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Management of combined tendon, nerve, and vessel injuries of the volar wrist: a retrospective study of functional outcome

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Abstract

Background: Combined tendon, nerve, and vessel injuries of the volar wrist are complex and often result in significant functional impairment. This study aimed to evaluate the etiology, injury patterns, and functional outcomes following surgical repair.

Methods: A retrospective analysis was conducted on 32 patients with combined volar wrist injuries treated between March 2021 and March 2024 in the Department of Plastic and Reconstructive Surgery. Data on mode of injury, structures involved, and postoperative outcomes were collected. Vascular patency was assessed clinically, sensory recovery was evaluated using the two-point discrimination test, and motor recovery was determined by measuring the total active range of motion (TAM) of the fingers.

Results: Of 32 patients, 29 (90.6%) were male, with the majority aged 21–30 years (53.1%). Injuries involved the dominant hand in 18 (56.2%) patients. The most common causes were accidental workplace injuries (46.9%) and self-inflicted cuts (25%). Radial artery injury occurred in 14 (43.7%), ulnar artery injury in 12 (37.5%), and both arteries in 6 (18.8%) patients. Median nerve injury was present in 15 (46.9%) and ulnar nerve injury in 12 (37.5%) patients. The flexor digitorum superficialis (62.5%) and flexor carpi ulnaris (56.2%) tendons were most frequently involved. Two-point discrimination of 2–5 mm was achieved in 24 (75%) patients. TAM assessment showed excellent function in 10 (31.3%) and good function in 12 (37.5%) patients. All arterial repairs remained patent.

Conclusion: Combined volar wrist injuries predominantly affect young males, commonly from workplace accidents. Despite good vascular patency and satisfactory sensory recovery, motor recovery remains limited in cases involving both ulnar and median nerve injuries. This study reinforces that early intervention and structured physiotherapy significantly influence final functional outcome.

Keywords: volar wrist injuries; tendon and neurovascular repair; ulnar triad injury; two-point discrimination test

Introduction

Combined injuries involving the tendons, nerves, and vessels of the volar wrist are common due to the close anatomical proximity of these vital structures in the distal forearm. Zone V flexor tendon injuries occur in the forearm, proximal to the carpal tunnel. The important structures at the volar wrist include two major arteries (radial and ulnar), two nerves (median and ulnar), and twelve tendons. The finger flexor tendons comprise the flexor digitorum superficialis (FDS) and flexor digitorum profundus (FDP), while the thumb flexor tendon is the flexor pollicis longus (FPL). The wrist flexors include the flexor carpi radialis (FCR), flexor carpi ulnaris (FCU), and palmaris longus (PL).

Puckett and Meyer defined "spaghetti wrist" as a sharp laceration of the volar wrist between its distal skin fold

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and the flexor musculotendinous junction involving transection of at least three structures, including a minimum of one nerve and one vessel [1]. The most common mechanisms of injury include glass and knife cuts, occupational trauma from machinery such as electric saws, and self-inflicted wounds [2,3]. These injuries are particularly prevalent in the working-age population [4]. Prognosis depends largely on timely surgical intervention and structured postoperative rehabilitation to optimize functional recovery. Associated nerve injuries significantly affect outcomes even after successful tendon repair, while vascular compromise may further impede tendon healing [5].

The objective of this study was to evaluate the etiology and pattern of volar wrist injuries involving tendons, nerves, and vessels, and to assess the functional outcomes following surgical repair in terms of total active range of motion and sensory recovery.

Materials and methods

This retrospective descriptive study was conducted in the Department of Plastic and Reconstructive Surgery at SSIMS & RC, Davangere, Karnataka, over a period of three years, from March 2021 to March 2024. Ethics committee approval was obtained for this study. A total of 32 patients who fulfilled the inclusion criteria were included in the study. The study population comprised both male and female patients aged between 11 and 60 years who presented with combined injuries involving tendons, nerves, and vessels of the volar wrist. Patients with associated life-threatening injuries or those with isolated tendon injuries without neurovascular involvement were excluded from the study.

Demographic data including age, sex, occupation, and hand dominance were obtained from hospital records. The history of the presenting complaint, mechanism of injury such as accidental workplace injury, suicidal attempt, assault, or road traffic accident and time since injury were documented. Clinical examination focused on neurovascular, musculotendinous, and skeletal assessment of the affected limb. Particular attention was given to the site of injury, vascularity of fingertips, and the presence of sensory or motor deficits.

