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Original Research Article

Management and Functional Outcomes of Combined Injuries of Flexor Tendons, Vessels and Nerves at the Wrist: A Prospective Study at SKIMS

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Abstract:

Background: The injuries at volar aspect of wrist are a common but difficult problem for the patient, surgeon and hand therapist. They require a great deal of rehabilitation and subsequent procedures thereby causing a significant cost to patients and health care system.

Objectives: This study was undertaken to determine various modes of wrist injury, nature of structures involved, frequency of injury to various structures at wrist, functional outcomes of various structures repaired at wrist.

Methods: Fifty patients of volar wrist injuries were prospectively studied. After identification the involved structures were taken up for repair. The tendon repair was done by modified Kessler technique (core suture) with 4-0 proline reinforced by epitenon sutures (6-0 proline). After wound closure light dressings were applied and dorsal splint was applied keeping the wrist in 20-45degrees of flexion and metacarpophalangeal joints in 40-60degree of flexion. Post operatively the patients were followed up to six months for assessment of tendon function, deformity, opposition, intrinsics and sensations. All the patients were followed with strict standard post-op rehabilitation protocol

Results and Conclusion: In this study male patients accounted for majority of cases (86%) while females comprised 14% of cases with mean age of male patients 28.7years and mean age of female patients was 30.7years. Glass cut was the main mode of injury in the studied patients accounting for 64%. Tin injury, bandsaw injury, knife and axe injuries were the next in frequency. Most of the patients had right sided involvement (74%), whereas left sided injuries were noticed in 26% of patients. Most of the patients had a wound size between 5-7cm. Wound sizes ranging from 2cm to 10cms. The mean wound size was 6.2cm. FDS was the most common tendon involved in 66% of the patients. FCU and FDP were the next in frequency accounting for 48% and 42% respectively. 16% of the patients had no tendon involvement whereas 18% had all tendons affected. Most (60%) of the patients had 1-3 tendons cut. Ulnar nerve was the most frequently injured nerve in 54% of cases whereas median nerve was involved in 42% of cases. Simultaneous injury of both nerves was observed in 16% of patients. 20% of the patients had no nerve injury. Ulnar artery was most commonly involved vessel accounting for 48% of cases. Radial artery was affected in 24%of patients. Combined injury of both vessels was observed in 10% of cases. 38%of patients had no vascular injury. Tendon function was found to be excellent in 92% of cases. 4% patients had well and another 4% had poor function. Opposition was excellent in 86% of the patients and poor in 4% of patients. Intrinsic function yielded similar results with majority of patients (78%) exhibiting excellent function. Sensory recovery was reported excellent in 74% of patients. 12% had well, 10% had fair and another 4% had poor sensory recovery. Deformity was classified as minor if there was either claw hand or ape thumb. Major deformity was defined as presence of both claw hand and ape thumb. Only 4% of patients developed minor deformities. This study emphasized early mobilization and use of microsurgical repair of structures involved. From the study we concluded that overall good functional outcomes of wrist injuries can be obtained in majority of patients and early post-operative mobilisation can have a very beneficial effect in determining such results. Furthermore, any small looking incised wound need not to be overlooked and its timely exploration and repair of injured structures coupled with use of microsurgical techniques, magnification, use of finer sutures and early post-operative mobilisation form the cornerstone for a successful outcome.

Keywords: Volar Wrist Injuries, Tendons, Nerves, Vessels, Microsurgical Repair, Early Mobilization.

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Introduction

Philosophically, physiologically, and anatomically, the interaction of the hand and the brain uniquely identify Homo sapiens. Throughout history the progress of mankind has been measured through the evolution of a strong and mobile upper limb with an independently opposable thumb and the cognitive powers to use them. The balance, precision, and specialization of the hand give it a central functional and communicative role. The goal of surgical treatment of the injured, diseased, or dysfunctional hand is to retain maximum useful part length; stable motion; and unimpaired mobility of sensate parts.

