Evaluation of Occupational Crush Fractures of the Hand and Time Off Work

MARGARET R. WANG, BS; TIMOTHY JENG, BA; ISHAN SHAH, BS; NIKHIL SOBTI, MD; ERNEST DIMBO, MPhil; MATTHEW LEE, BA; REENA A. BHATT, MD

ABSTRACT

BACKGROUND: Occupational injuries of the hand are a major cause of disability. This study analyzes crush injury fractures of the hand and resultant time off work at a Level I Trauma Center in Providence, Rhode Island.

METHODS: Adult patients presenting to the emergency department with acute fractures to the metacarpals or phalanges following occupational hand crush injuries between July 2011 and June 2023 were retrospectively identified. Patients were evaluated for demographic variables, injury patterns, treatment, and time to return to work (RTW). Bivariate and multivariate regression analyses assessed RTW in relation to covariates with a significance level set at <0.05.

RESULTS: One hundred and thirty-five (135) patients met study criteria, of which the mean age of presentation was 42.4. Almost all patients were engaged in manual labor (n = 123, 91.1%); 78.5% of injuries were open fractures (n = 106), 20.0% were intra-articular (n = 27) and 54.8% were comminuted (n = 74). Amputation injury occurred in 30.4% (n = 41) of cases. One-third, (n = 45, 33.3%) required surgery. The median RTW was 67.5 days post-injury. Regression analysis demonstrated that Hispanic/Latino ethnicity, increased age, intra-articular fractures and middle phalanx and metacarpal fractures were significantly associated with longer RTW.

CONCLUSION: Occupational hand crush fractures are associated with considerable time off work, with a median of 67.5 days demonstrated in our cohort. Several factors may be associated with prolonged RTW, including older age and more complex injury patterns. These findings underscore the importance of providing equitable care to facilitate timely RTW._

KEYWORDS: Occupational hand injury; hand crush injury; return to work; retrospective study

INTRODUCTION

Hand injuries are common injuries that are a major cause of disability worldwide, with many occurring in occupational settings.[1-4] Crush injuries, often due to industrial machinery with high energy mechanisms, can result in complex and severe injuries to the hand.[5,6] Such injuries can impair a worker's daily and occupational function and lead to significant time out of work, in some cases leading to permanent disability.[7-9] In the United States, Worker's Compensation Insurance covers both medical care as well as compensation for lost time and is associated with high costs.[10-12]

A multitude of factors affect Return to Work (RTW) after hand injury, including pain, physical hand function and socioeconomic pressure. Demographic factors and occupational factors have also been found to be associated with RTW after occupational injury in previous studies.[13,14] Despite hand injuries being a common occupational injury presenting to the Emergency Department, the epidemiology and individual burden have not been well characterized.[7,15,16] This study analyzes the mechanisms and sequelae influencing RTW following hand fractures due to occupational crush injury at a tertiary academic hospital located in a mid-sized city in the northeastern United States. We hypothesize that while injury severity likely correlates with lengthened recovery, there are also socioeconomic drivers that affect return to work outcomes following occupational hand injury.

METHODS

Data Collection

A retrospective medical record review was conducted of patients who presented to the Emergency Department (ED) with hand crush injuries seen by the Plastic Surgery Hand Service between July 2011 and June 2023 at Rhode Island Hospital in Providence, Rhode Island. Study inclusion criteria consisted of adult patients with acute fracture injuries limited to the hand, where injuries occurred in an occupational setting. Injuries that did not result in acute fractures as seen on radiographical imaging or injuries that extended beyond the hand (i.e., proximal to the metacarpals) were excluded. Polytrauma injuries were also excluded. Patients' records were evaluated for demographics including occupation, language spoken, injury mechanism and pattern, treatment required including ED procedures and surgeries, and follow-up duration. Manual labor was defined as any occupation that primarily involves physical and repetitive tasks, including those in the manufacturing, construction, transport, warehouse and food service industries. Estimated time to return to work (RTW) data was gathered from medical documentation, including physician completed Worker's Compensation reports. For those who remained out of work

at last follow-up appointment due to functional impairment, RTW date was estimated using medical documentation of work clearance when available. For those that had yet to achieve work clearance, the last follow-up date was used as the return-to-work date. All aspects of this study were approved by the authors' Institutional Review Board (#1683478).