All 32 patients underwent surgical repair on the same day of presentation under regional anesthesia and tourniquet control to minimize blood loss. Procedures were performed under loupe magnification for precise identification and repair of the injured structures. Following meticulous wound debridement, the proximal and distal cut ends of tendons, nerves, and vessels were identified. Repair was performed in layers, beginning with the deeper structures and progressing to the superficial ones. Tendon repair was carried out using the modified Kessler's core suture technique with 3-0 Prolene, reinforced by epitendinous suturing with 5-0 Prolene. Arterial repair was performed using 8-0 Ethilon, and nerve repair was accomplished with epineural suturing using 8-0 Ethilon.

Postoperatively, the hand was immobilized in a dorsal plaster of Paris splint, maintaining flexion at the wrist, metacarpophalangeal, and interphalangeal joints. Physiotherapy was initiated within 24 hours of surgery. Passive flexion exercises for interphalangeal joints were encouraged while the hand remained in the dorsal-blocking splint. Between the third and sixth week, the splint was removed, and patients were instructed to begin active flexion and extension exercises with the wrist in a neutral position. After six weeks, gentle passive extension exercises were introduced, and patients were encouraged to gradually resume daily activities.

Follow-up assessments were performed at one month, three months, and six months postoperatively to evaluate progress and rehabilitation. Arterial patency was assessed using a handheld Doppler device. Sensory recovery was evaluated by monitoring Tinel's sign during follow-up and by performing a two-point discrimination test at six months (Table 1). Motor recovery was assessed by measuring the total active range of motion of the fingers (Table 2).

Table 1: Interpretation of two point discrimination test.

Measurement	*Interpretation*
2-5mm	Normal
6-10mm	Fair
11-15mm	Poor
One point of perception	Protective
No point perceived	Anaesthesia

Table 2: Evaluation of Tendon function.

Interpretation	*Tendon function*
Excellent	Individual tendon function was evident with 85% to full range of motion or finger flexion to 1.0 cm or less from the distal palmer crease
Good	70–84% total normal range of motion or 2.0 cm from the distal palmar crease.
Regular	50–69% total normal range of motion
Poor	Fixed contractures or adhesions

Statistical analysis

All data were analyzed using Microsoft Excel (Version 2016). Descriptive statistics were applied, and results were expressed as frequencies and percentages.

Results

A total of 32 patients with combined injuries involving tendons, nerves, and vessels of the volar wrist were included in the study. Of these, 29 (90.6%) were male and 3 (9.4%) were female. Seventeen (53.1%) patients were in the age group of 21–30 years, 11 (34.4%) were between 31–40 years, and 4 (12.5%) were between 41–50 years. The right hand was affected in 21 (65.7%) cases and the left hand in 11 (34.3%), with 18 (56.2%) patients sustaining injuries to their dominant hand.

The most common etiology was accidental workplace injury, observed in 15 (46.9%) patients, followed by suicidal injury in 8 (25%), assault in 5 (15.6%), and road traffic accidents in 4 (12.5%) (Figure 1). Among the vascular injuries, 14(43.75%) patients had injury to the radial artery, 12 (37.5%) to the ulnar artery, and 6 (18.75%) had injuries involving both arteries (Figure 2). With respect to nerve injuries, 15 (46.9%) patients had median nerve involvement, 12 (37.5%) had ulnar nerve involvement, and 5 (15.6%) sustained combined median and ulnar nerve injuries (Figures 3,4 and 5).

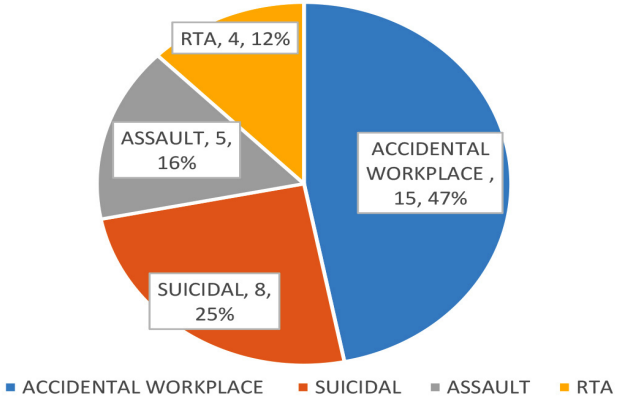

Figure 1: Mode of injury.

