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Crush versus sharp injuries in spaghetti wrist trauma: Analysis of 13 years of experience

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Abstract

Spaghetti wrist injury pertains to profound volar wrist lacerations with the potential to disrupt a complex interplay of anatomical structures. In our study, we wanted to highlight the importance of etiological factors that have not been previously investigated for this type of injury. Patients diagnosed with spaghetti wrist injury between 01.01.2010-01.01.2023 who subsequently underwent surgical intervention at our institution were identified from the database of our institution and relevant data has been recorded. Contact information for all patients was extracted, and patients were invited for follow-up examinations. A comprehensive hand examination was conducted for patients attending the follow-up assessment. Finally, patients completed the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire for a comprehensive assessment. Fifty-three patients were included in our study. The mean age of the patients was 44. The ratio of females to males is 7/46. The mean follow-up period was 7 months. The ratio of the left hand to the right hand is 21/32. Forty-two sharp and 11 crush injuries are present. The range of motion values of sharp injuries were significantly better than those of crush injuries. Opposition results were compared with each other, but no significant difference was found. However, when intrinsic muscle function was compared, ulnar nerve function recovered significantly worse after crush injury. According to both the Semmes-Weinstein Monofilament Test and two-point discrimination, sharp injuries healed with significantly better sensory outcomes. DASH questionnaire scores were compared, and no significant difference was found. Sharp injuries showed significantly better functional results than crush injuries. Our study contributes substantively to the existing literature on spaghetti injuries, particularly by examining previously unexplored areas such as injury aetiology and presents comprehensive findings on these subjects.

Keywords: crush, flexor tendon, function, sharp, spaghetti wrist

1. Introduction

Our hands are the organ that makes human beings superior to other creatures. Hand injuries constitute approximately 20% of all emergency injuries (1,2). Spaghetti wrist injuries represent one of the most devastating types of hand injuries, which pertain to profound volar wrist lacerations with the potential to disrupt a complex interplay of anatomical structures. These structures encompass a constellation of 16 distinct elements, comprising 12 tendons, two crucial nerves, and two vital arteries (3). According to Puckett and Meyer, a spaghetti wrist injury should involve injury to a minimum of three structures on the volar aspect of the wrist (between the distal wrist fold and the musculotendinous junction), along with at least one major nerve and often an artery (4). Sharp injuries are injuries in which structures such as tendons, nerves and arteries are cut flat and without linting and amenable to primary repair. Crush injuries, on the contrary, can be considered more severe and prognostically worse injuries requiring extensive debridement of the proximal and distal stumps of the cut structures, followed by tight repair or grafting. Our institution is a regional hospital. All local hospitals in the region refer severe hand injuries to us. In our study, our large group of patients operated with the diagnosis of spaghetti wrist was examined especially in terms of etiological cause and functional results.

2. Materials and Methods

Between 01.01.2010 and 01.01.2023, patients who were diagnosed with spaghetti wrist injury and operated on in our department were identified from the database of our institution, and 305 patient records were found. Patients with less than six months of follow-up and patients with recurrent injuries in the same extremity, fractures, amputations, multiple level injuries were excluded from the study. The remaining patients were invited for a comprehensive hand examination, and 53 patients participated. Parameters such as age, gender, mean follow-up time, injured hand direction and dominance, number of tendons and nerves, and etiology of injury were recorded. Range of motion was measured with a goniometer and evaluated according to the Buck-Gramcko system (**Hata! Başvuru kaynağı bulunamadı.**, **Hata! Başvuru kaynağı bulunamadı.**).

According to the Noaman classification, opposition skills in patients with median nerve injuries and intrinsic muscle functions in patients with ulnar nerve injuries were evaluated and recorded as motor evaluation (**Hata! Başvuru kaynağı bulunamadı.**) (5).