Data Analysis

Bivariate and multivariate regression analyses were conducted to assess return to work duration in relation to injury patterns and surgical intervention. Shapiro-Wilk tests were used to evaluate normality, and non-parametric tests were used to compare RTW times between groups. Linear regression models were used to assess predictors of lengthened time to RTW. All statistical analysis was completed at a significance level of 0.05 using IBM SPSS Version 29 (Armonk, NY).

RESULTS

Patient Demographics

Three-hundred-fifty-seven (357) patients were reviewed, of which 135 occupational crush injuries were identified per study criteria. The median age of presentation was 42 years old, with a range from 19 to 71. The average age of presentation was 42.4 (SD 13.3). 85.9% of patients were male (n = 116) and 14.1% were female (n = 19); 51.5% of patients identified as White (n = 69), 9.6% identified as Black (n = 13), 3.0% as Asian (n = 4) and 36.3% (n = 49) as other. In terms of ethnicity, 32.6% (n = 44) identified as Hispanic or Latino; 37.0% of patients (n = 50) did not have documented health insurance, while 34.1% (n = 46) possessed commercial insurance and 28.9% had public insurance (n = 39) including Medicaid and Medicare. Worker's compensation claims were documented in 74.8% of cases (n = 101). In terms of English language proficiency, 21.5% (n = 29) were documented as requiring an interpreter. The majority of patients with limited English proficiency were of Hispanic/Latino ethnicity (n = 23. 79.3%).

A past medical history of diabetes was documented in 7.4% (n = 10), and 43.0% (n = 58) of patients were either current or former smokers. Right-hand dominance was noted in 85.2% (n = 115), and 7.4% (n = 10) were left-hand dominant. Two patients (1.4%) were noted as ambidextrous and eight patients (5.9%) did not have documentation of hand dominance. Descriptive statistics for patient demographics are detailed in **Table 1**.

In terms of patient employment, 91.1% (n = 123) of patients were engaged an occupation associated with manual labor. The largest occupational sectors represented were manufacturing (n = 43, 31.8%), maintenance and repair, including automotive repair (n = 22, 16.3%), transportation and warehouse work (n = 21, 15.6%), and construction (n = 18, 13.3%). Distribution of patient occupation is detailed in **Table 1**.

Table 1. Demographics and Occupational Variables of Entire Cohort (N = 135)

Age at presentation	
Mean (±SD)	42.4±13.3
Median (Range)	42 (19–71)
Sex (n, %)	
Male	116 (85.9%)
Female	19 (14.1%)
Race (n, %)	
White	69 (51.1%)
Black	13 (9.6%)
Asian	4 (3.0%)
Other	49 (36.3%)
Ethnicity (n, %)	
Hispanic or Latinx	91(67.4%)
Non-Hispanic or Latinx	44 (32.6%)
Limited English Proficiency	29 (21.5%)
Insurance (n, %)	
Private	46 (34.1%)
Public (Medicaid, Medicare)	39 (28.9%)
No Insurance	50 (37.0%)
Past Medical History (n, %)	
Diabetes	10 (7.4%)
Hypertension	32 (23.7%)
Positive Smoking History	58 (43.0%)
Hand Dominance (n, %)	
Right	115 (85.2%)
Left	10 (7.4%)
Ambidextrous	2 (1.4%)
Unknown	8 (5.9%)
Worker's Compensation Claim (n, %)	101 (74.8%)
Manual Laborer (n, %)	123 (91.1%)
Occupational Sector (n, %)	
Construction	18 (13.3%)
Manufacturing	43 (31.8%)
Transportation/Warehouse	21 (15.6%)
Maintenance/Repair	22 (16.3%)
Food Service/Production	8 (5.9%)
Fisheries	3 (2.2%)
Forestry	1 (0.7%)
Healthcare	2 (1.5%)
Hospitality	1 (0.7%)
Administration	2 (1.4%)
Education	2 (1.4%)
Not recorded	2 (1.5%)

Table 2. Injury Characteristics and Management of Entire Cohort (N = 135)