Wrist injuries have been known to mankind since times immemorial. The impact and consequences of such injuries has been understood through the ages. These injuries which may be cutaneous, tendinous, neurovascular and skeletal are on an increase in the present day. Wrist injuries have been a common but difficult problem for the patient, surgeon, and the hand therapist. They occur in all age groups. They require a great deal of rehabilitation and may require subsequent procedures; thus, a significant cost to patients as well as to the health provider system exists. The impact to patients may include loss of function, hand stiffness, vocational impairment, and associated social and economic hardships. Hence early recognition and appropriate treatment are essential if one is to optimise recovery. Wrist injuries whether induced by major or minor trauma, often result in devastating clinical debility for the patient. Both from the standpoint of pain and lost function of the involved extremity, these injuries are incapacitating. It follows that reconstruction of wrist injuries if not executed with technical proficiency and, more important, an adequate understanding of the relevant reconstruction issues, can be disastrous for the patient. Conversely, proficiency in repair and reconstruction of such injuries prevents chronic sequelae and restores functionality to the affected extremity. The more recent innovations in repair of such injuries are the use of delicate techniques, the proper magnification, and use of finer sutures and avoidance of excessive tension across the repaired site. These are definite assets and are not to be underestimated.

Lacerations to the volar wrist surface have the potential to be severely debilitating, mainly due to the superficial location and high density of tendons, nerves and arteries in that area. Extensive injuries to flexor tendons and surrounding structures are sometimes referred to as “spaghetti wrist”. Various mechanisms of injuries are: accidental Glass lacerations, knife wounds, suicide attempts, road traffic accidents, electric saw injuries, domestic violence etc. Spaghetti wrist injuries can be daunting even to the experienced hand surgeon. Most of the times the size of the wound does not match the number of injured structures. Small-sized wound may have almost all structures injured, as in a stab wound, while a superficial cut wound may have small number of injuries. A systematic approach can simplify the problem. Knowledge of the cross-sectional anatomy of the wrist is the key; this coupled with the proper technique can yield satisfactory outcomes.

The volar aspect of wrist has important structures crossing over it and as such this area deserves special mention. Within the distal forearm and proximal wrist there are 12 flexor tendons, 2 major nerves, and 2 major arteries. The flexor digitorum superficial is (FDS) tendons lie volar to the flexor digitorum profundus (FDP) tendons: each is made up of 4 tendons. Other tendons include: 2 flexor carpi tendons (ulnar and radial), the flexor pollicis longus, and the sometimes absent palmaris longus tendon. The nerves include the median and ulnar nerves which lie in relative proximity to the radial and ulnar artery respectively. The median nerve sensory distribution in the hand includes almost the entire palmar surface, except for the ulnar side of the ring finger and the entire little finger which are ulnar nerve territory.

Aims and Objectives:

1. To determine the various modes of wrist injuries.
2. To determine the nature of structures injured in various modes of injuries.
3. To determine the frequency of injury of various structures.
4. Present functional outcome of tendon and nerve repair.

Materials and Methods

The study was conducted in the department of Plastic and Reconstructive surgery at Sher-i-Kashmir Institute of Medical Sciences Srinagar. This was a prospective study which included 50 patients of wrist injury encountered during the course of study (June 2008 to October 2010).

The patients were received in the accident and emergency department of SKIMS. The patients were examined in detail. Complete general physical examination and systemic examination was done to rule out any associated injury. Special emphasis was put on wrist and hand examination. The flexor tendons were evaluated by assessing the

movements at wrist, thumb, and metacarpophalangeal, promixal interphalangeal and distal interphalangeal joints. Any loss of function was noted. Each major nerve was examined in detail for loss of sensory and motor functions. Vascular status was assessed clinically. In all cases investigations done were complete blood counts, kidney function tests, blood glucose, chest radiography and ECG. Besides these special investigations were also done in selected cases viz. vascular Doppler. Any co-morbidity if present was taken care of.

All patients were operated within 48hours of presentation. The patients were subjected to general or regional anaesthesia. The affected part was prepared with povidone ioine and savlon (0.3%w/v chlorhexidine and 0.6%w/v cetrimide). Under tourniquet control extensile exposure was obtained. The extension of the wound depended upon depth, size, shape and the site of wound. Extensile exposure was obtained for deep wound involving major wrist injuries.