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Table 1. Buck-Gramcko method for post-operative assessment of flexor tendon repair

Degrees		Points
Distance between fingertip and distal palmar crease (cm)/composite flexion (deg)	0-2,5 / >200	6
	2,5-4 / >180	4
	4-6 / >150	2
	>6 / <150	0
Extension deficit (deg)	0-30	3
	31-50	2
	51-70	1
	>70	0
Composite flexion minus composite extension (deg)	>160	6
	>140	4
	>120	2
	<120	0
Evaluation	Excellent	14-15
	Good	11-13
	Fair	7-10
	Poor	0-6

Table 2. Buck-Gramcko method of assessment of tendon outcomes for the thumb

	Degrees	Points
Flexion of interphalangeal joint	50-90	6
	30-49	4
	10-29	2
	<10	0
Extension Lag	0-10	3
	11-20	2
	21-30	1
	>30	0
Total active motion	>40	6
	30-39	4
	20-29	2
	<20	0
Evaluation	Excellent	14-15
	Good	11-13
	Fair	7-10
	Poor	0-6

Table 3. Noaman classification

	Tendon function	Opposition	Intrinsics	Deformities	Sensation
Excellent	Individual tendon function was evident with 85% tofull range of motion or finger flexion to 1.0 cm or less from the distal palmer crease	When the tip of the thumb moves freely over the three phalanges of the other four fingers	When the patient can do both finger abduction and adduction with negative Froment sign	Major if there is both claw and ape hand	When the two-point discrimination is less than 10 mm
Good	70–84% total normal range of motion or 2.0 cm from the distal palmer crease	When the tip of the thumb touches only the tip of the other four fingers	When the patient can do both finger abduction and adduction with positive Froment sign		When the two-point discrimination is 10–20 mm
Fair	50–69% total normal range of motion	When the tip of the thumb cannot reach the tip of the other four fingers	When the patient can do either finger abduction or adduction with positive Froment sign	Minor if there is either claw or ape hand	When the two-point discrimination is more than 20 mm with light touch and pain prick sensation
Poor	Fixed contractures or adhesions		When the patient cannot do finger abduction or adduction with positive Froment sign		When there is trophic changes or skin ulceration

Table 4. Semmes – Weinstein monofilament test scoring

Number of Filaments	Target Force (g)	Hand Thresholds
2,83	0,07 g	Normal
3,61	0,4 g	Decreased Light Touch
4,31	2 g	Decreased Protective Sensation
4,56	4 g	Loss of Protective Sensation
6,65	300 g	Deep Pressure Sensation Only

The baseline 5-piece Tactile Monofilament Hand Assessment Kit® was used to measure the perception threshold of cutaneous sensation in patients with nerve injury (**Hata! Başvuru kaynağı bulunamadı.**). Two-point discrimination (2-PD) was also assessed and recorded using the Discrim-A-Gon 2-Point Discrimination Set® in accordance with the norms of the American Society for Surgery of the Hand (ASSH) (**Hata! Başvuru kaynağı bulunamadı.**).

Table 5. 2-PD discrimination criterias according to ASSH

<6 mm	Normal
6-10 mm	Fair

11 – 15 mm	Poor
Only 1 point can be perceived beyond 15mm	Protective
No sensation	Anesthetic

Finally, the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire was applied to the patients.

2.1. Statistical Analysis

IBM SPSS Statistics 26® was used for statistical analyses. Mean, standard deviation, median, minimum, and maximum values for quantitative (numerical) variables and frequency (%) values for qualitative (categorical) variables were used as descriptive statistics. Kruskal Wallis H Test was used in the comparison of DASH scores. For the comparison of qualitative (categorical) variables, Yates Chi-Square analyses were performed to compare the proportions. Significance was evaluated at $p<0.05$ level in all comparisons.