Variable	Number of Patients (n, %)
Injury Laterality	
Right	74 (54.1%)
Left	60 (44.4%)
Bilateral	2 (1.5%)
Dominant Hand Injury	70 (51.9%)
Open fracture	106 (78.5%)
Comminuted fracture	74 (54.8%)
Intra-articular Fracture	27 (20.0%)
Amputation Injury	41 (30.4%)
Complete Amputation	18 (13.3%)
Partial Amputation	24 (17.8%)
Distal Phalanx Fracture	104 (77.0%)
Tuft Fracture	85 (63.0%)
Middle Phalanx Fracture	13 (9.6%)
Proximal Phalanx Fracture	20 (14.8%)
Metacarpal Fracture	13 (9.6%)
Extensor or Flexor Tendon Injury	11 (8.1%)
Flexor Tendon Injury	2 (1.5%)
Extensor Tendon Injury	9 (6.7%)
Number of Fingers Fractured	
One	117 (86.7%)
Two	14 (10.4%)
Three	3 (2.2%)
Four	1 (0.7%)
Finger Fractured	
Thumb	16 (11.9%)
Second	28 (20.7%)
Third	30 (22.2%)
Fourth	28 (20.7%)
Fifth	15 (11.1%)
Multiple Fingers	18 (13.3%)
Machine Injury	63 (46.7%)
Door Injury	13 (9.6%)
Management Technique	
Any ED Procedure	111 (82.2%)
ED Amputation Revision	27 (20.0%)
Any OR Procedure	45 (33.3%)
OR Reduction and Fixation	29 (21.5%)
OR Amputation Revision	10 (7.4%)
ED to OR Amputation Revision	8 (5.9%)
Flexor or Extensor Tendon Repair	8 (5.9%)
Occupational Therapy Participation	74 (54.8%)

Injury Patterns

The right hand was injured in 54.1% (n = 74) of cases, while 44.4% (n = 60) involved the left. Two cases (1.5%) involved both hands. Over half of patients injured their dominant hand (51.9%, n = 70). Most patients presented within a day of injury (90.4%, n = 123), with all remaining patients presenting after one day (9.6%, n = 13). The most commonly fractured structure was the distal phalanx, involved in 77.0% (n = 104) of cases. Of these, 81.7% (n = 85) were tuft fractures. Injuries proximal to the distal phalanx, involving the middle, distal phalanx, metacarpals, were seen in 26.7% of cases (n = 36). Specifically, there were 13 (9.6%) middle phalanx fractures, 20 (14.8%) proximal phalanx fractures and 13 (n = 9.6%) metacarpal fractures. Amputation injury occurred in 30.4% (n = 41) of cases, with 24 partial amputations and 18 complete amputation injuries. There were 11 (8.1%) patients that had a concurrent flexor or extensor tendon injury, with two (1.5%) flexor tendon injuries and nine (6.7%) extensor tendon injuries. The majority of fractures were described as open (78.5%, n = 106), while 54.8% were described as comminuted fractures (n = 74). Intra-articular involvement was described in 20.0% of cases (n = 27).

Most patients injured one finger (77.2%, n = 105), while 19.1% injured two fingers (n= 26). Four patients injured three fingers (2.9%). One patient injured four fingers (n = 1, 0.7%). Of patients that injured one finger, the most frequently fractured finger was the middle finger (n = 30, 22.2%) followed by the second (n = 28, 20.7%) and fourth fingers (n = 28, 20.7%). In terms of injury mechanism, industrial machinery was involved in 46.7% (n = 63) of cases. Descriptive statistics for injury characteristics are detailed in **Table 2.**

Management, Procedures and Surgeries

One-third of patients (33.3%, n = 46) required surgical repair while 82.2% (n = 111) required an ED procedure including reduction, washout and closure or revision amputation. Twenty-seven (27) amputation revisions were performed in the ED. In the operating room (OR)there were 10 amputation revisions, 29 OR reduction and fixations and eight extensor or flexor tendon repairs. Eight patients that underwent ED amputation revision required subsequent OR revision. There were a total of 72 surgeries completed across the 45 patients that required surgery, an average of 1.6 surgeries per patient (range 1–5). For surgical reduction and fixation, 96.5% of patients (n = 28) underwent Kirschner wire (K-wire) fixation. In patients with metacarpal fractures (n = 13), six (46.2%) patients underwent K-wire fixation, one patient (7.7%) underwent fixation with an intramedullary screw, and the rest were managed non-operatively (n = 4, 30.8%). All patients were treated with standardized post-operative immobilization, finger vs. short arm splint with digits held in intrinsic plus as indicated. In terms of occupational/hand therapy (OT), 54.8% (n = 74) of patients had documented OT participation. Descriptive statistics for management technique are detailed in **Table 2.**