This was achieved by cruciate incision for the transverse wound or by extending the laceration in proximal and distal fashion using transverse incision in oblique wound. Structures were identified from deep-to-superficial, and a checklist of lacerated structures was recorded. Knowledge of the cross-sectional anatomy of the wrist was the key to expedient identification of the injured structures. Both injured and non-injured structures were identified by their anatomic locations and characteristic appearances.

The proximal and distal ends of the injured structures were marked and caught by syringe needles of different colours to facilitate repair. Nerves are whitish-gray in appearance with longitudinal ridges and fascicles on cut end, soft in consistency, often with an artery running longitudinally along its length; they can be oriented by the angle of the cut ends, the anatomic location (its volar and dorsal surfaces) by avoiding the twist, the matching of the corresponding fascicles as regard the numbers and the size and the location of the nutrient artery, if present.

Tendons are whiter in appearance and firmer in consistency and were identified, through their actions, by pulling on the distal ends. The proximal ends of the lacerated tendons were more difficult to identify. They were matched to their respective distal ends by anatomic location, size, obliquity of the cut, and degree of slack on approximation of the ends.

This was followed by repair of the involved structures. Any associated bone fractures were fixed first. This was followed by repair of neurovascular structures. Vessels were repaired end-to-end with 8-0 nylon interrupted sutures. Nerve repair was done with 8-0 nylon in epineural fashion. Tendons were repaired last of all. Tendon repair was done by modified Kessler technique (core suture) with 4-0 proline reinforced by epitenon sutures (6-0 proline). After wound closure light dressings were applied and dorsal splint was applied keeping the wrist in 20-45degrees of flexion and metacarpophalangeal joints in 40-60degree of flexion.

Postoperative Rehabilitation Protocol: Kleinert splint with rubber bands was used with the wrist in 20–45degree of flexion, the metacarpophalangeal joints in 40–60degree of flexion, and the interphalangeal joints allowed to extend fully.For first 4 weeks active extension of fingers and passive flexion formed part of rehabilitation protocol.

The dorsal block was then removed followed by active flexion and extension for the next two weeks. At 6–8 weeks, tendon gliding exercises were initiated, and light activity of daily living was encouraged. At 8 weeks, blocking and light-resistive exercises were begun. At 12 weeks, there was return to full activity.

The patients were followed up regularly for six months. At the end of six months the patients were assessed for

Tendon function: This was graded as:

- Excellent: - Individual tendon function was evident with 85% to full range of motion or finger flexion was 1.0cm or less from the distal palmar crease
- Good: - Individual tendon function was 70-84% of total normal range of motion or 2.0cm from the distal palmar crease.
- Fair: - Where tendon flexion was 50-69% of total normal range of motion.
- Poor: - fixed contractures or adhesions.

Opposition

- Excellent: - When the tip of the thumb moved freely over the three phalanges of the other 4 fingers
- Good: - When the tip of the thumb touched only the tip of the other 4 fingers.
- Fair: - When the tip of the thumb could not reach the tip of the other 4 fingers.

Intrinsics

- Excellent: - When the patient could do both finger abduction and adduction with negative froment sign.
- Good: - When the patient could do both finger abduction and adduction with positive froment sign.
- Fair: - When the patient could not do either finger abduction or adduction with positive froment sign.

- Poor: - When the patient could not do finger adduction and abduction with positive froment sign.

Deformity

- Major: - If there was both clawing and ape hand.
- Minor: - If there was either clawing or ape hand.

Sensation

- Excellent: - When the two point discrimination was less than 10 mm.
- Good: - When the two point discrimination was 10-20mm.
- Fair: - When the two point discrimination was more than 20 mm wit light touch and pain prick sensation.
- Poor: - when there were trophic changes or skin ulceration.

Results: The study included a total of 50 patients following observations were made: -

Table 1: Age distribution of male patients

Age (yr)	Male	
	n	%
≤ 20	10	20
21 to 40	28	56
41 to 60	3	6
> 60	2	4
Total	43	86.0
Mean ± SD	28.7 ± 12.6 (16, 75)	

Male patients accounted for majority of cases (86%). Most of the male patients were in the age group of 21-40yrs (56%). The mean age was 28.7yrs.