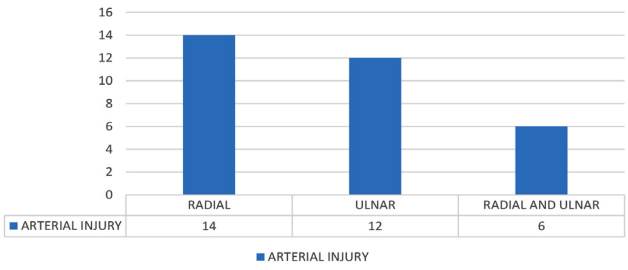

Figure 2: Arterial injury.

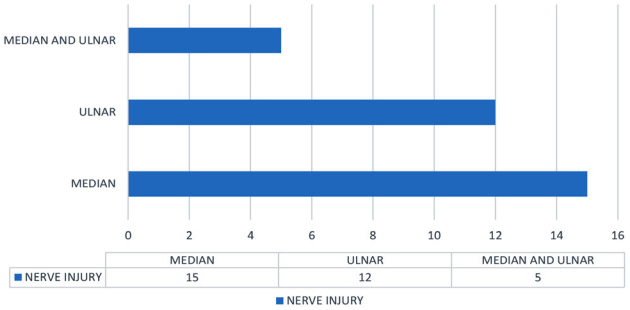

Figure 3: Nerve injury.

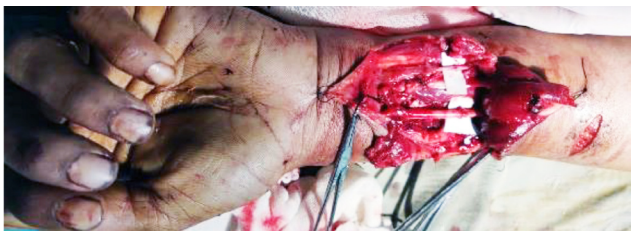

Figure 4: Image showing median nerve repair and ulnar artery repair (on a white background). Also visible are the sutured ends of the ulnar nerve, tendons of the Flexor Digitorum Profundus (FDP) of the 2nd, 3rd, 4th, and 5th fingers, Flexor Carpi Ulnaris (FCU), and the reflected cut ends of the Flexor Digitorum Superficialis (FDS) of the 2nd, 3rd, 4th, and 5th fingers.

Figure 5: Image showing the cut ends of the Flexor Carpi Ulnaris (FCU), ulnar artery, and ulnar nerve (ulnar triad injury). Also visible are the repaired tendons of the Palmaris Longus (PL), Flexor Digitorum Superficialis (FDS), and Flexor Digitorum Profundus (FDP) of the 4th and 5th fingers.

Regarding tendon involvement, the FDS was most commonly affected in 20 (62.5%) patients, followed by the FCU in 18 (56.2%), Flexor pollicis longus (FPL) in 16 (50%), FCR in 15 (46.8%), PL in 15 (46.8%), and FDP in 12 (37.5%) patients (Table 3). A Chi-square goodness-of-fit test comparing tendon injury distribution across the six tendons yielded a Chi-square value of 2.38 ($p = 0.80$), indicating no statistically significant difference among tendon groups. This suggests that tendon injuries were relatively evenly distributed across the different structures assessed.

Table 3: Tendon injury.

Tendons injured	*Frequency*
Flexor carpi radialis (FCR)	15(46.8%)
Flexor carpi ulnaris (FCU)	18(56.2%)
Flexor digitorum superficialis (FDS)	20(62.5%)
Flexor digitorum profundus (FDP)	12(37.5%)
Flexor pollicis longus (FPL)	16(50%)
Palmaris longus (PL)	15(46.8%)

In the two-point discrimination test, 24 (75%) patients were able to discriminate 2–5 mm stimuli, 6 (18.75%) patients discriminated 6–10 mm stimuli, and 2 (6.25%) patients identified 11–15 mm stimuli (Figure 6). Evaluation of tendon function using total active range

of motion revealed excellent function in 10 (31.3%) patients, good in 12 (37.5%), fair in 7 (21.8%), and poor in 3 (9.4%) patients. Vascular patency, assessed by handheld Doppler, was confirmed in all 32 (100%) patients who underwent arterial repair of either the radial or ulnar artery, or both.