Table 3. Descriptive Statistics: Time to Return to Work and Follow-Up Duration

	Time to Return to Work (Days)	Follow-Up Duration (Days)
Number of Patients	100	135
Mean ± SD	118.9±160.2	144.8±242.6
Median (IQR)	67.5 (33.0–146.8)	62.0 (12.–161.0)
Range	0–934	0–1623

Return to Work

Overall, 74.0% (n = 100) of patients had a RTW date recorded, with a median of 67.5 (IQR 113.75) days post-injury, average of 118.9 days (SD 160.2) and range of 0 to 934 days. Patients had a median follow-up time of 62 (IQR 149) days, average of 144.8 days (SD 242.6) and range 0 to 1623 days. Six patients remained unable to work due to functional impairment at last follow-up appointment. Descriptive statistics for RTW and follow-up times are detailed in **Table 3.** Of note, increased RTW is defined as increased time to return to work in results reported below.

Statistical Analysis

RTW time was not found to be normally distributed ($p < 0.001$). Mann Whitney U tests demonstrated significantly increased RTW duration in patients who identified as Hispanic or Latino compared to those who did not identify as Hispanic or Latino ($U = 1423.5$, $Z = 2.194$, $p = 0.028$). Increased RTW duration was demonstrated in patients with intra-articular fractures ($U = 1103.0$, $Z = 2.315$, $p = 0.021$), comminuted fractures ($U = 1556.5$, $Z = 2.148$, $p = 0.032$) and metacarpal fractures ($U = 845.0$, $Z = 2.865$, $p = 0.004$). Increased RTW was also demonstrated in patients undergoing ED revision amputation ($U = 1138.5$, $Z = 2.073$, $p = 0.038$) and those requiring operative intervention ($U = 1870.5$, $Z = 4.718$, $p < 0.001$). Age at presentation was found to be positively correlated to RTW time (Pearson's Correlate: 0.233, $p = 0.020$). There was no significant difference in RTW found between race, insurance status, smokers vs. non-smokers and those with diabetes vs. no diabetes. There were no differences

Table 4. Comparing Return to Work (RTW) across different variables for patients with RTW to work date (N = 100). Mann-Whitney U tests conducted at a significance of $p < 0.05$.

	Groups	N	Median (IQR)	Mean Rank	U	Z	P
Ethnicity	Not Hispanic	66	58.0 (99)	45.93	1423.5	2.194	**0.028**
	Hispanic	34	88.5 (110)	59.37			
Limited English Proficiency	No	80	66.0 (129)	49.31	895.0	0.819	0.413
	Yes	20	78.0 (75)	55.25			
Smoking History	Negative	56	68.0 (108)	51.20	1193.0	–0.271	0.787
	Positive	44	66.5 (113)	49.61			
Hypertension	No	75	73.0 (116)	52.05	822.50	–0.916	0.360
	Yes	25	59.0 (74)	45.90			
Diabetes	No	93	68.0 (113)	50.74	303.0	–0.304	0.761
	Yes	7	63.0 (63)	47.29			
Dominant Hand Injury	No	46	70.5 (115)	50.73	1231.5	–0.073	0.942
	Yes	54	65.0 (115)	50.31			
Industrial Machine Injury	No	48	58.5 (148)	47.97	1369.5	0.838	0.402
	Yes	52	71.5 (90)	52.84			
Open fracture	No	20	64.0 (140)	49.25	825.0	0.215	0.829
	Yes	80	68.5 (105)	50.81			
Intra-articular Fracture	No	79	63.0 (111)	47.94	1103.0	2.315	**0.021**
	Yes	21	111.0 (194)	63.52			
Comminuted Fracture	No	47	55.0 (105)	43.88	1556.5	2.148	**0.032**
	Yes	53	83.0 (115)	56.37			
Tendon Injury	No	89	63.0 (126)	49.29	597.0	1.184	0.236
	Yes	11	98.0 (70)	60.27			
Amputation Injury	No	66	61.0 (78)	46.85	1363.0	1.754	0.079
	Yes	34	93.5 (141)	57.59			
Distal Phalanx Fracture	No	25	111.0 (81)	59.22	719.5	–1.736	0.083
	Yes	75	62.0 (81)	47.59			
Middle Phalanx Fracture	No	90	64.0 (111)	49.42	547.0	1.115	0.625
	Yes	10	83.0 (354)	60.20			
Proximal Phalanx Fracture	No	85	63.0 (98)	48.52	806.0	1.627	0.104
	Yes	15	125.0 (153)	61.73			
Metacarpal Fracture	No	87	61.0 (94)	47.29	845.0	2.865	**0.004**
	Yes	13	150.0 (410)	72.0			
Two or More Fingers Fractured	No	77	63.0 (128)	49.32	976.0	0.741	0.458
	Yes	23	83.0 (74)	54.43			
ED Revision Amputation	No	77	61.0 (90)	47.21	1138.5	2.073	**0.038**
	Yes	23	98.0 (162)	61.5			
Any OR Procedure	No	60	48.5 (77)	39.33	1870.5	4.718	**<0.001**
	Yes	40	111.5 (150)	67.26			