Table 2: Age distribution of female patients

Age group	n	%
<20 yrs	2	4
21-40 yrs	5	10
>40 yrs	0	0
Mean ± SD	30.7 ± 9.8 (15, 40)	

Females accounted for 14% of patients. Most of the patients were in the age group of 21-40 yrs. The mean age was 30.7 yrs.

Table 3: Mode of injury

	n	%
Axe	3	6
Saw	3	6
Glass	32	64
Knife	3	6
Tin	4	8
Others	5	10

Glass cut was the main mode of injury in the studied patients accounting for 64%. Tin injury, bandsaw injury, knife and axe injuries were the next in frequency.

Table 4: Involved side

	n	%
Right	37	74
Left	13	26

Most of the patients had right sided involvement (74%), whereas left sided injuries were noticed in 26% of patients.

Table 5: Wound Size (cm)

Wound Size (cm)	n	%
2 to 4	12	24
5 to 7	25	50
8 to 10	13	26
Mean ± SD	6.2 ± 2.1 (2, 10)	

Most of the patients had a wound size between 5-7cm. Wound size ranging from 2cm to 10cms. The mean wound size was 6.2cmThe following line chart shows the average size of wound was about 5-7cm in 50% of patients.

Table 6: Tendon Involved

Tendon	n	%
FDS	33	66
FDP	21	42
FCU	24	48
FCR	16	32
PL	16	32
FPL	14	28

FDS was the most common tendon involved in 66% of the patients. FCU and FDP were the next in frequency accounting for 48% and 42% respectively.

Table 7: Total Number of Tendons Involved

	n	%
None	8	16
One	12	24
Two	10	20
Three	8	16
Four	1	2
Five	2	4
Six	9	18

16% of the patients had no tendon involvement whereas 18% had all tendons affected. Most (60%) of the patients had 1-3 tendons cut.

Table 8: Nerve Involved

Nerve Involved	n	%
Median	**21**	**42**
Ulnar	**27**	**54**

Ulnar nerve was the most frequently injured nerve in 54% of cases whereas median nerve was involved in 42% of cases. Simultaneous injury of both nerves was observed in 16% of patients. 20% of the patients had no nerve injury.

Table 9: Total Nerves Involved

	n	%
None	10	20
One	32	64
Both	8	16

Table 10: Artery Involved

Artery	n	%
Radial Artery	12	24
Ulnar Artery	24	48

Ulnar artery was most commonly involved vessel accounting for 48% of cases. Radial artery was affected in 24%of patients. Combined injury of both vessels was observed in 10% of cases. 38%of patients had no vascular injury.

Table 11: Total Arteries Involved

	n	%
None	19	38
One	26	52
Both	5	10

Table 12: Tendon function

Tendon function	n	%
Excellent	46	92
Good	2	4
Poor	2	4

- Excellent: - Individual tendon function evident with 85% to full range of motion or finger flexion to 1.0cm or less from the distal palmar crease.
- Good: - 70-84% total normal range of motion or 2.0cm from the distal palmar crease.
- Fair: - 50-69% total normal range of motion.
- Poor: - Fixed contractures or adhesions.

Tendon function was found to be excellent in 92% of cases. 4% patients had good and another 4% had poor function.

Table 13: Opposition

Opposition	N	%
Excellent	43	86
Good	6	12
Poor	1	2

- Excellent: - When the tip of the thumb moves freely over the three phalanges of the other 4 fingers
- Good: - When the tip of the thumb touches only the tip of the other 4 fingers.
- Poor: - When the tip of the thumb cannot reach the tip of the other 4 fingers.

Table 15: Sensations

Sensations	n	%
Excellent (<10mm)	37	74
Good (10-20mm)	6	12
Fair (>20mm)	5	10
Poor	2	4

Opposition was excellent in 86% of the patients and poor in 4% of patients.

Table 14: Intrinsics

Intrinsics	N	%
Excellent	39	78
Good	8	16
Fair	2	4
Poor	1	2

Excellent: - When the patient can do both finger abduction and adduction with negative froment sign.