3. Results

The mean age of the patients was 44 (min. 27 - max. 70). The ratio of female to male is 7/46. The mean follow-up period was 7 months (min. 6 months - max. 12 months). Twenty-one patients (39.6%) were injured in the left hand and 32 patients (60.4%) in the right hand. The ratio of dominant to non-dominant hand is 33/20. Injury etiologies are categorized under two main headings: sharp injuries (glass, knife, razor blade) and injuries causing crush trauma such as sawmills, chainsaws, and avulsions. Forty-two sharp (18 accidental glass injuries; 18 punches through glass, six knife or razor blades) and 11 crush injuries are present. Two hundred fifty eight tendons were injured in total (34 flexor digitorum superficialis-3, 34 flexor digitorum superficialis-4, 30 flexor digitorum superficialis- 2, 29 flexor digitorum superficialis-5, 25 flexor carpi ulnaris, 21 palmaris longus, 19 flexor carpi radialis, 15 flexor digitorum profundus-3, 14 flexor pollicis longus, 13 flexor digitorum profundus-2, 13 flexor digitorum profundus-5, 11 flexor digitorum profundus-4). There were 25 patients with ulnar nerve injury and 23 patients with median nerve injury. In four patients, both nerves were injured. In one patient, no nerve was transected.

A total of 81 (73%) traumatized fingers healed with excellent range of motion in patients injured by sharp objects. Eighteen (16.2%) of the traumatised fingers were evaluated as good, six (5.4%) as fair, and six (5.4%) as poor. In crush injuries, 14 (45.2%) fingers healed with excellent range of motion, eight (25.8%) were rated as good, two (6.5%) as fair, and seven (22.5%) as poor (**Hata! Başvuru kaynağı bulunamadı.**). Range of motion values of sharp injuries were significantly better than crush injuries (p=0,007<0,01).

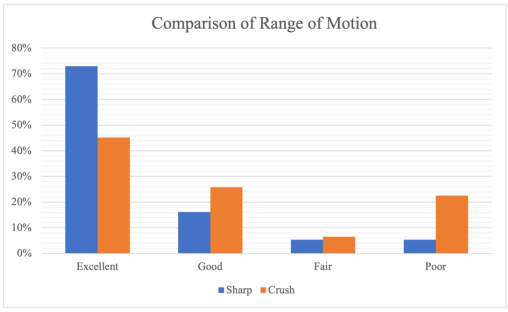

Fig. 1. Comparison of range of motion

The motor evaluation was assessed by the opposition and intrinsic muscle function examination according to the injured nerve. For the median nerve healing; of the nerves injured with sharp objects, 15 (71.4%) were evaluated as excellent, five (%23,8) as good and one (%4,8) as fair. No nerve was rated as poor. For crush-injured nerves, four (66.7%) were rated as excellent, one (16.7%) as fair, and one (16.7%) as poor (Fig. 2). Opposition results were compared with each other, but no significant difference was found between etiologies (p>0,05).

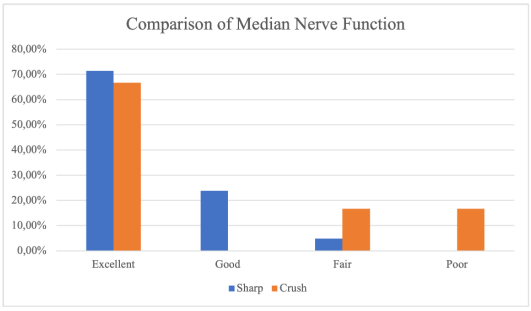

Fig. 2. Comparison of median nerve function

If the ulnar nerve evaluations are compared, there are four (%18,2) excellent, four (%18,2) good, nine (%40,9) fair, and five (%22,7) poor results in sharp injuries. Crush injuries have two (%28,6) fair and five (%71,4) poor results. No nerve was rated as excellent or good in crush injuries (**Hata! Başvuru kaynağı bulunamadı.**). However when intrinsic muscle function was compared, ulnar nerve function recovered significantly worse after crush injury (p=0,047<0,05).