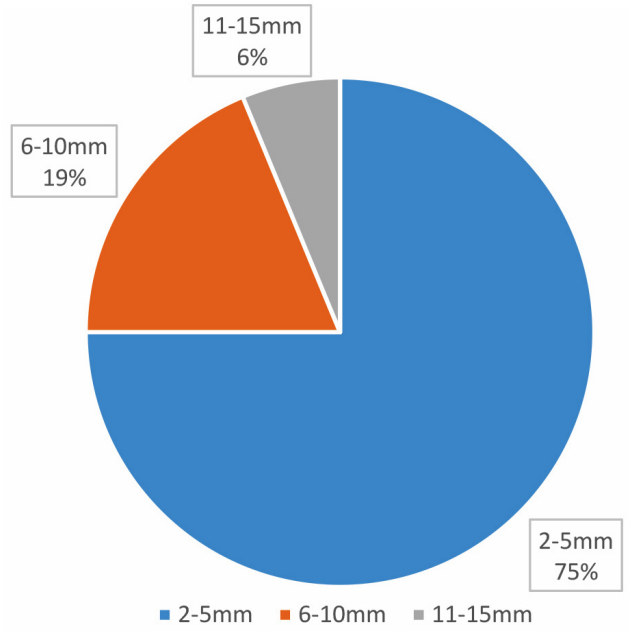

Figure 6: Sensory assessment with two point discrimination test.

Overall, the results demonstrate favourable postoperative outcomes following timely surgical intervention and structured rehabilitation. Patients who presented early and underwent meticulous repair under magnification achieved better sensory and motor recovery compared to those with delayed presentation. Combined median and ulnar nerve injuries were associated with slower and incomplete functional restoration. Consistent physiotherapy and patient compliance were observed to play a critical role in optimizing long-term outcomes and minimizing residual disability.

Discussion

Combined injuries of tendons, nerves, and vessels of the volar wrist frequently occur due to the superficial location of these critical structures, rendering them vulnerable to penetrating trauma. In the present study, the majority of patients were male (n = 29, 90.6%) and between 21–40 years of age (n = 28, 87.5%). In the study by Noaman et al., 31 patients were male and 11 were female, with a mean age of 17.1 years (range, 2–40 years) [2]. Weinzweig et al. reported 41 (68.3%) male and 19 (31.7%) female patients, with a mean age of 29 years [6]. Similarly, Boynuyogun et al. observed 20 patients (15 male and 5 female) with a mean age of 32.7 years (range, 18–47 years) [7]. Rogers et al. found that the majority of their 26 patients were young male adults (mean age 28.7 years), with a male-to-female ratio of 5.2:1 [8]. Yazdanshenas et al. also reported a predominance of male patients (n = 122, 89%) with an average age of 28.3 years [9].

Involvement of the dominant hand significantly impacts a patient's occupational performance and daily function. In the current study, 18 (56.2%) patients sustained injuries on the dominant hand. Rogers et al. found similar results, reporting 16 dominant-hand injuries out of 26 cases [8]. Noaman et al. noted right-hand involvement in 28 (66.7%) patients [2], while Boynuyogun et al. reported 12 (60%) right-hand and 8 (40%) left-hand injuries [7]. Yazdanshenas et al. observed right-hand involvement in 128 (83.6%) patients [9].

The most common etiology in the present study was accidental workplace injury (n = 15, 46.9%), followed by suicidal injury (n = 8, 25%). In contrast, Noaman et al. reported glass cuts as the leading cause (59.5%), followed by knife stabs (23.8%) and electrical saw injuries (11.9%) [2]. Weinzweig et al. documented accidental glass cuts in 61% of patients, knife wounds in 23.7%, and suicidal injuries in 8.5% [6]. Rogers et al. found that deliberate punching of glass often under intoxication accounted for 38% of injuries, while accidental glass falls or sharp object lacerations caused 27%, and suicidal injuries 19.2% [8].

In this study, the radial artery (n = 14, 43.7%) and median nerve (n = 15, 46.9%) were most frequently injured. Noaman et al. observed that the median nerve (83%) and ulnar structures (57%) were most commonly affected [2]. Boynuyogun et al. found frequent involvement of the ulnar nerve and artery, with 16 (80%) patients having both ulnar and median nerve injuries [7]. Yazdanshenas et al. also reported high rates of ulnar (86.3%) and median (73.9%) nerve involvement [9].

