., A.K.; **Methodology:** A.A., E.B., A.K., I.S., S.K., M.H.; **Project administration:** I.S., S.K., M.H.; **Resources:** I.S., M.H.; **Software:** E.B.; **Supervision:** E.B., A.K.; **Validation:** A.A., E.B., I.S.; **Visualization:** A.A., E.B.; **Writing – original draft:** A.A., E.B.; **Writing – review & editing:** A.A., E.B., A.K. All authors have read and agreed to the published version of the manuscript.

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