- Good: - When the patient can do both finger abduction and adduction with positive froment sign.
- Fair: - When the patient can do either finger abduction or adduction with positive froment sign.
- Poor: - When the patient cannot do finger adduction and abduction with positive froment sign.

Intrinsic function yielded similar results with majority of patients (78%) exhibiting excellent function.

- Excellent: - When the two point discrimination is less than 10 mm
- Good: - When the two point discrimination is 10-20mm
- Fair: - When the two point discrimination is more than 20 mm wit light touch and pain prick sensation
- Poor:- When there is trophic changes or skin ulceration

Sensory recovery was reported excellent in 74% of patients.

12% had well, 10% had fair and another 4% had poor sensory recovery.

Table 16: Deformity

Deformity	n	%
None	48	96
Minor	2	4

Deformity was classified as minor if there was either claw hand or ape thumb. Major deformity was defined as presence of both claw hand and ape thumb. Only 4% of patients developed minor deformities.

Discussion

Microsurgical repair has brought a revolutionary change in the management of injuries at wrist in the recent past following considerations given to the level and extent of injury, technical skill and strategy employed by the surgeon. Timely exploration of the wounds plays an important role in predicting the outcome of the injuries. In our series of patients, the outcome was comparable with the worldwide literature.

The present study conducted at Sher-i-Kashmir Institute of Medical Sciences, Srinagar, a sole tertiary care institute in Jammu and Kashmir State, India, highlights the demographic characteristics,

clinical profile and the outcome of wrist injuries observed in the region.

In our series of patients, the commonly affected age group was between 21years to 40 years and the mean age was 28.9years. Males (86%) outnumbered females (14%) in our study. Concordant findings were noted by Weinzweig N et al [8] who observed that the average age of their patients (60) was 29 years and out of these, 41 were males and 19 were females. In the study conducted by Noaman H. et al.[18] majority of patients were males (31) and average age of patients was 17.1years. Iconomou et al. [6] observed that the mean age of the patients was 9 years which included 15 male and 6 female patients. All these facts reveal that young adult men are the vulnerable group for the wrist trauma.

Glass cut injury accounted for majority of wrist injuries contributing 64% of cases. Weinzweig N [8] also observed that glass cut injuries were the main causative agent. Iconomou et al. [16] observed that 84.2% of their patients suffered a sharp glass cut injury. In the study conducted by Noaman H et al. [18] accidental glass lacerations were the main mode of injury at wrist accounting for 55% of cases. All these studies reflect the seriousness of the glass cut injuries suffered by our patients, most of whom were young adults and, therefore were not experienced in handling the causative agent.

About 74% of our patients had right sided injuries. This is in accordance with the observation made by Selma et al. [10] who had right sided afflictions in 71% of their patients. This may be due to the fact that the glass (main causative agent) when not carefully handled, slips from the hand to cause injury on the wrist. All of our patients were taken for early repair and primary repair of the involved structures was done. The specific aid in diagnosing the involvement of various structures was by exploring the wound. In the study conducted by Iconomou et al [6] thorough wound exploration formed an essential criteria for diagnosing the underlying injury to the deep structures. In the study conducted by Noaman et al. [18] wound exploration was the specific aid in diagnosing the involvement of wrist structures. Bukhari et al. [15] in their study performed emergent and primary repair of the involved structures after thorough wound exploration. All these studies therefore direct us to lay emphasis on thorough wound exploration to be employed to search for damage to the underlying essential structures. It is also emphasised that not to underestimate, the degree of injury beneath a small looking incised wound of the wrist.

As regards the frequency of the tendon involved, the flexor digitorum superficialis was involved in 66% of patients and was the commonest involved tendon at wrist. This is inaccordance with the observation made by Noaman H et al. [18] who found that FDS was the most commonly involved tendon in wrist injury. This may be due to the specific superficial location of the tendon. FCU and FDP were the next in frequency accounting for 48% and 42% respectively.

Ulnar nerve injuries accounted for majority of nerve injuries amounting 54% whereas median nerve injuries was observed in 42%. Combined injury of both nerves was seen in 16% of patients. Study conducted by Iconomou et al.(6) showed that for wounds below the elbow, the ulnar nerve was the most frequently involved nerve in 26% of their patients and median nerve was involved in 16% of their patients.