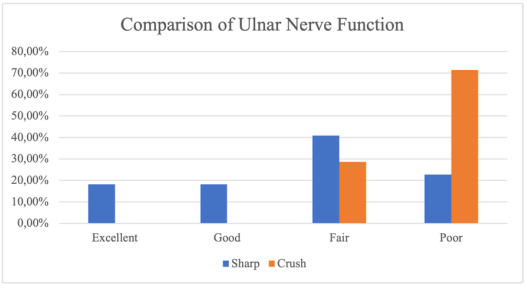

Fig. 3. Comparison of ulnar nerve function

Sensory recovery was evaluated with 2-PD and SWMT. For the SWMT, sharp and crush injury results are as follows respectively: as normal seven (%16,3) vs. 0 patients (%0); as decreased light touch four (%9,3) vs. 0 patients (%0); as decreased protective sensation 13 (%30,2) vs. two patients (%15,4); as loss of protective sensation nine (%20,9) vs. three

patients (%23,1) and as deep pressure sensation only ten (%23,3) vs. eight patients (%61,5) (**Hata! Başvuru kaynağı bulunamadı.**).

Fig. 4. Comparison of semmes-weinstein monofilament test results

For the 2-PD, sharp and crush injury results are as follows respectively: as normal seven (%16,3) vs. 0 patients (%0); as fair eight (%18,6) vs. one patient (%7,7); as poor six (%14) vs. 0 patients (%0); as protective sensation 22 (%51,1) vs. 10 patients (%76,9); as anesthetic 0 (%0) vs. two patients (%15,4). According to both SWMT and 2-PD, sharp injuries healed with significantly better sensory outcomes (p=0,02 and p=0,019 < 0,05) (**Hata! Başvuru kaynağı bulunamadı.**).

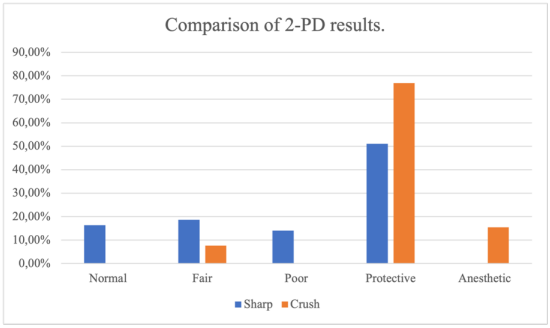

Fig. 5. Comparison of two point discrimination results

DASH questionnaire scores were compared according to the aetiologies of injury grouped in two main groups and no significant difference was found (p=0,375>0,05).

4. Discussion

In our study, sharp and crush injuries were compared in many aspects in spaghetti wrist injuries. In total, 36 patients (68%) were injured with glass, followed by 11 patients (21%) with crush injuries. six patients (11%) were injured by other sharp objects, such as knives or razor blades. When other studies are analysed, glass injuries are generally more predominant (4,6–18). In the study of Puckett and Meyer, only sharp injury patients were included, and crush or avulsive injuries were excluded. They stated that the reason for this was that the recovery of patients exposed to high-energy trauma was more unpredictable and more likely to be poor (4). Kabak et al. also included only sharp injuries in their study (12). In most of the studies, the second most common aetiology is sharp object injuries other than glass (6,8–10,12–16,18). In the study of Boynuyoğun et al., the most common aetiology was crush injuries (19). In our results, the second etiology was high-energy trauma due to work tools such as sawmills and chainsaws. The reason for this is that a significant part of the industrial branches in our region are dependent on forest and wood products, and secondly, products such as wood for heating purposes are widely used especially in rural areas and villages. In the study of Hudson, crush injuries ranked first with a rate of 40% and glass injuries ranked second with a rate of 33% (20). Vaughn et al. used the term "work accident" for the most common injury with a rate of 50%, but did not explain the exact etiology of the injury (21).

In terms of functional outcomes, in our study, sharp injuries heal with a better range of motion (ROM) than crush injuries (p=007<0.01). Nevertheless, our ROM results evaluated as excellent or good in sharp or crush injuries are over 70% (89,2% and 71%). Almost most authors have reported good results in terms of finger ROM in spaghetti wrist injuries. ROM evaluations are excellent or good in the majority of studies - such as our study - at over 70 percent (4–6,9,10,12–19,22). The reason for good tendon repair results in flexor zone-5 is the absence of a fibroosseous tendon sheath in this zone, and the tendon gliding effect that occurs as the finger moves in this zone is not interrupted by this sheath (23).