in RTW duration observed across different occupations, injuries involving industrial machinery, nor across dominant- vs. non-dominant-hand injuries. There was no significant difference demonstrated in rate of machine injury in Hispanic patients compared to non-Hispanic patients (54.5% vs 42.9%, p = 0.137). There was also no significant difference in RTW with amputation- vs. non-amputation injuries or open vs. closed fractures. Concurrent extensor or flexor tendon injuries were not associated with increased RTW in this cohort. Results of this bivariate analysis comparing RTW times across groups are detailed in **Table 4.**

Linear Regression Analysis

To avoid overfitting models, separate regression models were built to evaluate patient demographics, injury characteristics and management as predictors for increased RTW. The first model evaluated patient demographics and past medical history, including insurance coverage, age, race, ethnicity, limited English proficiency, diabetes and smoking history. This model (R^2 = 0.092) found that increased age (p = 0.08) and Hispanic and/or Latino ethnicity (p = 0.015) were significant predictors of increased RTW.

The second model (Adjusted R^2 = .275) evaluated fracture location, adjusting for patient age and ethnicity given previous significant findings. This model found that metacarpal (p = 0.001) and middle phalanx fractures (p = 0.016) were significant predictors of increased RTW, while age (p = 0.017) and ethnicity (p = 0.018) also remained significant. Proximal phalanx fractures did not reach significance as a predictor (p = 0.056), and distal phalanx fractures were not found to be significant.

The third model (Adjusted R^2 = 0.198) evaluated injury characteristics including open fractures, intra-articular fractures, comminuted fractures and amputation injuries, number of fingers injured, again adjusting for age and ethnicity. This model found that intra-articular fractures were a significant predictor of lengthened RTW (p <0.001). Number of fingers fractured was no longer found to be a significant predictor on this analysis.

The fourth model (Adjusted R^2 = 0.279) evaluated clinical management, including any ED procedure, ED revision amputations, any OR procedure, OR reduction and OR revision amputation. This model found that OR revision amputation was a significant predictor of lengthened RTW (p <0.001). Any OR procedure approached significance (p = 0.090) Age and ethnicity remained significant predictors in both these models. These models are detailed in **Tables 5.**

The last model (Adjusted R^2 = 0.329) was a combined model of all predictors previously found to be significant or near significant. This model included age, ethnicity, metacarpal, middle phalanx and proximal phalanx fractures, intra-articular fractures, comminuted fractures, any OR procedure and OR revision amputation. This model found that metacarpal fractures were the strongest predictor of increased RTW (p =

Table 5. Logistic Regression Analysis for Predictors of Lengthened RTW by Predictor Category. All tests conducted at a significance of p <0.05. Only significant or near significantly associated variables are listed in the table. *0 signifies negative presence of a variable.