Daoutis et al. [24] observed median nerve crush injuries in 47% of their patients whereas ulnar nerve crush injuries comprised 45% of their patients. In the study conducted by Noaman H et al. [18] median nerve was affected in 83% of cases. Ulnar artery was involved in 48% of cases whereas radial artery was affected in 24% of cases. Combined injury of both vessels was observed in 10% of cases. This is in accordance with the study conducted by Noaman H et al. [18] who found ulnar artery to be involved in 54% of cases, radial artery was involved in 28.5% of cases. Combined injury of both vessels was observed in 16% of cases.

As already stated early surgical repair of the injured structures was carried out in all of our patients. This is in accordance with the study conducted by Iconomou et al.(18) and Selma et al.(10) in whom majority of patients were operated on emergency basis. Timely address of the injured structures forms the cornerstone for successful outcome of the repaired structures and same was applied in our patients. Fifty patients of wrist injury operated were followed up for six months and range of motion of affected tendons at six monthly follow up revealed excellent results in46 patients (92%), good in 2 patients(4%) and poor in 2 patients. This is in accordance with the observations made by Noaman H et al. [18] who in his study observed excellent function in 89% of patients, good in 8% and poor in 2.6% of patients. Kitsis et al. [7] in his study observed excellent or good tendon function in 92% of his patients. Rogers G D et al [4] in their prospective study on combined injuries of both major nerves and flexor tendons at the wrist found that tendon repair yielded good restoration of hand mobility and strength. Hudson et.al studied [5] the results of repair of simultaneous laceration of the median & ulnar nerves with flexor tendons at the wrist and found that most patients regained a functional range of wrist movement.

In our study opposition was excellent in 43 patients (86%), good in 6 and poor in 2 patients. Intrinsic muscle recovery was excellent in 39 patients (78%), good in 8 patients, fair in 2 and poor in 1 patient. Sensory recovery was excellent in 37 patients (74%), good in 6, fair in 5 and poor in 2 patient. This is in accordance with the study conducted by Noaman H et al. [18] who reported excellent opposition in 81.6% of patients, excellent intrinsic muscle recovery and excellent sensory recovery in 84.5% of patients. As regards arterial injuries patency was found to be 100% in all vessels repaired which is in accordance with the study conducted by Noaman H et al. [18].

Thus the analysis made by our study proves that in order to obtain the best outcome in wrist injuries, the injury must not be underestimated from the description of the wound and thorough exploration should be done to identify the underlying vital injuries if present and timely address should be made to repair the damaged nerve.

Summary and conclusion

The present study was a prospective study of 50 patients of wrist injuries on flexor aspect conducted by the department of Plastic and Reconstructive Surgery at Sher-i-Kashmir Institute of Medical Sciences. All the patients were evaluated in detail for the presence of injuries acquired to the vital structures at the wrist. Analysis included clinical profile, baseline investigations and more specifically the surgical exploration of wound. Early repair of the involved structures was taken in the study. In the post-operative period continuous and periodic follow-up of the patients was done to assess the outcome. Following conclusions were drawn from the present study: -

- Wrist injuries are more common in males
- Younger age group is more vulnerable
- Glass cut injuries account for most of the injuries of wrist
- The injuries have right sided predilection
- Ulnar side of wrist has more vulnerability than radial aspect
- Wound exploration is an essential aid in diagnosis
- The most commonly involved tendon in the injuries is flexor digitorum superficialis
- Ulnar nerve is more frequently involved than median nerve in wrist trauma
- Ulnar artery involvement in wrist injuries is more than that of radial artery
- Early repair of involved structures has a favourable effect on the outcome
- Early mobilisation enables the patients to achieve excellent functional outcome

Thus our study concluded that overall good functional outcomes of wrist injuries can be obtained in majority of patients and early post-operative mobilisation can have a very beneficial effect in determining such results. Furthermore, any small looking incised wound need not to be overlooked and its timely exploration and repair of injured structures coupled with use of microsurgical techniques, magnification, use of finer sutures and early post-operative mobilisation form the cornerstone for a successful outcome.

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