Ulnar nerve motor function results showed significantly better healing (p=0,047<0,05). However, the same cannot be said for the median nerve (p>0,05). One of the reasons for this is that the oppositional function of the median nerve is partially taken over by the Flexor Pollicis Longus tendon after paralysis of the tenar muscles. In El-Lamie's study, it is said that opposition showed adequate improvement but ulnar motor function was prolonged and could not be completed (7). Stefanich et al. emphasised that motor recovery after median nerve incision was better, but recovery after ulnar nerve transection was more variable (24). Nasab et al. reported that injuries, especially involving the ulnar nerve, had a worse outcome (18).

According to both SWMT and 2-PD, sharp injuries healed with significantly better sensory outcomes (p=0,02 and p=0,019). Irwin et al. reported that there was a relationship between mechanism of injury and symptoms and sharp injuries were less associated with cold intolerance (25). In their study on digital nerve injuries, Altissimi et al. and Wang et. al. reported that nerves repaired in crush injuries had worse two-point discrimination compared to nerves repaired due to a simple laceration (26,27). Dellon stated that a cleanly transected nerve would theoretically produce less fibrosis on both sides of the injury than a crush injury. (28). According to Pettengill, crush or blunt traumas are more scarred and heal poorly (29). However, if the nerve is further debrided and then repaired, tension will build up in the suture line and decrease the final result (30). In his article related to the spaghetti wrist, Demirdover briefly stated that high-energy traumas have negative effects in terms of functional results compared to sharp traumas (16).

There was no significant difference between the DASH questionnaire results (p=0,375>0,05). However, DASH is a subjective questionnaire dependent on the patient's perception. In the observations we made during the patient examinations, although most of the patients had some limitations due to the injury, they were able to adapt themselves to their daily lives and work and learned to use their hands as effectively as possible. In addition, the reason for the lack of a significant difference between the results of the questionnaire and the relatively low scores (values close to 0 represent a successful result and values close to 100 represent a failed result) may be the subjective well-being of the patient in terms of saving the gruesomely injured limb and its relative functioning (31).

This study is retrospective and represents patients from a single center. The mean follow-up period in our study was 7 months. Longer follow-up periods are required for adequate analysis of nerve healing. The short mean follow-up period of the patients can be interpreted as one of the limitations of the study. We think that the reason for such short follow-up periods for the patients in our study is that our institute is a regional hospital, almost all of the patients with hand injuries apply to our hospital and most of these applications are outside the province, and the follow-ups cannot be continued regularly and continuously due to low socioeconomics. One of the other limitation factors of our study may be the total number of patients. Only 53 patients out of 305 patient records applied to our institute for a comprehensive hand examination. Again, like the short follow-up period, we think that the reason for this is the low socioeconomic status of the patients. Finally, arterial injuries and related data were not included in our study. There was no significant difference between the two groups in terms of arterial injuries due to the limited sample size. Perhaps our study will be a light for future studies, and this issue will be investigated with larger sample groups.

Spaghetti wrist injuries are combined injuries affecting multiple structures, such as tendons, nerves, and vessels in the wrist and forearm. The prevailing consensus among medical practitioners underscores the amalgamation of appropriate surgical intervention and hand rehabilitation as the optimal therapeutic approach. Nevertheless, the nuanced intricacies governing functional outcomes and the multivarious factors modulating them remain a subject of profound scholarly investigation, as comprehensive comprehension of these facets remains elusive (4,20,32). In our study, we wanted to highlight the importance of aetiological factors that have not been previously investigated for this type of injury.

Conflict of interest

The authors declared no conflict of interest.

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None to declare.

Authors' contributions

Concept: İ.A., M.S.E. Design: İ.A., M.S.E. Data Collection or Processing: İ.A. Analysis or Interpretation: İ.A., M.S.E. Literature Search:İ.A. Writing: İ.A., M.S.E.

Ethical Statement

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Clinical Research Ethics Committee of Ondokuz Mayıs University (Date: 12.07.2023/No:2023/208).

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