Model 1: Patient Demographics. Included variables: Age, Ethnicity, Race, Insurance Coverage, Diabetes, Smoking (R^2 = 0.092).					
Predictor	**Odds Ratio**	**Std. Error**	**Sig. (p)**	**95% CI**	
				Lower	**Upper**
Intercept	36.1	54.6	0.5	–72.2	144.5
Age	2.2	1.2	**0.008**	0.8	5.6
Ethnicity (non-Hispanic)	–80.2	32.4	**0.015**	–144.5	–15.8
Model 2: Fracture Location. (Adjusted R^2 = 0.275).					
Predictor	**Odds Ratio**	**Std. Error**	**Sig. (p)**	**95% CI**	
				Lower	**Upper**
Intercept	428.2	111.5	.000	206.7	649.6
MC Fx = 0	–198.0	58.3	**0.001**	–313.9	–82.1
P2 Fx = 0	–118.9	48.4	**0.016**	–215.1	–22.8
P1 Fx = 0	–91.0	47.0	**0.056**	–184.3	2.4
P3 Fx = 0	–63.4	52.4	0.2	–167.5	40.6
Age	2.6	1.1	**0.017**	0.5	4.7
Ethnicity = 0	–72.0	29.9	**0.018**	–131.4	–12.6
Model 3: **Fracture Characteristics**. Included Open, Comminuted Fracture, Intra-articular Fracture, Number of Fingers Injured, Amputation injury. Age Ethnicity. (Adjusted R^2 = 0.198).					
Predictor	**Odds Ratio**	**Std. Error**	**Sig. (p)**	**95% CI**	
				Lower	**Upper**
Intercept	138.3	58.2	0.019	22.8	253.8
Intra-articular Fracture = 0	–131.1	35.2	**<0.001**	–201.0	–61.3
Age	3.2	1.1	**0.004**	1.0	5.5
Ethnicity (non-Hispanic)	–81.1	30.5	**0.009**	–141.6	–20.7
Model 4: Clinical Management. Included ED Procedure, ED Revision Amputation, Any OR Reductions, OR Revision Amputation, Age, Ethnicity (Adjusted R^2 = 0.279)					
Predictor	**Odds Ratio**	**Std. Error**	**Sig. (p)**	**95% CI**	
				Lower	**Upper**
Intercept	219.9	61.3	0.001	98.2	314.7
OR Revision Amputation = 0	–179.5	48.3	**<0.001**	–275.3	–83.7
Age	3.2	1.1	**0.003**	1.1	5.3
Ethnicity (non-Hispanic)	–66.7	29.0	**0.024**	–124.3	–9.1
OR Required = 0	–52.8	30.8	0.090	–113.9	8.3

Table 6. Model Including all Significant Predictors

(Adjusted R^2 = 0.329) *0 signifies negative presence of a variable.

Predictor	Odds Ratio	Std. Error	Sig. (p)	95% CI	
				Lower	Upper
Intercept	503.8	115.6	0.000	273.1	732.4
MC Fx = 0	–172.8	58.0	**0.004**	–287.9	–57.6
Age	2.9	1.0	**0.006**	0.8	4.9
Ethnicity (non-Hispanic)	–67.1	29.1	**0.023**	–124.8	–9.3
OR Revision Amputation = 0	–112.2	52.5	**0.035**	–216.4	–7.9
P2 Fx = 0	–100.2	47.9	**0.039**	–195.3	–5.0
Intra-articular Fx = 0	–72.4	35.7	**0.046**	–143.3	–1.4
P1 Fx = 0	–58.5	46.5	0.2	–150.9	33.9
P3 Fx = 0	–42.4	50.1	0.4	–141.9	57.2
OR Required = 0	–3.5	34.7	0.9	–72.3	65.4

0.004). This was followed by age (p = 0.006), ethnicity (p = 0.023), OR revision amputation (p = 0.035), middle phalanx fractures (p = 0.039) and intra-articular fractures (p = 0.046) were significant positive predictors of lengthened RTW. Comminuted fractures, proximal and distal phalanx fractures and any OR procedures were not significant predictors in this model. This model is detailed in **Table 6.**

DISCUSSION

The hand and fingers have been documented as the most frequent type of work injury presenting to the Emergency Department in the United States.[4] The present study evaluates factors associated with return to work (RTW) following occupational bony crush injuries of the hand. Through a retrospective analysis of 135 patients presenting to the Emergency Department with acute fractures, we found a median RTW of 67.5 days post-injury. On multivariate linear regression analyses, increased age at presentation and Hispanic and Latino ethnicity were consistently found to be significant predictors of lengthened RTW. As many of these patients are manual laborers and with lower socioeconomic backgrounds, these findings highlight not only the burden of such occupational injuries on individuals, but also the disparities among the populations affected.