Among tendons, the *flexor digitorum superficialis* (FDS) was the most commonly injured in this study (62.5%), followed by *flexor carpi ulnaris* (FCU) (56.25%). Noaman et al. reported frequent involvement of FDS 2–4 (81%), FDP (66%), and FPL (40%) [2]. Boynuyogun et al. noted that the *palmaris longus* (PL) and FDS tendons were universally injured among their patients [7], while Yazdanshenas et al. found FDS 3 and 4 to be the most frequently affected structures (98%) [9].

The "ulnar triad injury," which includes injury to the ulnar nerve, ulnar artery, and FCU tendon due to their close anatomical relationship, was noted in 17 (53.7%) patients in this study. Boynuyogun et al. reported ulnar triad injuries in 14 (70%) patients [7], Yazdanshenas

et al. in 77 (55.3%) [9], and Weinzweig et al. in 41.7% [6]. Kumar-Kempelingaiah et al. also observed frequent involvement of the ulnar nerve (73%) and FCU (68%) [4]. Another common injury pattern involved the *flexor carpi radialis*, *palmaris longus*, and median nerve. Weinzweig et al. noted this pattern in 26% of their patients [6], while Lee et al. found that PL tendon injuries associated with median nerve lacerations were more common in self-inflicted cases [10].

In the present study, sensory recovery of the fingers, as measured by the two-point discrimination test, was satisfactory, with most patients regaining near-normal sensation. Noaman et al. reported excellent sensory recovery (<10 mm) in 32 patients, good (10–15 mm) in 5, and fair (>15 mm) in 1 [2]. Weinzweig et al. found disappointing long-term sensory outcomes, with only 3 patients achieving 2–6 mm discrimination and 5 between 7–12 mm [6]. Yazdanshenas et al. reported excellent sensory recovery in 28 patients (<10 mm) and good in 46 (10–15 mm) [9].

Early mobilization following repair plays a critical role in preventing adhesions and optimizing function. In this study, passive finger motion within the splint was initiated within 24 hours of surgery. Bukhari et al. emphasized that controlled early stress enhances tendon healing, whereas prolonged immobilization predisposes to adhesion formation [11]. In the current series, poorer outcomes were observed in patients with combined median and ulnar nerve injuries, where motor recovery lagged. Kabak et al. found that among patients with combined median and ulnar lacerations, the median nerve showed superior recovery compared to the ulnar nerve [12]. Noaman et al. reported excellent tendon function in 34 patients and good in 3 [2], while Weinzweig et al. noted excellent range of motion in 12 and good in 7 patients [6]. Boynuyogun et al. observed excellent outcomes in 60%, good in 20%, and fair in 20% [7]. Yazdanshenas et al. reported excellent tendon recovery in 78% of their cases [9].

Recent investigations suggest that evolving rehabilitation protocols and earlier mobilization may further enhance functional recovery in volar wrist injuries. For instance, early-active motion protocols using dedicated orthotic devices have shown significant improvements in objective hand function scores without increased complication rates [13]. Moreover, large multicentre reviews have begun to identify specific predictors of poorer outcomes such as combined arterial injuries, delayed repair beyond 24 hours, and crush mechanisms rather than sharp lacerations [14]. Looking ahead, studies capturing data up to 2024 emphasise the need for standardized injury classifications and long-term functional assessment tools to reliably compare outcomes across centres [15].

In this study, vascular patency was maintained in all 32 patients who underwent arterial repair, with no cases of ischemia or re-exploration. Similar results were noted by Noaman et al., who reported a 100% patency rate following vascular repair [2].

Limitations: The study is limited by its small sample size, retrospective design, and single-centre setting, which may restrict the generalizability of findings. Being a descriptive study, no comparative statistical analysis was performed. Parameters such as grip strength, intrinsic muscle function, and opposition were not assessed, which could provide a more comprehensive understanding of long-term functional recovery. Future prospective multi-centre studies with validated functional scoring systems may provide more generalizable evidence.

Conclusion

Combined injuries of tendons, nerves, and vessels of the volar wrist commonly affect young male workers and result in significant functional impairment. Optimal outcomes depend on prompt diagnosis, meticulous surgical repair within 24 hours, and adherence to a structured physiotherapy protocol. Sensory recovery of the median and ulnar nerves was generally satisfactory and comparable; however, motor recovery was slower in patients with combined median and ulnar nerve injuries. Early intervention and comprehensive rehabilitation are essential to maximize function and minimize long-term disability in these complex injuries.

Conflicts of interest

Authors declare no conflict of interest.

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