Patient Demographics

Our patient cohort largely consisted of male patients, a finding consistent with males comprising nearly three quarters of manufacturing and construction sectors from 2021-2023.[17] Additionally, using insurance coverage as a proxy for socioeconomic status, we find that most of our patient cohort possessed public insurance or was uninsured, suggesting that these injuries disproportionally affect those of low income. Notably, Latino and Hispanic patients were found to have significantly higher RTW than non-Latino and Hispanic patients, highlighting potential disparities in injury severity and access to care. This is also consistent with national research demonstrating significant increases of work-related disabilities amongst foreign-born Hispanic workers.[18] This finding is particularly important given the high proportion of Hispanic/Latinx individuals in Rhode Island, comprising 16.6% of the state's population (2020 US Census).[17] This finding must also be put interpreted in the context that Hispanic workers may be more likely to work in dangerous conditions, leading to more severe injury and prolonged RTW.

Furthermore, the majority our patients suffered injuries in an industrial setting, while operating machinery or engaged in manual labor. Occupational hand injuries are more likely to occur in industries such as manufacturing, construction and food preparation.[4] Such blue-collar workers are disproportionally affected by these possibly debilitating injuries, with low-income individuals bearing greater economic consequences from prolonged time away from work.[13]

Interestingly, there was no differences in RTW observed between English speakers compared to those that required an interpreter. However, there was a significantly greater proportion of non-English speakers in the Hispanic patient cohort compared to those with of non-Hispanic ethnicity. Notably, language proficiency was collected from information in the medical chart and may not have accurately reflected the patients' English proficiency. This finding suggests that language barriers may influence patient outcomes, and future research is needed to evaluate its impact on occupational injury and return to work outcomes.

Return-to-Work Durations

A systematic review of prognostic factors related to RTW following occupational hand injuries found that impairment severity and lower pre-injury income were two of the most significant predictors of delayed RTW, underscoring the role of socioeconomic status in occupational injury.[16] This finding suggests that workers from lower-income backgrounds, who may be overrepresented in blue-collar jobs like construction and manufacturing, face unique challenges in post-injury RTW. This may be due to greater injury severity and difficulty navigating comprehensive post-injury care like workers compensation.

One retrospective review found that patients with traumatic soft tissue and nerve injuries to the hand may experience delayed workers compensation resolution before RTW.[19] Our findings reinforce these observations, as patients who received OR revision amputations, who likely faced greater soft tissue damage to the hand, were more likely to have increased RTW times. Prolonged RTW following

occupational hand injuries highlight the difficulties of achieving effective and timely recovery among patients facing severe hand trauma.

Reported RTW timelines vary globally, with one study reporting 38 days as the average RTW time for hand injuries in Australia.[11] In contrast, our US-based study population faced longer RTW times, with a median of 67.5 days, with older patients and those of Latino and Hispanic ethnicity facing even longer RTW durations. This disparity may reflect racial inequities that delay a patient's daily function and subsequent ability to return to full-time employment. It is worth noting, however, that this disparity may also be confounded by fundamentally different approaches to healthcare between the US and Australia.

Fracture Location, Injury Patterns, and Treatment

The distal phalanx (i.e., fingertip) was the most fractured hand structure in the present study. Despite this, our analysis found that metacarpal fractures—comprising 9.6% of the present study's patients—were associated with the greatest increase in RTW duration. The multitude of soft tissue structures, such as nerves, ligaments, and tendons, near the metacarpals may explain the increased RTW duration in metacarpal fractures. Middle phalanx fractures were also observed to associated with increased RTW in our study cohort. This may be similarly explained by its anatomy and the role of the middle phalanx in grip, an important hand function for many manual labor occupations. In contrast, proximal phalanx fractures were not observed to be associated with lengthened RTW, likely attributable to the limited sample size of our cohort. Similarly, comminuted fractures, often indicative of more severe injuries, were not significantly associated with RTW on our analysis. Larger cohort studies are required to clarify the role of comminuted and proximal phalanx fractures on RTW outcomes.

Interestingly, open fractures were not associated with increased RTW in the present study. This finding may be attributed to most of the present study's fractures being described as open, consistent with high impact crush injury mechanisms that result in both soft tissue and bony injury. These results suggesting that soft tissue injury may not be a core factor in recovery outcomes.

Our study also finds intra-articular fractures, suggestive of more severe and complex injuries, were associated with increased RTW. A study by Yamamoto et al out of rural Japan found that 76.6% of patients were able to return to work after 150 days following traumatic hand/forearm injury.[20] This study found that increased injury severity and female sex were associated with delay in RTW. While our study did not replicate the finding of lengthened RTW in female patients, the correlation of injury severity with longer RTW is supported.

When comparing the difference in RTW between injuries of the dominant versus non-dominant hand, the present study found no difference. This is consistent with studies from Shi et al and Bear-Lehman et al., both of which reported similar conclusions.[16,21] It suggests that hand dominance may not be as critical of a factor in determining RTW after occupational hand injuries. This result highlights that the extent of functional impairment and hand function—fine motor skills, sensation, and grip strength—may have stronger correlations with recovery times than the patient's dominant or non-dominant hand. Occupational tasks require precision and dexterity independent of the impacted hand. As a result, injury severity and its impact on the patient's ability to perform occupational tasks may outweigh the contribution of hand dominance in determining RTW. In terms of treatment, over one-third of patients required surgical intervention, with amputation revisions found to be significantly associated with lengthened RTW duration. This finding is consistent with increased injury severity as a predictor of prolonged recovery and subsequent return to work.

Limitations

This study is limited by the retrospective nature, with data collection and return to work (RTW) dates gathered through chart review limited by prior documentation. In turn, RTW dates used in the study were not confirmed by patients and may not precisely reflect real life circumstances. Study power and generalizability are decreased due to the single-center study design and limited patient cohort and follow-up. This small patient cohort was associated with a broad range in RTW times, which limits conclusions that may be drawn from this data. Furthermore, the study does not account for potential biases and social determinants, such as how Hispanic individuals may be more likely to work in more hazardous work environments. Future studies may address these limitations through a multi-center, prospective or cross-sectional study design with larger study cohorts.

CONCLUSION

Overall, we find that occupational crush injury-related fractures of the hand result in prolonged RTW periods, often spanning several months or longer. Several factors impact recovery time and subsequently result in delayed RTW. These include may include older fractures to the metacarpals, middle phalanx fractures, intra-articular fractures and injuries requiring operative intervention. With such crush injuries disproportionately affecting manual laborers in the manufacturing and construction sectors, these findings underscore the importance of ensuring equitable access to quality and timely care for these patients to improve recovery times, reduce time out of work and alleviate individual burden.

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Authors

Margaret R. Wang, BS, Medical Student, Department of Plastic Surgery, Warren Alpert Medical School of Brown University, Providence, Rhode Island.

Timothy Jeng, BA, Medical Student, Department of Plastic Surgery, Warren Alpert Medical School of Brown University, Providence, Rhode Island.

Ishan Shah, BS, Medical Student, Department of Plastic Surgery, Warren Alpert Medical School of Brown University, Providence, Rhode Island.

Nikhil Sobti, MD, Plastic Surgery Resident, Department of Plastic Surgery, Warren Alpert Medical School of Brown University, Providence, Rhode Island.

Ernest Dimbo, MPhil, Medical Student, Department of Plastic Surgery, Warren Alpert Medical School of Brown University, Providence, Rhode Island.

Matthew Lee, BA, Medical Student, Department of Plastic Surgery, Warren Alpert Medical School of Brown University, Providence, Rhode Island.

Reena A. Bhatt, MD, Division Chief of Hand Surgery, Department of Plastic Surgery, Warren Alpert Medical School of Brown University, Providence, Rhode Island.

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Correspondence

Margaret Wang, BS
222 Richmond St
Providence, RI, 02903
647-886-7095
margaret_wang1@brown.edu